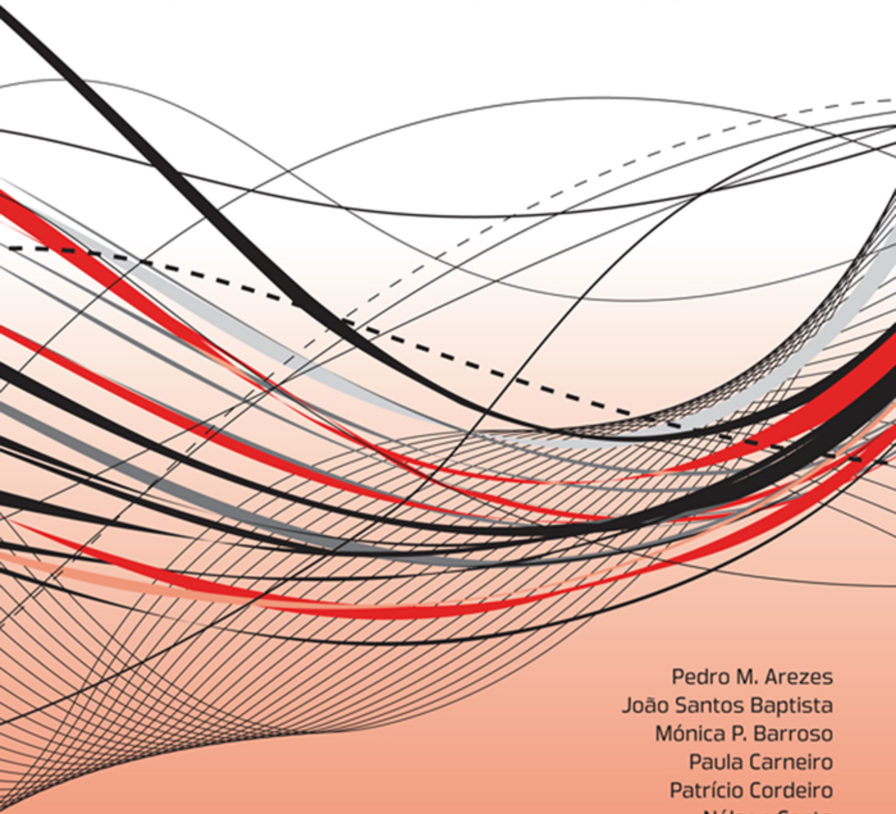
Occupational Safety and Hygiene III



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Occupational Safety and Hygiene III

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Foreword

This book is the third edition of this series of publications that are entitled "Occupational Safety and Hygiene". The main contributions for this book were, once again, the works previously submitted and approved to be presented at the annual Symposium of the Portuguese Society of Occupational Safety and Hygiene (SPOSHO), which is celebrating its 11th edition in 2015. The SHO2015—International Symposium on Occupational Safety and Hygiene, similarly to the past seven years, was held in the School of Engineering at University of Minho in Guimarães, Portugal.

The 94 papers included in this book are authored by more than 345 authors from 16 countries and all of them were individually reviewed by the international Scientific Committee (SC) of the Symposium, which has involved more than 120 international specialists in the various scientific fields covered by the event.

As in the last edition, we take this opportunity to thank our academic partners of the organisation of SHO2015, namely, the School of Engineering of the University of Minho, the Faculty of Engineering of the University of Porto, the Faculty of Human Kinetics of the University of Lisbon, the Polytechnic University of Catalonia and the Technical University of Delft. We also thank the scientific sponsorship of more than 20 academic and professional institutions and the official support of the Portuguese Authority for Working Conditions (ACT), as well as the valuable support of several Companies and Institutions, including the several media partners, which have contributed to the broad dissemination of the event.

Finally, we also hope that the papers included in this book can be a valuable contribute to improve the way research results in the mentioned domains are shared, by presenting the state-of-the-art of the considered topics, as well as to show the practical application of new research methodologies and the relevance of emergent topic within the domain of occupational health and safety.

The Editors,

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The editors wish also to thank all the reviewers, listed below, which were involved in the process of reviewing and editing the papers included in this book.

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Ergonomics analysis in operators of electric power control centers: Proposed methodology

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ABSTRACT: The electric companies increasingly face challenges related to health and well-being of workers in particular those related directly to the operation and maintenance of electrical systems. However, there are some ergonomic factors in particular that always need to be improved. In these systems, a confusing Human Computer Interface (HCI) with an operator can result in misinterpretation and induce errors during decision making. Therefore, these systems require, among other characteristics of data quality, safety, adaptability, training facility, learning and appropriate use. It was shows some results of workload in operators of in two countries Brazil and Portugal. It is analyze aspects of cognitive ergonomics and human factors in electric power control centers and contribute to a proposed methodology covering the following topics in ergonomics: Human; Computer; Workload, Interface and Critical Factors.

1 INTRODUCTION

One of the major challenges that companies increasingly face is related to the health and well-being of workers especially those directly related to the operation and maintenance of electrical systems. These technicians have to perform tasks that mobilize knowledge and reasoning for which they received training, which from the point of view of the current rules are adequate. However, there are some factors that need to be improved because there are still accidents and incidents caused mainly caused by fatigue. In these systems, a confusing Human Computer Interface (HCI) with an operator can result in misinterpretation and induce errors during decision making. Therefore these systems require, among other characteristics of quality, safety, adaptability to different users and levels of experience, and training facility associated with their learning and use (Lima, 2006; Vieira, *et al*., 2009.).

Figure 1 shows a typical installation of an electric power of operation and control center, where there are individual monitors in the background and monitors with synoptic data on general line of power systems panels. In general there is a complex information system with the operator at the center of decisions among different monitors, tables and diagrams that take up your entire field of vision. The complexity of the Human-Computer Interface (HCI) is high in the operation and control centers for the following reasons May (2008):

Figure 1. Typical installation of a room of the electrical power control and operation system (Source: ONS, 2014).

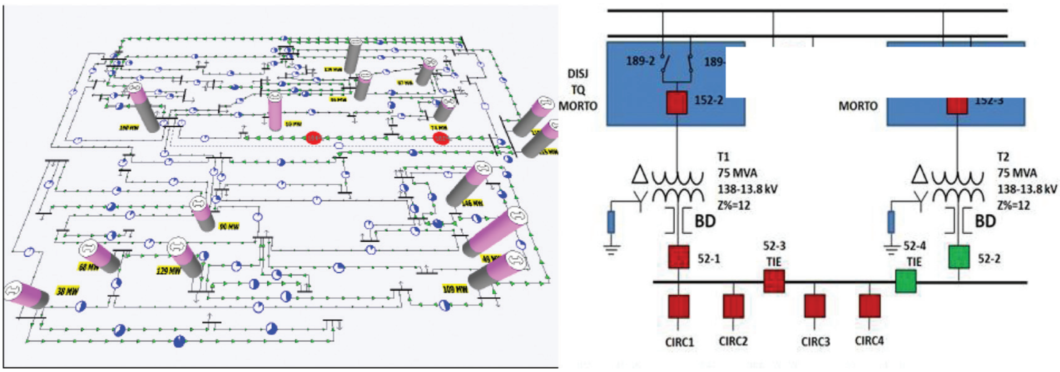

Figure 2a and 2b. Data representation of a electrical system of 3D (a) and 2D (b) (Source: Wiegmann *et al.*, 2006).

- Demand for sustainable energy generation leading to an increased amount of variable sources of power generation with low predictability like wind energy
- Further integration and increase in the size of national and regional networks
- Increased complexity of coordination arising from the implementation of optimal power flow based on the electricity markets
- Increased demand for resilient networks of energy, in the form of permanent micro-networks or islanding that may help to protect the larger instabilities in voltage networks and other complications include the maintenance

In this case they have to take into account a large amount of multivariate data. As a simple example information on load flows of electricity, there is a potentially large number of dependent variables, such as the load flows in the transmission lines and sub-transmission, bus (substations), generators database of active and reactive power; data from various equipment such as transformers, circuit breakers, switches, lightning arresters, among others. With systems containing many bus, the major challenge is to present this data in a way that can be quick and intuitive. (Wiegmann *et al.*, 2006).

The information associated with energy systems has generally been shown using a Two-Dimensional interface (2D) and 3D display often consisting of a one-line diagram of a system as shown in Figures 2(a) and (b). In this diagram the black bars mean substations and the lines are electric power transmission lines. In the same Figure 2 the smaller circles with internal insertion blue inform the electrical system load, the arrows indicate the direction of the flow of electrical power and pink and gray bars represent the power generation.

This article aims to analyze the aspects of ergonomics and human factors in electrical power control centers and contribute to a proposed methodology of study and analysis that includes the following topics HCIC; 1-Human (Operators: Work (Feature, experience, life quality, personal and anthropometric data), 2-Computer (control centers: organizational work, organizational culture, activities shift; attention, information safety);-3 Interface HCI: (tasks, monitoring, supervision, planning, operation, equipment, monitors, computers, supervisory panel system);-4 Critical Factors: (quantity of information, quality information, workload, fatigue, stress, environmental factors, noise, lighting, thermal comfort).

2 THE USE OF VIRTUAL REALITY (VR) ON THE HCI STUDIES STARTED

In a very broad sense, the VR is a way to transport a person to a reality in which they are not physically present, but it seems they are there. It is clear that any form of simple media, for example, a text or a picture or representation of a painting can provide a similar sensation in the reader or viewer, picked up from a familiar environment for those within the story or picture.

The virtual reality is the use of computer modeling and simulation that allows a person to interact with an artificial Three-Dimensional (3D) visual environment (Vilar, 2010, 2009; Vieira, 2010). VR applications immerse the user in a computer generated environment that simulates reality through the use of interactive devices that send and receive information and are used as goggles, headsets, gloves, or body (Rebelo *et al.*, 2010–1, 2010–2). This type of tool is increasingly being used for training and education of workers (Robert, Laponte, 2000; Santos *et al.*, 2001).

3 METHODS AND MODELS

There are several methods of evaluation for the cognitive aspects and workload. Among various used subjective assessment tools is NASA-TLX, which is part of a multidimensional measure arising from a global score (minimum 1 to maximum 20 balanced workload guided the weighted average of reviews of six sub-scales. The NASA-TLX has turned out to be appropriate, taking into account its practicality and simplicity in the questionnaire and for assessing globally the workload. These six factors involve: The Level of Achievement (LA) refers to satisfaction with personal performance to the achievement of the task. The Level of Effort (LE) refers how much you have to work physically and mentally to achieve a good performance. The Level of Frustration (LF) is the factor that inhibits completion of the work as insecurity, irritation, lack of stimulation, setbacks. The Mental Requirement (MD) involves mental activity required to perform the work. The Physical Requirement (RP) corresponds to physical activity required for execution of the work and the Time Requirement (TR) for the level of pressure imposed for the completion of the same (Correa, 2003).

The proposed methodology for the analysis of ergonomics and human factors studies of interfaces in control centers and power operations follows the flow diagram in Figure 3.

Step 1-Work Situation Analysis-Operator (experience, activity, age, lifestyle and life quality, personal and biomechanical data, anthropometric data); -Organizational (organizational culture, shift work, commitment to work, strain at work, attention, concentration, information security, automation) -Environmental (temperature, noise level, lighting, layout, position monitors, supervision, furniture panels and especially the chairs of operators);

Step 2-Analysis of the Activities; Posture-Activities in Visual Systematic Observations and Labor; -Worker's Strategies to accomplish the task; -Communication with other workers.

Step 3-Analysis of Perceptions; -Collecting data with a significant sample through questionnaires: (cognitive, mental workload, types of tasks, difficulty of execution, switch and emergency operations). These questionnaires, using the methods described above, with emphasis on methods for evaluating workload as the NASA-TLX, SWAT and additional psychometric methods that assess concentration and attention; -Interviews with a selected small sample group. It is recommended that the interview is quick with structured responses to provide a better understanding of the factors involved between the work situation and ergonomic aspects.

—Collecting data with the interview: (type of software, colors, symbols, size of the graphics system, modeling of equipment, types of screens, web design and other data). -At this stage the main ergonomic factors as well as the general that will be included in the simulation in Virtual Reality environment in the following Step 4 will be defined.

Step 4-Application of Virtual Reality-Definition of the real and the virtual environment (AV) of typical installations with selected frames and operator panels and control as well as warnings and signals to be analyzed; Collecting data with a small sample of operators on their perception of these virtual environments of normal and emergency work situations.

4 RESULTS

The Figure 4 shows some results of the research of the comparative data from Portugal and Brazil with 54 operators. There is the data of the six variables of NASA-TLX subjective assessment tools: MD (mental demand), RP (Requirement Physics), TR (Temporal Requirement), LA (Level of Achievement), LE (Level of Effort) and LF (Level of Frustration). The scale corresponds to the first minimum value 1 and the maximum index 20.

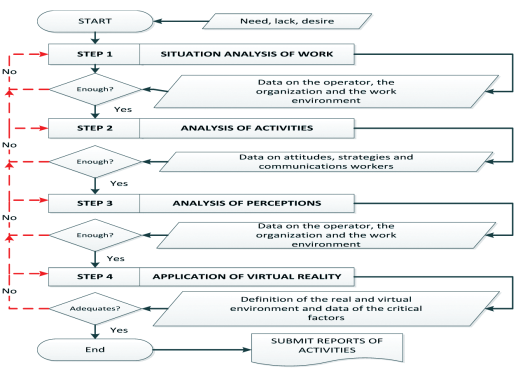

Figure 3. Flow diagram of the proposed methodology (Source: Own elaboration).

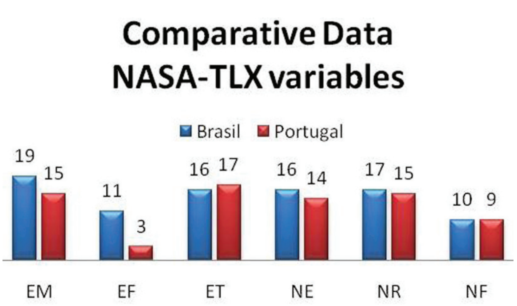

Figure 4. Comparative data between Brazil and Portugal of NASA-TLX variables (MD, RP, TR, LE, LA and LF).

5 CONCLUSION

- The activities of the operator of the Electric Power Control and Operation Centers are extremely complex, with many variables and the coach has a high degree of uncertainty. Their tasks are associated with hazardous processes and systems that depend on a system of specialized supervision. Some critical emergency events occur infrequently and with regularity, but need monitoring and decision quickly and continuously.
- The results of NASA-TLX in the variable Mental Demand (MD) indexes are high in both countries, although data in Brazil are higher than 25% for Portugal. The high values found in both countries featuring a kind of work with difficult, complex task, requiring much mental effort to achieve the goal
- Regarding the Temporal Requirement (TR) also found high rates in both countries. Thus the types of operators of this task are characterized by a fast and frantic pace, with lots of pressure for the completion of activities.
- As for the variable Level of Effort (LE) were moderate. It is emphasized that this index brings together internally to the mental and physical demands, although the value of Mental Requirement (MD) has shown high values the Physical Requirement (RP) had very low values leading the overall index value for moderate.
- With this methodology, there will be a contribution to the analysis of the ergonomic aspects. This new procedure will improve existing procedures with an innovative character, including studies and other topics such as cognitive ergonomics and Human-Computer Interface.
- There will be a contribution to the strategic planning of electric power companies providing data for a better adaptation of the activities of these operators contributing to the reduction of operational errors.

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Perceptions of employees of the importance of safety in the energy industry in Cyprus

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ABSTRACT: The recent discovery of hydrocarbons, in large quantities, in Cyprus has brought to the surface, fundamental issues dealing with previously unknown and unchartered, locally, territories. In a sort time, Cyprus will have to transform itself, from a services oriented economy to a hydrocarbon producing and trading economy. The local energy storage industry comprises of small energy storage facilities (7 companies) in a congested area. The plan for the next five years, includes the construction (some of it has already been done) of big energy producing and storage facilities. By default some—if not all—of the existing safety officers and workers, will be part of the new era.

The aim of the study was to measure a number of parameters that make up safety culture. In particular—based on previous literature—parameters such as the existence of safety policies, safety performance, safety climate and other were measured with the use of a survey tool in the form of a questionnaire.

1 INTRODUCTION

Safety Management is the procedure for identifying workplace hazards and reducing accidents to harmful situations and substances and to provide training of personnel in accident prevention. Safety climate is considered to describe the shared employee perceptions of the operationalization of safety management practices in the workplace at a particular time frame (Zohar, 1980, Byron and Corbridge, 1997, Cooper & Phillips, 2004). This term is related to safety culture. It is viewed as a sub-component of safety culture, its manifestation, or even by some authors as just an alternative term for it (Guldenmund, 2007). A high or positive safety climate indicates managerial commitment to a proactive safety approach. In contrast a "low" safety climate indicates that employees avoid reporting of near-miss accidents or unsafe practices for fear of punishment and that operational efficiency takes priority against safety (Chowdhury and Endress, 2010). A positive safety climate provides employees with resources like low time pressure and assistance with hazardous tasks, while it also gives a sense of control over work. Some of the main dimensions of safety climate include managerial commitment, safety systems, supervisor support, and work pressure (Christian et al, 2009, Griffin and Neal, 2000). Management policies and programs of health and safety in organizations such as safety training, provision of safety, integrated safety policies and written detailed safety procedures will be examined in this paper through questionnaires and then by using statistical analysis.

Safety performance has been a metric used quite often in safety literature as an indication of the success or not of the safety management system in place as well as of the existence or not of a safety culture (Strickoff, 2000). Evidently in literature (Cohen, 2002; Begg et al, 1999, Gabbe et al, 2003), the measurement of safety performance has been very difficult as it is mainly based on accident rates, therefore being a reactive measure. A number of authors (Caroll et al, 2014; Cooper and Phillips, 2004; Glendon and Litherland, 2001; Griffin and Neal, 2000) have produced work detailing the relationship of safety performance with a number of safety parameters. Safety culture appears in the mid-80's in literature, with the occurrence of the Chernobyl disaster. Guldenmund (2007), Zohar (1980), Cooper (2000) and others discuss its dimension and attempt to describe the term. Guldenmund (2007) suggests that despite the extended reference in literature, safety culture has not "advanced beyond its developmental stage". Energy infrastructure is associated with (a) higher risk probabilities and (b) tighter safety measures (reactive). Safety culture is a proactive measure. Despite the somewhat rare occurrence of catastrophic incidents, the impact of these catastrophes can be devastating. The concept of safety cultures first appeared in the nuclear industry (IAEA, 1986) in the aftermath of the Chernobyl accident. The oil and gas industry has also been widely covered. Mearns (2009) discuss in detail the influence of national cultures in safety in the oil and gas industries. This paper attempts to shed light in this issue from a Cypriot point of view.

Based on the above the following Hypotheses were devised:

H1—There is a relationship of Safety performance with safety training provided.

H2—There is a relationship of Safety training with the number of accidents.

H3—There is a relationship of Safety Performance with the existence of safety policy in a firm.

H4—There is a relationship of Safety Performance with organizational commitment.

H5—There is a relationship of organisational commitment with the existence of safety policy in the organisation.

H6—There is a relationship of demographics with number of accidents.

H7—There is a relationship of demographics with safety performance.

2 METHODOLOGY

In order to examine and identify Safety Culture, a survey was conducted from four energy storage facilities in Cyprus (out of seven totally). A pilot study was conducted to identify the best possible methodological tool. A self-administered questionnaire, in the presence of the interviewer, was chosen. A standardized questionnaire focusing on five basic areas of safety performance was employed. The questionnaire included a section on demographics and it covered five basic areas:

1. Management of Safety Policies—was measured with a five item Likert scale similar to that of Dejoy, et al., 2004.
2. Safety Climate in the Industries—elements from Hahn's et al (2008) Likert scale with six items were used in the questionnaire.
3. Perception of Workplace Safety.
4. Safety Performance—a four item Likert scale was used, parts of the items of the scale were adapted from the literature (Griffin and Neal, 2000, Ford and Tetrick, 2011).
5. Job Satisfaction—was measured with a three item Likert scale as it was used by Lee et al, 2007.

The methodology used, provided sufficient findings and the response rate of the research was constructive and supportive as all participants responded. In total the study surveyed 70 out of total 90 safety personnel in energy storage facilities in Cyprus. The results of the study were statistically analysed with the use of specialized software (SPSS).

3 RESULTS AND DISCUSSION

Table 1 shows that Pearson's r is close to 1, meaning that changes in one variable are strongly correlated with changes to the second variable. This confirms

Table 1. ***H1***. Safety performance has a positive correlation with safety training provided.

		organization has	protective	part in the	co-	follow	is an
Q11.My organization has high levels of Safety Training	Pearson Correlation	1	.785**	.703**	.636**	.557**	.685**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	Sum of Squares and Cross-products	30.586	22.174	25.300	14.571	12.886	19.043
	Covariance	.443	.326	.367	.211	.187	.276
	N	70	69	70	70	70	70
Q22.I use personal protective equipment (e.g. fire extinguishers, fire blankets etc) and / or I have free and easy access to safety equipment if needed	Pearson Correlation	.785**	1	.874**	.686**	.618**	.742**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	Sum of Squares and Cross-products	22.174	26.203	28.681	14.406	13.145	19.014
	Covariance	.326	.385	.422	.212	.193	.280
	N	69	69	69	69	69	69
Q23.I often take part in the development of safety requirements for my job	Pearson Correlation	.703**	.874**	1	.668**	.684**	.792**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	Sum of Squares and Cross-	25.300	28.681	42.300	18.000	18.600	25.900
	Covariance	.367	.422	.613	.261	.270	.375
	N	70	69	70	70	70	70
Q24.I help co-workers with safety related issues	Pearson Correlation	.636**	.686**	.668**	1	.842**	.830**
	Sig. (2-tailed)	.000	.000	.000		.000	.000
	Sum of Squares and Cross-products	14.571	14.406	18.000	17.143	14.571	17.286
	Covariance	.211	.212	.261	.248	.211	.251
	N	70	69	70	70	70	70
Q25.I follow documented standard work procedures	Pearson Correlation	.557**	.618**	.684**	.842**	1	.901**
	Sig. (2-tailed)	.000	.000	.000	.000		.000
	Sum of Squares and Cross-products	12.886	13.145	18.600	14.571	17.486	18.943
	Covariance	.187	.193	.270	.211	.253	.275
	N	70	69	70	70	70	70
Q26.There is an established accident reporting mechanism (including near misses e.g. accidents that almost happened)	Pearson Correlation	.685**	.742**	.792**	.830**	.901**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	
	Sum of Squares and Cross-	19.043	19.014	25.900	17.286	18.943	25.271
	Covariance	.276	.280	.375	.251	.275	.366
	N	70	69	70	70	70	70

**Correlation is significant at the 0.01 level (2-tailed).

H1 that safety performance has a positive correlations with safety training provided. The Sig. 2-tailed values are less than or equal to 0.05, resulting to a significant correlation between the variables.

Similarly it is proven that:

H2—Safety Training does not have a positive correlation with the number of accidents.

H3—Safety Performance has a positive correlation with the safety policy in a firm.

H4—Safety Performance has a positive correlation with organizational commitment.

H5—Organisational commitment has a positive correlation with the existence of safety policy in a firm.

H6—Relationship of demographics with number of accidents has a negative correlation.

H7—Relationship of demographics with safety performance has a negative correlation.

4 CONCLUSIONS

The paper presents and discusses the results of this survey. Results illustrate that all organizations have been using safety management policies and their safety performance metrics are positive, however all have limitations. The non-proof of Hypothesis 2 (the relationship between the number of accidents and safety training) shows that the small size of the establishments has an impact on the perceptions of the employees. It also serves as an example that, in the future, a more expanded version of the questionnaire should be used; in order to avoid similar shortcomings.

It was noticed, on the field, that the small size of the establishments both in area and number of workers altered some of the characteristics of the firms. It should also be noted that a number of areas have been identified during this work and as a result a follow up study of qualitative nature followed.

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Biomechanical evaluation of semi-mechanized activities of forest establishment in mountain regions of Brazil

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ABSTRACT: This study aimed to biomechanically evaluate the semi-mechanized activities carried by the workers involved in holes digging and cleaning of plantation's weeds in forests at mountainous regions of Brazil, utilizing the two-dimensional biomechanical model for predicting postures and static forces (2DSSPP™), developed by the University of Michigan, USA. the results showed that in the semi-mechanized activity of digging holes, the load limit recommended for all joints of the body was exceeded and, when the operator moved between holes, 99% had risk of injury to the elbow joint and spinal disc L_5-S_1. Still, 89% of workers presented risks of injury to the knees. In semi-mechanized operations of weeds cleaning, the recommended load limit was not exceeded for elbows, shoulders, knees and ankles joints, 2.0% of workers presented risk of injury to the L_5-S_1 disc and 4.0% were not able to perform this function without risk of injury to the coxofemoral joints.

1 INTRODUCTION

In Brazil, the forest sector has grown significantly in the last years (Abraf, 2010). Therefore it is necessary to seek new alternatives to implement forests in mountainous regions with appropriate technology to achieve economical, environmental and social sustainability and ensure worker's health and safety.

The implementation of eucalyptus forests involves a set of operations that can start with the terrain selection and finish with the trees ready to harvest. The steps are usually: terrain cleaning, roads construction, erosion control, ants and termites control, site preparation (marking holes, digging holes, soil scarification, fertilizing, acidity correction, etc.), planting and replanting, irrigation and cleaning of the forest stand (weeding with herbicides or other manual mechanisms). These operations can be performed either manually, by semi-mechanized or mechanized methods, depending on the land topography and economical, environmental and social factors.

The forest establishment operations such as semi-mechanized hole digging and terrain cleaning presents a number of ergonomic problems such as high physical workload, high noise and vibration levels, high demand of strength, forced postures, lack of pauses and repeatability of movements.

According to Kisner & Colby (1998), depending on how forestry activities are performed, workers needs often lift and carry loads which weight goes beyond the tolerable limits. In addition, they usually perform these movements in an incorrect and continuous manner, thus compromising the integrity of the spinal musculoskeletal system, which is very likely to lead to the wearing of all joints involved.

This study aimed to biomechanically evaluate the semi-mechanized activities performed by workers involved in holes digging and cleaning of plantation's weeds in forests at mountainous regions of Brazil.

2 MATERIALS AND METHODS

2.1 *Characterization of the study area*

This study was conducted in areas belonging to a forestry company in the State of Minas Gerais, Brazil, with an average altitude of 800 meters. According to the Köppen climate classification, the prevailing climate in the region is Aw—rainy tropical savanna, in other words, dry winter and maximum rains in the summer, with the rainy season between the months of October and March (Tonello et al. 2006). According to Leite et al. (1997), the average annual rainfall was 1,300 mm. The soil in the area was classified as Red-Yellow Latosol, loamy soil and undulated topography (slopes greater than 25º).

2.2 *Sampling the population of workers*

The sample was consisted of 126 forest workers, representing 100% of the population involved in semi-mechanized activities of holes digging and cleaning of plantation's weeds.

Figure 1. Semi-mechanized operations of digging holes (left) and cleaning of plantation's weeds (right). (Photos by L.J. Minette).

2.3 *Characterization of activities and machines analyzed*

The study scope consisted of semi-mechanized operations of both digging holes and cleaning of plantation's weeds in *Eucalyptus* deployment (Fig. 1). Earth Augers (brand Stihl BT 130; weight 9.9 kg; power 1.4 kW and displacement 36.3 cm^3) were used for digging holes while brushcutters (brand Stihl FS 290; weight 7.9 kg; power 2.0 kW and displacement 38.9 cm^3) were used for the cleaning of plantation's weeds. The holes were dug 3.0 m distance from each other and 0.30 m depth.

2.4 *Biomechanical evaluation of the activities*

The biomechanical evaluations of the activities were carried out by the analysis of the computer program of two-dimensional biomechanical model for predicting postures and static forces, developed by the University of Michigan, United States (UNIVERSITY OF MICHIGAN, 1990). The analysis using the software provides the recommended load limit, which corresponds to the weight that over 99% of men and 75% of women can lift without an increased risk of developing work-related musculoskeletal symptoms or disorders. The recommended load limit induces a compression force (measured in Newtons) of 3,426.3 N on the spinal disc L5-S1 of the vertebral column, which can be tolerated by most young workers in good health.

3 RESULTS AND DISCUSSION

3.1 *Semi-mechanized hole digging operation with earth auger*

In the semi-mechanized operation moving the Earth Auger from pit to pit, 99% of workers presented risk of injury to the elbow joint and the L_5-S_1 spinal disc and 89% of workers presented risk of injury to the knees. In all body joints evaluated the recommended load limit was exceeded.

3.2 *Semi-mechanized cleaning of plantation's weeds*

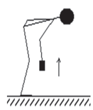
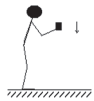
In this activity, the recommended load limit was not exceeded for the elbows, shoulder, knees and ankle joints, however 2.0% of workers present risk of injury to the joint of the L5-S1 vertebral disc and 4.0% were not able to perform this function without risk of injury to the coxofemoral joints.

3.3 *Biomechanical analysis*

Table 1 shows the results of biomechanical analysis for the activities of semi-mechanized holes digging operation and cleaning of plantation's weeds. For each of the phases of these activities, table shows which joints present risks of injury caused by the workload or not. The acronym NRI means "No Risk of Injury in Joints", which means that over 99.0% of workers can support the load imposed by the activity without risk to the joints involved and the acronym RI means "Risk of Injury", meaning that recommended load limit was exceeded, indicating that less than 99.0% of workers can support the load imposed by the activity without risk to the joints involved.

Table 2 shows the compression force of the L5-S1 vertebral disc in the evaluated activities. The results showed that the activity of semi-mechanized holes digging, in the phase of shift between the pits, presents risk of compression of the L5-S1 disc of the vertebral column, with compression force equal to 4,709.0 N. This value was above the recommended by the two-dimensional

Table 1. Results of biomechanical analysis for the semi-mechanized activities of forest deployment and maintenance.

			Joints and their respective conditions to support the load					
Activity	Cycle phase	Worker posture	Elbows	Shoulders	L_5-S_1 Disc	Coxo-femoral	Knees	Ankles
Semi-mechanized hole digging	Digging holes		NRI	NRI	NRI	NRI	NRI	NRI
	Moving between holes		RI	RI	RI	RI	RI	RI
Semi-mechanized plantation weeds cleaning	Cleaning		NRI	NRI	RI	RI	NRI	NRI

No Risk of Injury (NRI) and Risk of Injury (RI), that is, recommended load limit exceeded.

Table 2. Limits and calculated compression force in the L_5-S_1 spinal disc for the operations studied.

Activity	Work cycle phase	Compression force limit in the L_5-S_1 disc (N)	Compression force in the L_5-S_1 disc (N)
Semi-mechanized holes digging	Holes digging	3,426.3	1,092 ± 30
	Moving between holes	3,426.3	4,709 ± 158
Semi-mechanized cleaning of plantation's weeds	Cleaning	3,426.3	2,334 ± 165

biomechanical model of postures prediction and static forces, developed by the University of Michigan, in the United States, which is 3,426.3 N and should be avoided, as they presented risks to worker health.

The semi-mechanized cleaning operation had a value of 2,334.0 N of compression force on the L5-S1 disc, which was below the recommended limit, without risks of injury to the L5-S1 spinal disc. However, this force could be less if appropriate postures were adopted.

4 CONCLUSIONS

The study conclusions were:

- In semi-mechanized holes digging operation, when the operator moved between holes, 99% of the workers presented risk of injury to the elbow joint and to the L_5-S_1 spinal disc; and 89% of workers presented a risk of injury to the knees. In all the evaluated body joints, the recommended load limit was exceeded. These risks could be less if appropriate postures were adopted.
- In semi-mechanized cleaning of plantation's weeds operation the recommended load limit was not exceeded for the joints of the elbows, shoulders, knees and ankles. However, 2.0% of workers presented risk of injury to the L_5-S_1 spinal disc and 4.0% were not able to perform this function without risk of injury to the coxofemoral joints.
- This result is related to the forces that machines have on the body of workers, adding to the constant movements and displacements during work, irregular conditions of the terrain and the presence of obstacles such as residues from forest harvesting.
- To carry out the activities studied, good posture is essential to avoid biomechanical overload and the joints should be preserved as much as possible, in its neutral position. In this position, the muscles and ligaments that extend between the joints are minimally tensioned and can release maximum strength.

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Application of the NIOSH lifting equation in the activity for manual fertilization of eucalyptus plantations in mountain regions, Brazil

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ABSTRACT: In the forest sector, there are activities manually performed by forest workers, men and women, with a high degree of repeatability and manual load lifting in questionable amounts. Therefore, the NIOSH developed an equation to evaluate the manual lifting of loads by workers, diagnose the risk of musculoskeletal disorders associated to these loads that the workers are subject to, in addition to indicating the appropriate load limits. This study aimed perform an ergonomic evaluation the manual activity of forest fertilization after planting in mountainous regions, considering the lifting of loads by workers according to the NIOSH methodology. The results showed that both the postures as a load lifting during the execution of activities presented high risks of injury in the musculoskeletal system for the forest workers. Thus, by NIOSH equation, a load limit of 15.0 and 12.0 kg was determined for lifting the fertilizer bag for men and women, respectively.

1 INTRODUCTION

The Brazilian forest sector has grown under positive rates over the last decades (Abraf, 2010). Considering a scenario with reduced workforce, especially in rural zones, the mechanization of forestry activities is desirable when seeking productivity increase and cost reduction by the forestry companies. However, there are still many situations in which human workforce is essential, especially in mountainous terrains where there are no suitable and low cost technologies. Such activities are carried under conditions of high energetic expenditure, repeatability and inappropriate postures that, together, may lead to the development of musculoskeletal disorders.

Among these activities, there are the manual post-planting fertilization, carried around 30 days after seedlings planting (may be retried up to four times in the first two years of the forest growth), aiming to correct the nutritional deficiencies of the soils (Higa et al., 2000). This activity is carried out by forest workers, men and women, using a bag loaded with fertilizers which need to be lifted several times a day, after its filling. Under this light, the task is ergonomically questionable considering the different pertinent national and international standards.

The high incidence of musculoskeletal disorders has as main cause the negligence in the postures and handling of excessive loads during the workday, which contributes to decreasing productivity, increasing the absenteeism and a decreasing the life quality of workers involved in this activity (Couto, 1996). For situations like of these, the National Institute for Occupational Safety and Health—NIOSH, in the United States, developed an equation to assess the limits of manual lifting of loads. The equation objectives are diagnose the risk of musculoskeletal disorders related with the load lifted by the worker and to indicate an adequate load limit for each activity, in a way that a certain percentage of the population could perform their task without risk of developing musculoskeletal disorders (NIOSH, 1994).

This study aimed carry out an ergonomic evaluation of the manual post-planting fertilization operation, in mountainous regions of Brazil in order to identify if the postures and the loads lifted are exposing the forest workers to a musculoskeletal disorders and to suggest acceptable load limits for lifting of loads for this activity, according to the NIOSH Lifting Equation.

2 MATERIALS AND METHODS

The study was carried out in forests belonging to a cellulose company in the State of Minas Gerais, Brazil. This company uses wood from Eucalyptus plantations at mountainous regions, with an average productivity of 300 m^3 ha^{-1}.

Were sampled 65 forest workers, which corresponds to 100% of the population involved in manual post-planting fertilization activities, working at irregular topography areas, with slopes greater than 25°. Worth highlighting the fact that 70% of the evaluated population consisted of women with a mean age of 35 yo.

(A) (B) (C)

Figure 1. Stages of the manual fertilization process: fill the bag (A), lift the bag (B) and fertilizer distribution (C). (Photos by A.P. Souza).

Storing fertilizer it was on the road at the top of the planting areas, where it was placed in bags weighing 50.0 kg. Subsequently, they were divided between two workers for application in the soil. Each worker had the responsibility to fill your purse with 25.0 kg of fertilizer, lifting her from the ground (stage which was aim of this study) and the distribution of fertilizer in the plantation areas. The fertilizer was distributed manually on soil surface, between the planting lines, in fillets one meter in length. The activity was carried out in open ground with irregular topography, high slopes and harvesting residues. After emptying the bag, the worker returns to the road to refill it and start a new cycle (Fig. 1).

The ergonomic analysis of lifting load in the manual fertilization activity was performed according to equation established by the National Institute for Occupational Safety and Health (NIOSH). This method aims to determine the maximum load to be manually lifted by a worker, during the execution of an activity, without risk of musculoskeletal disorders. The tool establishes that in a given situation there is a Recommended Weight Limit (RWL). Once the RWL is calculated, a comparison is made with the actual load lifted by a worker, obtaining then the Lifting Index (LI) (NIOSH, 1994).

The NIOSH equation determines the Recommended Weight Limit (RWL) as from six reduction factors from the constant of load. It is the Lifting Index (LI) that determines and quantifies the risk of musculoskeletal injury.

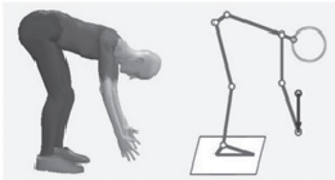
3 RESULTS AND DISCUSSION

The manual fertilizing activity was analyzed to indicate the most critical work cycle stage, having been determined that lifting the bag of fertilizer was the most critical phase. The postures were photographically registered, the load lifted was quantified and the data was analyzed by means of the NIOSH Equation. This analysis showed that the postures, associated with the excessive load lifted, presents a high risk of lesions in the musculoskeletal system to forest workers involved in this activity, according to the NIOSH criteria for determining Recommended Weight Limit.

The analysis was performed from three position for lifting the bag with 25.0 kg of fertilizer, as follows:

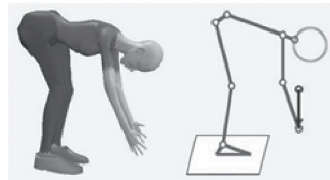
1. From the ground surface (hands located at 19 cm height from ground)—normal working position all day long;
2. From a place with hands located at 30 cm height at the ground surface—proposed to minimize risk of injury;
3. From a place with hands located at 75 cm height at the ground surface, which corresponds to the height of the bag plus the length of the handle extended to picks up—also proposed to minimize risk of injury.

In all analysis of recommended load, was considered for women a value 20% lower, according to the observations of proposed methodology, indicating the percentage of weight reduction for lifting loads by women, with no significant compromising of joints. All values of analyzed weights, as well as the risk of injury to each posture and the Recommended Weight Limit (RWL) are showed in Figure 2. Only to illustrate the analysis, in this figure the dummies were created using the 3D Static Strength Prediction Program™ software (University of Michigan, 2011).



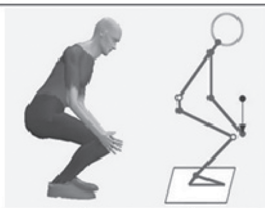
Current Weight		25.0 Kg
Determination of the Weight Limit		
LC	23.0	RWL$_{men}$ = 11.0 Kg
H	46.0	
LVH	19.0	
VDC	83.0	Li$_{men}$ = 2.30
A	0.0	High Risk
LFF	0.85	
HQF	1.00	

(A)



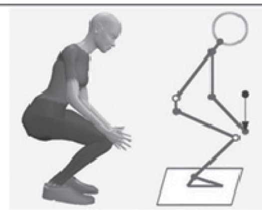
Current Weight		25.0 Kg
Determination of the Weight Limit		
LC	23.0	RWL$_{women}$ = 9.0 Kg
H	46.0	
LVH	19.0	
VDC	83.0	Li$_{women}$ = 2.78
A	0.0	High Risk
LFF	0.85	
HQF	1.00	

(B)



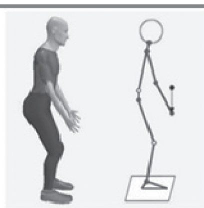
Current Weight		25.0 Kg
Determination of the Weight Limit		
LC	23.0	RWL$_{men}$ = 15.0 Kg
H	33.0	
LVH	30.0	
VDC	60.0	Li$_{men}$ = 1.67
A	0.0	Moderate Risk
LFF	0.85	
HQF	1.00	

(C)



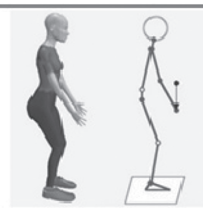
Current Weight		25.0 Kg
Determination of the Weight Limit		
LC	23.0	RWL$_{women}$ = 12.0 Kg
H	33.0	
LVH	30.0	
VDC	60.0	Li$_{women}$ = 2.08
A	0.0	High Risk
LFF	0.85	
HQF	1.00	

(D)



Current Weight		25.0 Kg
Determination of the Weight Limit		
LC	23.0	RWL$_{men}$ = 15.1 Kg
H	26.0	
LVH	75.0	
VDC	60.0	Li$_{men}$ = 1.65
A	0.0	Moderate Risk
LFF	0.85	
HQF	1.00	

(E)



Current Weight		25.0 Kg
Determination of the Weight Limit		
LC	23.0	RWL$_{women}$ = 12.1 Kg
H	29.0	
LVH	75.0	
VDC	60.0	Li$_{women}$ = 2.07
A	0.0	High Risk
LFF	0.85	
HQF	1.00	

(F)

Figure 2. Application of the NIOSH equation for the lifting activity of the bag with handle from the ground for men (A) and women (B), 30 cm from the ground for men (C) and women (D), and 75 cm from the ground for men (E) and women (F). *LC = load constant (23 kg); H = horizontal distance (cm); LVH = load vertical height (cm); VDC = vertical distance covered (cm); A = angle of lateral rotation of the body; LFF = lifting frequency factor; HQF = handle quality factor; RWL = recommended weight limit and LI = lifting index.

The Lifting Index (LI) for posture and load calculated with the hands placed at 19 cm from the ground was 2.30 for men and 2.78 for women, both classified as High Risk to the lifting a fertilizer bag with 25.0 kg and resulting in a Recommended Weight Limit (RWL) of the order of 11.0 and 9.0 kg for men and women, respectively.

The result of the LI for posture and load calculated with the hands placed approximately 30 cm from the ground was 1.67 for men, considered as Moderate Risk, and 2.08 for women, classified as High Risk to the lifting a fertilizer bag with 25.0 kg and resulting in a RWL of the order of 15.0 and 12.0 kg for men and women, respectively.

In turn, the result of the LI in the posture for lifting with hands at 75 cm from ground, was 1.65 for men, characterized as Moderate Risk, and 2.07 for women, classified as High Risk, to the lifting a fertilizer bag with 25.0 kg and resulting in RWL of the order of 15.1 and 12.1 kg for men and women, respectively.

4 CONCLUSIONS

The results of this study allowed the following conclusions:

- The postures and the loads lifted during the manual fertilization in eucalyptus plantation activities at mountainous areas constitute serious risks of injury to the musculoskeletal system at forestry workers.
- The weight of the fertilizer bag needs to be resized from the current 25.0 kg to 15.0 kg (men) and 12.0 kg (women) to avoid workers health damage and musculoskeletal disorders.
- The decrease of load, the adoption of best working postures, the introduction of a smaller fertilizer bag and a new lifting method constitute important ergonomics improvements, allowing the manual fertilization activity can be performed with minimal impact on the health and safety of workers.

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Direct action helpers at home care services: Consequences to the health of workers

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ABSTRACT: The aim of this research is to identify the association between Work-related Musculoskeletal Disorders with the home carers activity in providing care for the elderly arising from the risks to which they are exposed. For the development of this study a questionnaire was addressed to 90 workers from the domiciliary care services. It was found according to the studied dimensions that upper limbs, dorsal and lumbar areas prevailed, allowing to confirm that the direct action helpers have a high risk of acquiring Work-related Musculoskeletal Disorders (WRMSDs), considering that these are preponderant to the tasks performed such as: using excessive strength, inadequate postures and the repetition of movements.

1 INTRODUCTION

Work-related Musculoskeletal Disorders (WRMSDs) and injuries are syndromes of chronic pain which can occur during the professional activity. They include a wide range of inflammatory and degenerative conditions affecting muscles, tendons, joints, blood vessels and peripheral nerves. These injuries can affect several body parts (vertebral column, elbow, hand, wrist and knee) (Punnet et al. 2004).

Direct action helpers tasks are a high risk factor for WMSDs, whose development is facilitated by environmental factors in the workplace and biomechanical factors (repetitive movements, strenuous effort and inadequate postures) which have an impact on the health and quality of life of the worker (Aptel et al. 2002).

The daily tasks of direct action helpers consist of: costumers personal hygiene, changing clothes, change bed linen, transferring users from bed to wheelchair or shower, etc (Kim et al. 2010).

The home care services to the elderly have a rate of injuries of 61% due to the use of excessive force (Faucett et al. 2013). Truthfully the employer adopts an inappropriate posture to meet the requirements of the tasks and the inadequate conditions of the dimensional structure of the equipment, facing the anthropometric conditions.

In many tasks, the continuous weight lifting, the movement of heavy weights (since most users are dependent), as well as the need to adopt incorrect postures are hazards which are present in the daily lives of workers, leading to the appearance of critical and sometimes chronic injuries (Johanning, 2000).

The way work is organized and psychosocial risk factors also contribute to the development and worsening of WRMSDs (HSE, 2002).

2 METHODOLOGY

To develop this work, data was collected from questionnaires made to the direct action helpers from Institutions with Domiciliary Services, Portuguese Union of Mercy (PUM) and Private Institutions of Social Solidarity (PISS).

To deal with the information provided by the questionnaires, IBM® SPSS® Statistics version 21.0 was used. The statistical analysis took into account the nature of the variables involved in the study, having conducted an exploratory and an analytical study of the data, resorting to the most appropriate statistical techniques.

Firstly, the descriptive statistical analysis (mean, standard deviation, simple frequency, percentage), then we will look at the relationship between the main variables, symptom recognition and more contributory elements to the presence of grievances through the statistics of Chi-Square. The significance level assumed in the statistical test was $p < 0.05$.

The questionnaire used was an adaptation from the Nordic Questionnaire to analyse musculoskeletal symptoms by, Uva & Serranheira (2008), to which various issues related to work were added in context with the direct action helpers. The information was gathered through the questionnaire which was conducted during the month of July 2014. The questionnaire is divided into two parts. The first part is an adapted version of the

Nordic Questionnaire, which includes a section allowing for variables in demographic measurements (gender, age, weight, height, marital status, dominant upper limb, academic qualifications), and occupational (seniority within the institution, weekly working hours and shift work involved). It also includes the identification and characterization of complaints and musculoskeletal symptoms relating to the professional activity of direct action helpers. The complaints relate to nine body regions (neck, shoulders, dorsal region; elbows, lower back, wrists/hands, thighs, knees and ankles/feet) intended to assess workers self-reported pain/discomfort in the past 12 months and during the last seven days and if in this period of time there was absence from work.

Each question has a diagram showing the body location to be evaluated. The employee's self-assessment is based on a scale associated with pain/discomfort that is used to measure its intensity, taken at four levels (1—light to 4—very heavy). The same for its frequency, number of times a year (1—once to 4—four times and more than 6 times).

The second part of the questionnaire includes questions directly related to various unexplored aspects such as physical factors, psychosocial, repetition of tasks and auxiliary equipment used for moving costumers.

3 RESULTS

This study surveyed 90 Home Care Services employees and the response rate was of 96%. The study sample consisted of female individuals (100%). Age wise, it ranged between 20 and 60 years old, although, the majority were between 41–50 years old (37.2%) and the upper limb mostly affected was the right side (58.1%). Regarding marital status, most individuals are married (61.6%) and the education level that prevails is the 9th grade (59.3%).

Regarding anthropometric data, this sample consists of an average height of 161 cm and an average weight of 68.6 kg. It was found that the direct action helpers work on average 38.8 hours per week caring for the elderly and the seniority of service in the institution stands on average eight years. From the sample, 70.9% of direct action helpers have a fixed timetable and 29.1% do shift work.

In what concerns painful symptoms, particularly pain, discomfort, swelling and fatigue, found in the last 12 months prevails the lumbar region (86.0%), dorsal (82.6%), neck (66.3%), right shoulder (50.0%), left shoulder (14.0%), wrist/right hand (45.3%) wrist/left hand (5.8%), right knee (30.2%), left knee (5.8%), right elbow (24.4%), left elbow (1.2%), ankle/right foot (19.8%), ankle/left foot (7.0%), right thigh (15.1%) and left thigh (1.2%).

It should also be highlighted the presence of symptoms felt in different body areas, within the last seven days, namely the dorsal area (43.0%), lower back (37.2%), wrist/right and left hand (both 26.7%), right and left shoulder (both 17.4%), neck (16.3%), ankle/right and left foot (both 12.8%), right and left knee (both 11.6%), right and left elbow (both 8.1%) and left and right thigh (7.0%). There are also values related to work absenteeism with the following symptoms, shoulders (8.1%), neck, lower back, ankles/feet (7.0%), dorsal area, wrist/hands (4.7%) and knees (1.2%).

Regarding intensity, when analysing discomfort (pain, discomfort, swelling and fatigue) the highest discomfort index "very intense" was (30.2%) on lumbar area, and (24.4%) on dorsal area. For "intense" levels the lumbar region (44.2%) and the dorsal area (34.9%). Values of 20.9% stand out for "moderate" discomfort for the neck and 4.7% for "light" levels for the dorsal area.

Regarding the frequency of pain/discomfort (number of times per year) the highlighted values are of 47.7% for "more than six times" in the lumbar area and 34.9% "4–6 times" in the back area.

As regards the relationship between labour activity and the self-reported symptoms previously mentioned, it was found that workers mostly associated activities such as lifting and moving costumers, weighing between 70 kg to 90 kg and above 90 kg, connected to "totally related to symptoms". With a rate of "very related to symptoms", workers associated arm movement above shoulder height and repeatability of arm movements.

From the sample studied, 87.2% of workers say that they feel psychologically tired namely after the afternoon shift (75.6%). As for physical fatigue mentioned by respondents (95.3%), they feel tired when a shift is finishing being it mainly the afternoon shift the most tiring (82.6%).

Regarding the repetition of tasks, (95.3%) consider the lifting of costumers as the task that is performed most repeatedly, (52.3%) indicate that they have difficulty moving while performing certain tasks to the user and (73.3%) consider that the height of the bed is not the best.

As for the height of the boards used in the bath tubs, when asked if they were kept at a comfortable height to make personal hygiene to the patient, (62.8%) answered "no" and 60.5% mentioned not using proper equipment to perform tasks to include the transport and the movement of costumers.

3.1 *Statistical analysis of association*

The aim of this study was to try and understand if there would be a statistically significant relationship between the tasks performed by the direct action helpers working as Home care providers and the musculoskeletal complaints.

On the neck area, was noted that it was statistically significant with a variable "arms above shoulder level" (p = 0.003), where the most contributory factor for the relationship among the variables was that arms above shoulder level is directly related to "very related to symptoms".

On the shoulder region, was clearly noted among the variables "repetitive arm movement" (p = 0.000) that the most contributory factor for this association was the repetitive arm movement being "highly related to the symptoms".

In the wrist/hand, was identified a clear association between the variable "repeatability of hands/fingers" (p = 0.003) as the element that largely contributed to the association between the variables repeatability of hands/fingers being "totally related to symptoms". Still in this anatomical region was considered that "applying force with your hands or fingers" (p = 0.000) was also regarded to be "totally related to symptoms".

The dorsal area showed statistically significant connections between the variables "lifting costumers with weights above 90 kg" (p = 0.000), with the variable being "totally related symptoms" the component that mostly contributed to this association. We also found a statistically significant association with the variable "length of time providing services for the institution" (p = 0.009), in which the element that mostly contributed to the relationship between variables is the seniority of service which on average is around eight years.

The lumbar area identified a clear association between the variable "lifting and moving users with weights ranging between 70 kg and 90 kg" (p = 0.000), and the variable "totally related symptoms" being the component that mostly contributed to this association.

4 DISCUSSION

The data presented refers to adult female professional group where most of them have the minimum compulsory education.

The results of self-reported symptoms, prevails in the lumbar area (86.0%), dorsal region (82.6%), neck (66.3%), shoulders (64.0%) and wrist/hands (61.0%). As for work-related absenteeism it prevailed the shoulder region (8.1%) and the intensity index "very intense" (30.2%) in the lumbar region.

Most employees associated activities such as lifting and moving costumers weighing between 70 kg to 90 kg and above 90 kg, with the classification of being "totally related symptoms", showing that the workers have to handle very heavy weights and the majority 60.5%, mentioned not using proper equipment to perform tasks to include the transport and the movement of costumers. According to Nelson & Baptiste (2006), it is shown that the adoption of safe techniques when moving costumers by using the rightful equipment while transferring them, are effective in reducing the incidence of WRMSDs.

With the classification of "very related to symptoms" the employees associated arm activities above shoulder level and repetitive arm movement.

The workers also referred that, in general, costumers to whom they provide domiciliary services, are dependent so, not collaborating during the care giving service.

The frequent lifting of costumers to be moved and transported, the inadequate posture and the constant bending of the vertebral column in care activities to the elderly, can cause health problems to the service providers, such as fractures, lower back pains and varicose veins. Such causal factors are related to ergonomic agents (Freitas, 2008).

There are some epidemiological studies that unequivocally show that a high prevalence of pain in the dorsal-lumbar region is mainly due to the need of weight manipulation (Heran-Le et al. 1999).

The majority (95.3%) of employees consider that the lifting of costumers is the most repetitive task and is performed daily (Figs. 1 and 2).

Per norm, repetitive movements are mainly associated with quick finger or upper limb movements (Carneiro et al. 2014).

Figure 1. Getting costumers up.

Figure 2. Lifting costumers up.

Figure 3. Moving costumers.

From the results obtained, (52.3%) it is shown that there are problems with the movement during the performance of the various tasks to the costumers, due to the display of furniture as well as moving the wheel chairs between beds, having to push the beds every time a task needs to be performed.

It was also noted that (73.3%) considered the height of the beds not being adequate or adjustable to their heights and that contributes to the adoption of incorrect postures (Fig. 3). Other factor mentioned, is the beds being quite close to walls, so not having enough space to perform tasks properly. In what concerns the height of bath tub boards (62.8%), it was said that as they are not of adjustable height to bath the costumer, means that a lot of extra effort has to be used.

From the sample 87.2% of workers say that they feel psychologically tired namely after the afternoon shift (75.6%).

Among the psychosocial risks of workers, there is also an overburden issue prompted by the contact with the suffering of users, with pain and death, shift work, work pace, performance of multiple tasks, scattered and repetitive tasks, which may lead to headaches, breathing problems, sleep disturbances, depression, anxiety, alcohol intake and isolation (Baker el al. 2014).

Regarding physical tiredness (95.3%) feel tired when the shift ends being the afternoon shift (82.6%) the mentioned shift.

Several authors have referred that there is a strong combination between psychosocial and physical factors associated to the job itself and to the development of work-related musculoskeletal disorders (WRMSDs) (Carneiro et al. 2014).

5 CONCLUSIONS

Given the results, it is clear that the assessment of the levels of discomfort and pain arising from the musculoskeletal system is related to the type of work and the conditions under which it is performed.

To prevent WRMSDs it is absolutely necessary that the institutions are aware and alert to the employees' health who are exposed to this type of professional risk factors, mainly by observing it.

The worker's anthropometric dimensions, the equipment, most of it being standardized cause workers to adopt an inadequate posture to perform their daily tasks and an increase of physical effort, which may lead to a greater possibility of musculoskeletal problems.

It would be of paramount importance to introduce more breaks in each shift as there is an enormous feeling of tiredness, both physical and psychological in the end of each shift followed by task repetition.

The level of physical effort, (muscle strength, posture, repetition, etc.) felt by workers is largely determined by the degree of dependence of costumers, which may cause problems in the upper limbs and cervical area.

It is pertinent the use of auxiliary equipment in the handling and transportation of costumers, since many workers move heavy weights and have no concept of the maximum load that they should move or lift without any kind of help and so to avoid injuries.

Taking this in consideration, it's important to develop an awareness program within the institutions to emphasise the importance of special equipment to prevent workers from WRMSDs. We also consider that specific training is needed, mainly on how to care for the elderly and on the risks that may occur during work due to inappropriate postures while performing daily tasks.

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Injuries in surf athletes and the use of safety equipments

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ABSTRACT: Injuries are an inevitable part of every sport. Every athlete needs to be conscious of this, because awareness can prevent many injuries. The purpose of this paper is to compare the most common injuries in surfing on the waves through the literature review with methods of prevention, using the safety equipments. In the conception of this paper, was used foreign literature and studies from countries where surfing is highly developed. In reviewing the literature was found which are the most common injuries in surfing and which part of body is more exposed to injury. Studies have shown how important is the use of safety equipment for injury prevention. Lacerations, contusions and sprains are the most common injuries in surfing. The most frequently affected part of the body is head. It is impossible to avoid injuries in every case, but with the use of safety equipments (helmet, nose guard, soft fins …) would be possible to reduce and avoid the most of injuries. Thus, the use of safety equipment, with good physical and psychological preparation, surfing would be safer and more effective.

1 INTRODUCTION

Nowadays the society live in a time where people are increasingly burdened by stress and lack of time. Mostly spend their time sitting and rarely in motion. When looking for ways of active leisure, where they can relax and enjoy, there are several type of options. One of these options is practice of sports, it has countless positive attributes to human. It is important for their personal development, taking care of physical health and to keep fit. People often opt for one of sports that allow us to disconnect from the stress of routine life and that can provide a sense of freedom. One of such sport is surfing. It can be divided into recreational, amateur and professional. This kind of sport, which involve younger and older surfers.

Surfing is a sport, which is important muscular strength, endurance, balance and coordination. Learning surfing, it is not easy, takes a lot of perseverance and good physical and psychological readiness. Also, It is necessary to know how to swim, because paddling on a board, it is the basic movement of surfing. Surfers are constantly exposed to weather and the environmental changes (wind, ocean currents, type of seabed, air and water temperature) (Brasil, 2001; Filho, 2010; Moraes, 2012).

Surfing can be carried out on the coast, where waves are suitable for surfing. The total number of practicing sport in the world estimated by the International Surfing Association is 17 million people in more than 70 countries. USA, Australia and Brazil represent three countries with the largest number of athletes and specialized industry of surfing on the waves (Base, 2007).

When dealing with surfing it is necessary to provide security, due to the unpredictability in the maneuvers, the contact with the board and with the seabed (Sunshine, 2009). The safe surfing is a key skill of surfing, and the use of basic safety equipment, local knowledge about beaches (e.g. surf spots), monitoring weather conditions and good physical fitness. In this way, we can prevent many injuries caused by blows on the board, seabed, inadequate basic safety equipment and inadequate preparedness surfing. In order to, a better performance of surfing, we should be aware of possibility of injuries and understand how can be prevented or at least reduced.

In this paper the most common injuries in surfing were approached through the literature review and how to prevent these injuries using the safety equipments, such as, how to prevent surfing injuries in advance and thus spend more safely time on the waves.

2 MATERIALS AND METHODS

This study is based on a literature review on the topic, surfing injuries, the importance of prevention and the use of safety equipment to avoid injuries, in order, check the most common injuries in the practice of surfing and how frequently have been use safety equipment by practitioners of this modality. Still, this study presents the safety equipments, and strengthening their importance in surfing. In this study are related practitioners in professional, amateur and recreational level, in all ages and gender. For analysis of the most common injuries in surf were used researches from 2000 to 2014. The description of the most common injuries are presented by the causes of injuries, as well as, the affected or more exposed anatomical region to injury (head/neck, trunk, arms, legs and feet).

3 DISCUSSION AND RESULTS

Injuries are a part of our life. The injuries are confronted with physical, emotional and economic changes. The injury is a multifaceted problem that requires a multidisciplinary approach in developing and implementing effective solutions. We can reduce the frequency and severity of injuries, but unfortunately they cannot be eliminated (Whiting and Zernicke, 1998). Surfing has a relatively low risk of injury in comparison to a range of other sports, but, surfing is an unpredictable sport which the surfer must to pay attention to a several factors. The waves can often carry surfers against rocks or through the open sea. It is important to consider the natural factors such as waves, coast, ocean currents, wind and also other surfers.

In one of the first studies on injuries in surfing, Lowdon (1988), found that the most common injuries among surfers were lacerations, fractures, overdraw muscles, tendons and ligaments sprain. Also, found that cuts, abrasions and contusions happen frequently. Further studies were made by other authors worldwide as described in Table 1. The studies approached in this paper (Table 1) were limited by the year (2000–2014). The results were similar and the most common surf injuries were lacerations and contusions that often occur on the head and lower limbs, which as, the face, neck and feet are most affected. The most frequent cause of trauma is related to contact with their own surfboard, where the nose and the fins are largely responsible for the injuries. Nathanson et al. (2011) describes that there is no necessity for boards with very sharp fins and a pointed nose. The author suggests that the surface of the boards should be slightly rearranged, as this would not significantly change the characteristics of the sliding boards. Surfers can be affect with other type of injuries like sprains, strains, dislocations, damages in ear, eyes, muscles and ligaments. Also the age of athletes need to be considered, according

Table 1. Researches about surf waves injuries.

Author	Country	Gender	Surf level	Most common damage	Most common part of body	Most common cause of trauma
J. Steinman, 2000	Brazil	95% Male	Recreation	Laceration 44%	The head/neck and lower limb 54,4%	Contact with surfboard
A. Nathanson et al, 2002	USA (Havaii)	90% Male/10% Female	Amateur	Laceration 42%	The head/neck and lower limb 35,6%	Contact with surfboard
R. Frisby, 2003	New Zeland	90% Male/10% Female	Amateur	Contusion 55%	Feet 34%	Contact with surfboard
Taylor et al, 2004	Australia	90% Male/10% Female	General	Laceration 46%	Head, Face and feet 44%	Contact with surfboard
L.H. Base, 2007	Brazil	Male	Professional	Laceration 33,9%	The head and torso 86,6%	Contact with surfboard
A. Nathanson et al, 2007	USA	86% Male/14% Female	Professional	Sprain or Strain 45%	Lower limbs 45%	Contact with surfboard
C.S.M. Hay, 2009	England	80% Male/19% Female	Recreation	Laceration 73%	The head, upper and lower limb 72%	Contact with surfboard
J.L. Almeida, 2009	Portugal	90% Male/9% Female	Professional	Laceration 57,7%	Face and feet 50%	Contact with surfboard
Meir et al. 2011	Australia	85% Male/14% Female	Recreation	Laceration 31%	Head, Face and feet 65%	Contact with surfboard
Moraes et al, 2012	Brazil	Male	Recreation	Contusion 29%	Lower limb 46%	Contact with surfboard
G. Ulkestad, 2013	Norway	Male	General	Laceration/Abrasion 30,4%	The head/neck 43,3%	Contact with surfboard

Steinman (1995), says that older and more experienced surfers who surf bigger waves, are more vulnerable to damage. It also summarizes that back pain affects three out of ten surfers. It is assumed (Almeida, 2009; Hay, 2009; Moraes, 2012) that 90% of surfers had back problems (pain in the lower and upper back). According to a research (Freyda,1989) soft tissue of body injury represent the majority of injuries immediately after laceration. This is also confirmed by other studies (Lowdon, 1983; Lowdon, 1986, Steinman, 2000; Nathanson et al, 2011). The type of soft tissue injuries is related to minor injuries such as bruising (Kennedy and Vanderfield, 1976) and larger, such as the strain muscles and sprains ligaments. The most common parts of the body affected by injuries to the soft tissue include the neck, shoulders, lower back (Lowdon et al., 1987), knee and ankle (Van Tilburg, 1996).

According Steinman (2000), surfing is considered to be a sport that poses risk of injuries when compared with skateboarding, snowboarding, windsurfing, cannoning and diving. However, when comparing with risk sports, the United States Consumer Product Safety Commission, in 1979, reported huge difference between the incidence of injuries in surfing (9900) with injuries in skateboard (137,900), Lowdon et al (1987) reported an acute injury rate of 3.5 injuries/1000 surfing days and Taylor et al (2004) 2.2 injuries/1000 surfing days. These studies put the surf as a water sport relatively safe. Nonetheless, surfer is constantly exposed to the weather (sun, wind, rain, fog) and oceanic changes (type of seabed, the size of the waves, ocean currents). In studies (Taylor et al., 2004; Nathanson et al, 2007) it is possible to track a small percentage of the use of safety equipment (helmet, protection of nose seats, softer fins ...) 97% of surfers never used safety equipment. Above all, young people are of the opinion that the safety equipment is non-aesthetic and funny (Chalmers, 2003). The adoption and increased use of safety equipment would only be possible if used as a fashion or new style. Safety equipment used by professional and famous surfers in competitions would also be launched to recreational riders and everyone else would start using safety equipment (Nathanson et al., 2002). For safe surfing we need at least a basic knowledge of surfing, must to be aware of injuries that may occur and how to avoid it. Also, need to be consider at first, the surfboard structure, changing the sharp fins to flexible and soft fins, putting nose protection in pointy edges or changing the design of nose, rail protection with polymer (eg. rubber, sponge) or soft materials and good quality leash (more resistant). In the same time, needs to be consider safety equipment, like helmet, neoprene wetsuit, gloves, hood and boots (cold water), surf mask, lifejacket and waterproof sunscreen.

Surfing is a sport that has direct contact with nature, and risks in this activity depend on these natural factors such as the weather conditions, the location (reef break, beach break and point break), which the risk of injury can be higher. Therefore it can be said that as the environmental conditions and the use of safety equipment become more necessary and fundamental for a safe activity. According Barucq (2013) the helmet should not be missing in surfing equipment. Head can be protected from brain damage, broken skull and loss of consciousness when it comes to the various beats in the water. The helmet protects also from the sun burns (avoid skin cancer), protects against ear injuries and helps to keep heat when the surf occurs in colder weather. When used with face protection helps reduce face lacerations and eyes injuries.

Basically, in surfing the some equipments are essential for better performance and protection of surfers, like wearing wetsuit when the water temperature is less than 20 degree Celsius, boots, gloves and hood also can be used, but depend how long the surfers are in the water and the temperature of this water. It is recommended these equipments in winter season or oceans where the temperature of water it is lower. Independent of conditions for safety surf, it is necessary to change the hard and sharp fins to a more flexible and soft fins, put rail and nose board protections, use resistant leashes, waterproof sunscreen factor 30 or 50 and use helmet in all situations.

The life jacket is recommended when the surfers do not have experience in swimming and when the surf is practiced in bigger waves, surfers are usually transported by jet ski this type of wave. However, follow this rules it is not enough, according Felder et al. (1998) and Fleischmann et al. (2011) surfing is a physically demanding activity. It consists of a combination of different movements and mental activities. Surfer must be flexible, has good coordination and a good balance. Yet, Felder et al. (1998) say that 44% of the surf time is spent with paddling movement. So, the safety rules are just one part of safe surfing, it is necessary good conditions of body, consider warm up before start activity, stretching after activity and physical preparation training. According Almeida (2009), surfers who surf less often, are more exposed to injury. Rakuščcek (2010), emphasizes that all surfers need to use good sense and never overestimate their body and abilities. With this thought is possible to transform surfing in one of the most safety sports.

The surf on a vision of occupational health aiming at the professionals surf waves, but is important to emphasize the use of safety equipment and the overall view of occupational health in all surfing activities, which extends to the amateur and recreational athletes, especially beginners in surfing, because they have a lack of knowledge of the risks and about the environment where the practice occurs.

4 CONCLUSION

In sports that are strongly related to the nature there are the necessity to be more careful and aware, because are circumstances can suddenly surprise us, and easily lead to injuries that are an inevitable part of all sports.

In this article, the most common injuries in surfing, described the damage and the most vulnerable parts of the body as shown by researches and was also presented solutions to prevent or reduce damages. Among the most important ways of preventing injuries are included the use of safety equipment, muscle warm-up before surf and stretching after surf. In all researches cited in this article it was shown that only a minority of surfers use of safety equipment. Still, safety equipment for surfing are little promoted (base 2007), surfers are of the opinion that safety equipment (eg. Helmet) impair performance while surfing (Nathason et al, 2002). Using protective equipment (helmet, nose protection, softer fins ...) in professional competitions would help to promoting the use of safety equipment. Safety equipment can not eliminate all risks of injuries in surfing, injuries also often occur because of inadequate preparation of surfers. Therefore, warming up and stretching should be considered as a very important part in any sport.

It is significant emphasizes the importance of injury prevention through a preventive training. A greater promote of the use of safety equipment, especially in sports that depend on the factors of nature it is essential, that would be the first step for safe surfing a long term and at the same time inspire even larger number of people. The next step is mainly awareness among surfers and their responsibilities, and transfer of theory into practice and thus make surfing a safer sport.

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Information quality for health and safety management systems: A case study

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ABSTRACT: The paper deals with the problem of information quality for management systems. It is particularly focused on the health and safety management systems based on the standard OHSAS 18001:2007. Therefore, it presents the theoretical background to this standard. It also briefly discusses its fundamentals as they are a basis for the practical investigation. In the research part of the paper the information quality criteria for such systems are evaluated. For this aim, the respondents were asked to choose the most important quality criteria and within their application they assessed the health and safety management system in five areas. The results of the investigation show that information quality is the most important in such areas as: IS modules supporting data, reporting of actions and strategic assumptions.

1 INTRODUCTION

Nowadays, manufacturing companies are expected to manage occupational health and safety issues accurately, systematically and visibly. However, in practice over recent decades it was noticed that firms often developed their own management systems which went beyond. Therefore, a need of adoption of externally certified system such as OHSAS 18001 has appeared. The possession of this certification is particularly required by the stakeholders in the case of multinational companies such as Apple, Cisco and Tata motors (Lo et al. 2014).

This situation results from the fact that today, workers suffer the majority of occupational illness and accidents in an industrial setting. The International Labour Organisation (ILO) estimates that each year about 6,300 people die due to occupational accidents or work-related diseases. Moreover, more than 2.3 million will die by the end of each year. This problem is particularly noticeable in developing countries, where people are engaged in hazardous activities, mainly such as agriculture, fishing and mining, are at high risk (ILO 2013). However, in the well-developed countries the state is not always better. In many cases the understanding of safety is limited as there are unknown implications for both the safety of operational workers and other operational performance outcomes (Carvalho et al. 2008, Das et al. 2008, Pagell et al. 2013). Many safety practices, which allow to identify hazards, assess and control risks, are obeyed or not done properly. Furthermore, in the literature many predictions concerning how safety relates together with operational priorities and outcomes such as cost and quality are presented to increase the awareness of safety issues (Górny & Mrugalska 2013, Mrugalska & Arezes 2013a, b, Mrugalska 2014, Nazir et al. 2013, Santos et al. 2013) but they still do not bring the expected effects (Lo et al. 2014).

In order to facilitate the process of the design, implementation, maintaining and improvement of OHSAS 18001 to companies, information quality for such systems should be defined. Such quality requirements allow to determine when information is so usable that a set of data brings the expected effects. However, it is difficult to indicate a universal definition of "useful" information not taking into account its user, his information needs or situational context, where it will be used (Sławińska & Jurga 2012). However, it must be emphasized that quality requirements of system concern both information sphere (organization of information flow) and technological solutions (computer systems) (Wyrwicka & Mrugalska 2013). So, every time system should facilitate its user performance of standard activities and on the other hand, it should also allow to choose solutions and use the organization sources when unknown problems appear.

In the paper we paid particular attention to the information quality for OHSAS 18001:2007. For this aim a group of 90 respondents at first set up the quality criteria and then validated them in reference to OHSAS 18001 requirements. In order to achieve it within the OH&S management system five areas were established. The results of the studied indicated the role of information quality in management systems, in particularly the importance of such criteria as validity and appropriate reaction time.

2 HEALTHY AND SAFETY MANAGEMENT SYSTEM

Management systems aim at an implementation of the chosen organization strategy by paying attention to the resources in the areas which are crucial for company's success. Traditionally, they consist of three components: primary or core process, key supporting processes and management system supporting elements. The core process encompasses the identification and control of important health and safety aspects, whereas the key supporting process is focused on direct inputs to the primary process or measures the results of the output. Management system supporting elements include document control, record control and internal auditing (Kausek 2006). As far as healthy and safety management system is concerned it covers the aspects of providing a healthy and safety workplace, efficient work processes, better recognition of working environment and recruitment attractiveness (Tsai et al. 2009, Manca et al. 2012).

In Poland it is possible to differentiate two approaches to this system: the first one is based on the requirements stated in PN-N-18001 standard and the second one is covered in OHSAS 18001 standard. PN-N-18001 was created just a few month after OHSAS 18001 in spite of the fact that the most of the countries had already withdrawn their own nationwide standards. This standard is published by Polish Committee for Standardization and is only known in Poland. Therefore, foreign companies incorporated outside the Polish borders do not respect its certificates. In spite of this fact, it often happens that Polish companies apply for this certification as the Polish standard is well-recognized by national control and research institutions. The difference between these two standards relies mainly on paying attention to employees and their participation in design, implementation, maintenance and improvement of safety management system in PN-N-18001 whereas OHSAS is more focused on third parties.

The Occupational Health and Safety (OH&S) management system according to OHSAS does not provide specific occupational health and safety performance criteria, or detailed specifications for the design of a management system. It demonstrates that the company adheres high standards in this scope and enhances its reputation. It can be applied in any type of company, from small to large one, in any sector. Following it, any organization can be OHSAS 18001 compliant by:

1. establishing an occupational health and safety management system to eliminate and minimize risks to employees and other interested parties,
2. implementing, maintaining, and continually improving the OH&S system,
3. assuring its conformance with its OH&S policy,
4. complying to legal and other requirements,
5. demonstrating the conformance to others,
6. seeking certification/registration of its OH&S by an external organization,
7. self-determination and declaration of conformance with the standard's specifications (Matias & Coelho 2002, Pun & Hui 2002, Low & Pong 2003, Jasiulewicz-Kaczmarek 2013).

Shortly, it allows all organizations to implement a system which may contribute to the reduction of the health and safety risks (Vinodkumar & Bhasi 2011) but it does not have to be a solution to all safety problems (Ma et al. 2001). Without a strong management commitment and workers' support it is not possible to achieve it (Fernández-Muñiz et al. 2012). On the other hand, it is a soft-regulation, which shows that the company follows certain legal obligations and a pattern of working conditions confirms it. Moreover, it promotes the continuous improvement of health and safety conditions (Granerud & Rocha 2011) what is demonstrated to the workers, customers and public.

3 MATERIALS AND METHODS

The purpose of this study was to determine the usability of applications dedicated to OHSAS standard. For this aim a theoretical review of safety requirements according to OHSAS 18001 was done and then practical investigation of systems was carried out among a group of 90 respondents. The participants of the research study were extramural students who work in this branch and complement their theoretical knowledge at the university. Firstly, the respondents evaluated the importance of criteria for assessment of information quality of safety working conditions. They used such criteria as:

1. appropriate reaction time—time of system answer for a given question,
2. availability—gaining information which are essential to do the task,
3. completeness—mapping the present reality state described by given information,
4. validity—prevention of loss of part of information in comparison with original information.

Secondly, they analyzed five areas of the OH&S management system, in particularly OHSAS 18001:2007, by the application of earlier chosen quality information criteria. The first area concerned information about the OH&S policy. In particularly, it encompassed strategic assumptions for the OH&S management system, characteristics of

IS modules supporting obtaining data for management of OH&S, organization chart and scope of duties in the OH&S management system. Then, in the second area, information of characteristics of safety system was evaluated. The following issues were taken into account: functions, elements and tools. The third area concerned information about tactic activities in the OH&S management system such as: presentation of procedures, description of functions of computer science techniques used in performing executive acts. Next, information about operation activities was the subject of concern, in details the following issues were analyzed: monitoring of actions and reporting of actions. In the fifth area information about actions of planning internal audit and scheduling tasks within this management system was considered.

The research study was conducted in the period of four months. During this time the respondents had an access to applications supporting performing tasks about work safety management. The list of typical operation activities for health and safety specialists was elaborated. Then, the simulation of decision processes, which were the basis to make assessment and conclusions, was done.

Table 1. Assessment of information usability in OH&S management system.

Area and scope		A	B	C	D*
1.	OH&S policy				
1.1.	Strategic assumptions	30	80	76	82
	Characteristics of IS modules supporting data	60	76	82	73
1.2.	Organization chart	15	62	70	75
1.4.	Scope of duties	7	21	10	65
2.	Safety system characteristics				
2.1.	Functions	7	10	2	2
2.2.	Elements	3	8	12	10
2.3.	Tools	12	7	0	0
3.	Tactic activities				
3.1.	Presentation of procedures	25	83	15	10
3.2.	Description of functions of computer science tech	15	87	7	8
4.	Operation activities				
4.1.	Monitoring of actions	13	10	12	8
4.2.	Reporting of actions	72	87	63	53
5.	Actions of planning internal audit and scheduling	2	0	1	0

*A—Validity, B—Appropriate reaction, C—Completeness, D—Availability time (number of answers).

4 RESULTS AND DISCUSSION

According to the respondents the most important quality information requirements towards safety working conditions (among such a group as: appropriate reaction time, availability, comparability, completeness, details and validity (Sławińska & Jurga 2012)) are the following criteria: validity (52 answers), appropriate reaction time (21 answers), completeness (10 answers) and availability (7 answers). Afterwards these criteria were used to assess the computer-aided OH&S management systems available on the Polish market. The results of this investigation are presented in Table 1.

As it can be noticed in Table 1 the positive results were obtained in all the differentiated areas within the application of four criteria. The highest results were achieved for characteristics of IS modules supporting data (291 answers), reporting of actions (275 answers) and strategic assumptions (268 answers). It is also worth to emphasise that the perception of the importance of the individual criterion for these areas was almost on the same level, except validity in strategic assumptions. It indicates that during designing of such a system a designer should find solutions which will allow for the practical application of these criteria. Furthermore, the results of the study show that the users expect the applications to allow them appointing further directions of improvement of the OH&S management system. Due to information validity the system is supposed to become more comprehensible and bring together many OH&S topics. It should allow for its adjustment for new opportunities (organizational and legal) resulting from the changeable environment in which the enterprise does its business.

5 CONCLUSIONS

The resent situation has contributed to the adoption of several safety management practices, which enable to identify hazards, assess and control risks. The most popular tool to facilitate the organizations to manage health and safety issues and comply with the legislation is the OH&S management system in accordance with OHSAS 18001:2007. However, the safety management system itself cannot assure the efficiency of the contemporary enterprise. The efficient system is also required as it integrates all the elements of organizational chart into a neural system. It allows to obtain selected and credible information which is a clue factor for the effective control of the organization safety. The results of the study presented in the paper confirmed the importance of information validity, completeness, availability and appropriate reaction time in the management of the health and safety system. Its outcomes should be taken into account to assess and improve applications supporting performing tasks about work safety management available on the Polish market.

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Horse stable environment: What to expect regarding fungi and particles occupational exposure?

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ABSTRACT: The simultaneous presence of fungi and particles in horse stable environment can create a singular exposure condition because particles have been reported has a good carrier for microorganisms and their metabolites. This study intends to characterize this setting and to recognize fungi and particles occupational exposure. Air samples of 50 L were collected through an impaction method and surfaces samples were also collected by swabbing the surfaces of the same indoor sites. Particles measurements were performed in different tasks using portable direct-reading hand-held equipment. Round pen was the sampling site with the highest fungal load in air and the closed box during litter changing and the feed warehouse has the highest fungal load in surfaces samples. The higher median value for PM_{10} and PM_5 was obtained in the closed box during the horse brushing task ($p < 0.000$). The results obtained in this study highlight the need of further and more detailed research.

1 INTRODUCTION

Bacterial, fungal spores and floor material are the main constituents of respirable dust in stables, being released from fodder and bedding material as well as possibly growing on inner walls due to dampness from horses, especially when washing horses after training (Elfman et al., 2009). Fungi are easily accumulated and aerosolized, acting as indoor air biocontaminants especially in densely horse-populated environments and in enclosed buildings: the consequent exposure may result in respiratory damage (Robison et al.,1996). Besides high fungal contamination there are other risk factors that can be present in this setting such as dust and metabolites produce by fungi (mycotoxins) and bacteria (endotoxins) (Gallagher et al., 2007). The simultaneous presence of these risk factors can create a singular exposure condition because particles have been reported has a good carrier for mycotoxins and endotoxins, promoting exposure to these metabolites (Allermann et al., 2000; Viegas et al., 2013a,b).

Health effects related with exposure to particles exposure in different occupational settings have mainly been investigated with mass-measuring instruments or gravimetric analysis. However, more recently, there are some studies that support that size distribution and particle number concentration may have advantages over particle mass concentration for assessing the health effects of airborne particles (Viegas et al., 2014). It can be an alternative metric that give more detail information regarding the amount of particles that can reach and deposited onto the walls of the respiratory tract (Schmid et al., 2009).

Many people spend considerable amount of time each day in equine stable environments either as employees in the care and training of horses or in leisure activity. However, to our knowledge, this is the first Portuguese study in this setting that intends to characterize the horse stable environment and to recognize fungi and particles occupational exposure.

2 MATERIALS AND METHODS

2.1 *Equine center assessed*

This study was conducted during June 2014 in one equine center, situated in outskirts of Lisbon city. Samples and measurements were conducted near the workers nose and during the usual tasks developed in a horse stable. The criteria followed to choose the sampling sites were the ones where the workers spend more time and the tasks that were developed during more time or more frequently in each workplace, namely: closed box when brushing a horse, closed box during litter changing, round pen with horses, uncovered arena with horses, feed warehouse during the handling of feed, covered arena with horses and outdoor to be used as reference. The surface samples were collected in the same sampling sites excluding round pen, arenas and outdoor. The horses were bedded on straw, fed normally three times a day and had their boxes cleaned daily each morning.

2.2 *Fungal contamination*

Sample collections were performed in March of 2014. Air samples of 50 L were collected through an impaction method with a flow rate of 140 L/min onto Malt Extract Agar (MEA) supplemented with chloramphenicol (0.05%), using the Millipore air Tester (Millipore). Surfaces samples were collected by swabbing the surfaces of the same indoor sites, using a 10 by 10 cm square stencil disinfected with 70% alcohol solution between samples according to the International Standard ISO 18593 (2004). The obtained swabs were then plated onto MEA.

All the collected samples were incubated at 27ºC for 5 to 7 days. After laboratory processing and incubation of the collected samples, quantitative (colony-forming units - CFU/m^3 and CFU/m^2) and qualitative results were obtained with identification of the isolated fungal species. For species identification, microscopic mounts were performed using tease mount or Scotch tape mount and lactophenol cotton blue mount procedures. Morphological Identification was achieved through macro and microscopic characteristics as noted by Hoog et al. (2002).

2.3 *Particles assessment*

In each workplace were identified the tasks usually developed. Based on direct observations of work practices on a task-by-task basis, in the time spend by workers in each one, and in the professional judgment (the task that probably involves higher exposure to particles) it was define the ones to evaluate in each workplace (Table 1).

Measurements were performed using a portable direct-reading hand-held equipment (Lighthouse, model 3016 IAQ). The value of this instrument is its capacity to give information regarding mass concentration in 5 different sizes ($PM_{0.5}$; PM_1; $PM_{2.5}$; PM_5; PM_{10}). Additionally, data related with particle number concentration by each diameter size is also available. In this last case, particles results were given in six different diameters sizes, namely; 0.3 µm, 0.5 µm, 1 µm, 2.5 µm, 5 µm and 10 µm. As mentioned before, this data was also collected because might be more closely correlated with adverse particles health effects (Wichmann et al., 2000).The measurements were conducted near the workers nose and during tasks performance and for each task was done one measurement of approximately 5 minutes.

Table 1. Tasks assessed in each workplace.

Workplace	Nº of tasks	Tasks
Closed boxes	2	Changing litter and cleaning (with and without the horse inside); Horse brushing
Round pen	1	Training horses
Uncovered arena	1	Training horses
Feed warehouse	1	Handling feed
Covered arena	1	Training horses

The data analysis was performed in SPSS statistical software, version 21.0.

3 RESULTS

3.1 *Fungal load*

The air results from indoor spaces ranged from 0 $CFU \cdot m^{-3}$ to 100 $CFU \cdot m^{-3}$. Surfaces present higher load than the air with results that ranged from 20000 $CFU \cdot m^{-2}$ to 30000 $CFU \cdot m^{-2}$. Round pen was the sampling site with the highest fungal load in air and closed box during litter changing and feed warehouse has the highest fungal load in surfaces samples (Fig. 1). *Penicillium* sp. presented number of isolates impossible to count in air in closed box when brushing a horse. *Rhizopus* sp. also presented number of isolates impossible to count in air and surface samples in closed box during litter changing.

Besides the sampling site with higher air fungal load, also feed warehouse and closed box when brushing a horse presented more $CFU \cdot m^{-3}$ than the outdoor sample.

Eight different species of filamentous fungi were identified in air samples with a total of 260 isolates. *Aspergillus* genus presents the highest prevalence (53.8%). Species belonging to the *A. niger* complex (23.1%) and *A. fumigatus* complex (23.1%) were the most prevalent fungi in air sampling, but *A. flavus* complex was also isolated. *Syncephalastrum racemosum*, *Mucor* sp., *Penicillium* sp., *Scopulariopsis*

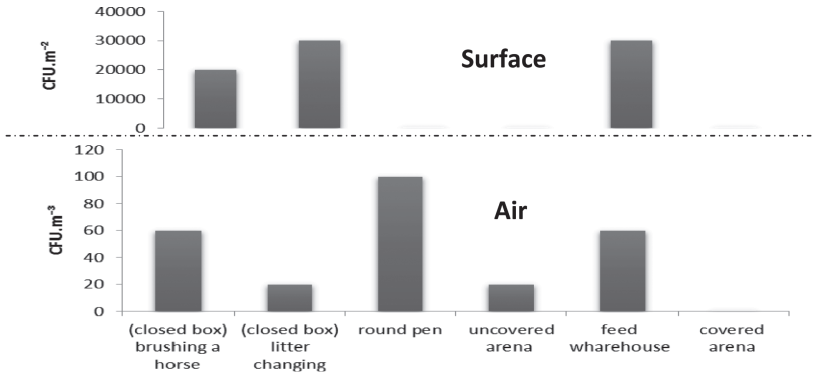

Figure 1. Fungal load distribution in the different sampling sites.

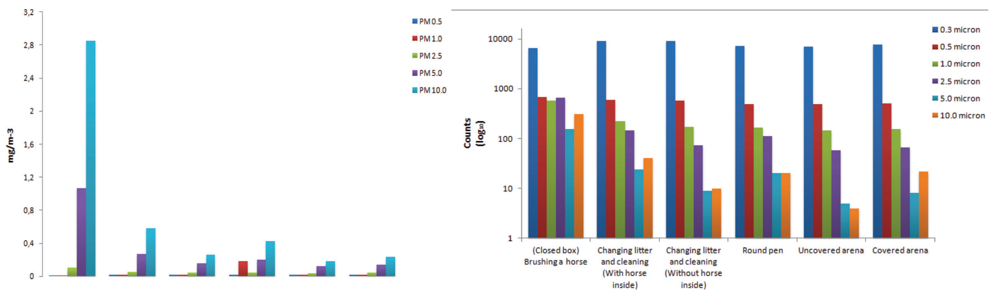

Figure 2. Distribution by size of mass (mg/m^3) and particle number (counts).

brevicaulis and *Fusarium oxysporum* were also identified in the air samples.

Four different species were isolated in surfaces samples with a total of 80000 isolates. *Aspergillus* genus also presents the highest prevalence (87.5%). *Aspergillus niger* complex (375%) and *A. fumigatus* complex (37.5%) were also the most found, but *A. versicolor* complex was also isolated.

3.2 *Particles*

Were detected differences statistically significant for all particles sizes between tasks (p's < 0.0001). However, it appears that the PM_5 and PM_{10} present higher values in all the tasks studied. The higher median value for PM_{10} and PM_5 was obtained in the closed box during the horse brushing task ($p < 0.000$) (Fig. 2).

As regards the particle number concentration distribution by size, we detected statistically significant differences for all particle sizes between tasks ($p = 0.000$). Note that, the particle number concentration for 0.3 µm size presented higher number of particles in all the tasks with higher median value obtained in the closed box during the litter changing without the horse inside the box. Moreover, the tasks developed inside the closed box had the higher median values for almost all the sizes of particles (p's < 0.000) (Fig. 2).

4 DISCUSSION

Fungal contamination may contribute to an increase in allergies and many other adverse health effects in horse-stable workers. Fungi may be responsible for a variety of diseases: allergic reactions such as asthma, allergic rhinitis, hypersensitivity pneumonitis, infections caused by the growth of the fungus in body tissues and toxic reactions, mainly related to mycotoxins and fungal cell wall components (Górny et al., 2002).

Regarding to the health risks derived from exposure to fungi, the World Health Organization (WHO) considers the value of 150 $CFU \cdot m^{-3}$ as a reason for concern, especially when potentially pathogenic species of fungi are present (Goyer et al., 2001) as the ones most prevalent in our study belonging to *Aspergillus* genera. None of the sampling sites surpass the WHO value, however, 3 from the 6 sampling sites presented higher fungal load than outdoor sample meaning that there are sources of indoor fungal contamination (Wouters et al., 2006). Besides the quantitative assessment, is crucial to analyze the fungal species present, since adverse health effects are depended on fungal species (Hoog et al., 2002). According to the American Industrial Hygiene Association (AIHA, 1996) in the Field Guide for the Determination of Biological Contaminants in Environmental Samples, the identification of the species *A. flavus* and *A. fumigatus*, both of them identified in this setting, requires implementation of corrective measures.

Is important to highlight that mycotoxins occur in occupational environments whenever fungi are present (Mayer et al., 2008), thus besides fungal burden caused by the most common fungal species found, some of these strains are also known for their toxigenic potential, including species from *Penicillium* genus, and species from *A. fumigatus*, *A. niger* and *A. flavus* complexes. Consequently, we must potentially consider simultaneous exposure to several mycotoxins (Thrane et al., 2004). This situation is more critical when we are facing settings prone in dust since mycotoxins can be transported to workers respiratory system through particles (Allermann et al., 2000; Viegas et al., 2013).

To our knowledge, this is the first study developed in horse stables that comprehensively assess exposure to particles and obtained, besides mass values, data regarding particle number concentration by size. Moreover, in others research work (Berndt et al., 2010), data is given by workplace or horse management system and not by task developed in each workplace as in the present research. Therefore, the data obtained gives more accurate information regarding exposure and, consequently, allows the identification of the more suitable preventive and protective measures. In this case interventions on the workplaces and tasks developed in the closed box can have substantial impact on worker's exposure and health effects related.

Similar to our results, Samadi and colleagues (2009) found that feeding and cleaning the stables were the tasks with higher exposure to inhalable dust. Earlier studies have shown also higher particle load during cleaning of boxes and daytime activity in the stable, compared with the time of day when the boxes are without activity (Rosenthal et al., 2006; Riihimäki et al., 2008). Some studies have shown also that type and hygienic quality of feed and bedding material have also a great impact on dust concentration. Additionally, other variables need to be reflected, namely: type of measurements and exposure metrics used, the type of ventilation, air humidity and work routines (Riihimäki et al., 2008). All these variables can influence results and, consequently, their interpretation. Additionally, the particles results can be higher in the winter since in previous research work (Riihimäki et al., 2008) found higher particle load during the winter than in the summer. Probably natural ventilation is less effective during the winter season.

Besides mass and particle number concentration there are other aspects that must be contemplated when considering the particles related health effects, such as: chemical proprieties (Almeida-Silva et al., 2014) and also the fact that particles may act as a carrier and a source of nutrients for fungi (Viegas et al., 2012; Raulf et al., 2014), bacteria (Halstensen et al., 2013) acting as airborne allergens (Raulf et al., 2014). Particles are also rich in endotoxins from the cell wall of gram-negative bacteria and, as mentioned before, are also associated with the exposure to mycotoxins produced by several fungi (Allermann et al., 2000; Viegas et al., 2013).

5 CONCLUSIONS

The results obtained in this study highlight the need of further and more detail research regarding occupational exposures. Despite the need of more detailed data, the results point out to the need for applying adequate preventive and protective measures.

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Analysis of occupational risks: A systematic review from "Bayesian Networks" tools

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ABSTRACT: Risk analysis is a tool to develop strategies of accident prevention, because it determines the factors involved and the acceptable risk level to a particular activity. One of the innovative methods gradually used to analyze occupational risks, as various areas of knowledge, are Bayesian Networks (BN). This paper aims to present a discussion about analysis of occupational risks with application of the BN as tool to identify risks. Thus was performed a systematic review analogous to protocol Statement for Reporting Systematic Reviews (Prisma).

1 INTRODUCTION

Conditions of combat during wartimes and the circumstances under which were performed the military operations submitted combatants to extreme discomfort levels, thereby, due to the need of reliability in the operations, generated great advances in the study about the risks and about how maximize the performance of activities (Lins, 2010).

Initially, definition of occupational risk emerges from consequences noticeable in performing tasks. This concept was grounded on several knowledge areas, such as safety engineering, hygiene, occupational medicine, toxicology and epidemiology. However, risk can be understood as product of the odds and consequences, because of this it should not be analyzed in a static way, due to constant changes in the organizational environment of the companies; nor can be eliminated in its entirety, because it is derived from probabilistic factor, thus the priority is to reduce or minimization of their impacts through strategies to interrupt the progression of the incident and control mechanisms (Khakzad et al., 2013; Nascimento et al., 2010).

Thereby, to understand risk as a probabilistic factor it is possible to analyze in a qualitative way through inferential methods. One of the innovative methods in the occupational risk area is the probabilistic modeling through Bayesian Networks (BN) (Abdat et al., 2014; Tighe et al. 2013; Wang et al., 2012). Thus, this paper aims to present a discussion about analysis of occupational risk with application of the BN as tool to identify occupational risks.

2 METHOD

This paper is a systematic literature review, for this the Statement for Reporting Systematic Reviews (Prisma) was used (Liberati et al., 2009), following steps: Search strategy—search was conducted in the digital databases such as Emerald, Web of knowledge, Science Direct and SCOPUS. In this research were selected the papers written in Portuguese, English and Spanish and published between the years 2009 and 2014. It used the keywords such as risk analysis, occupational risk, occupational accident, Bayesian Networks; exclusion and inclusion criteria—After to remove the duplicates, papers were evaluated with respect their Qualis (A1 to B2) academic significance based on Journal Citation Reports (JCR), and adjustment to research, respectively; Final choice of papers: were deleted texts relating titles and abstracts unsuitable with the search scope. Studies selected were submitted to the reading and analysis. The choice of the analyzed papers was based in the heterogeneity of the data resources, type of data and data analysis; these particularities were addressed by the set of the studies (Table 3).

3 DISCUSSION

Table 1 illustrates the amount of papers found and selected in each step of the research considering the above criteria. Papers that were suited to the scope this research were used to analysis and discussion in the next session. Table 2 describes the amount of papers for sector where it was applied to risk analysis using BN, and the Table 3 makes the distinction of papers by characteristics of the data.

Table 1. Filtering of the papers.

Phase	Total
Search	334
Exclusion of duplicates	181
Qualis and JCR	100
Suitable title	59
Suitable review	13

Table 2. Distinction of papers by sector of intervention.

Sector	Quantitative
Maritime transport	3
Civil construction	3
Industry	1
Road traffic	1
Undefined	5
Total	13

Table 3. Distinction of papers by characteristics of the data.

Requirements	Authors
Data sources	
Organizational factors	Akhta & Utne (2014); García-Herrero et al. (2013); García-Herrero et al. (2013b); Khakzad et al. (2013); Leu & Chang (2013); Martins & Maturana (2013); Wang et al. (2011).
Human factors	Akhta & Utne (2014); García-Herrero et al. (2013b); Khakzad et al. (2013); Leu & Chang (2013); Martín et al. (2009); Martins & Maturana (2013); Wang et al. (2011); Wang et al. (2013); Zhao et al. (2012).
Job demands	García-Herrero et al. (2013b).
Ergonomic	García-Herrero et al.(2012a); Martín et al. (2009).
Types of data	
Qualitative	Abdat et al. (2014); Akhta & Utne (2014); García-Herrero et al. (2013); García-Herrero et al. (2013b); Martín *et* al. (2009).
Quantitative	Khakzad et al. (2013); Leu & Chang (2013); Wang et al. (2011); Zhao et al. (2012).
Both	García-Herrero et al. (2012a); Martins & Maturana (2013).
Data analysis	
Only softwares	Khakzad et al.(2013); García-Herrero et al. (2013); García-Herrero et al. (2012a); García-Herrero et al. (2013b); Martín et al. (2009); Martins & Maturana (2013).
Software + experts	Abdat et al. (2014); Akhta & Utne (2014); Leu & Chang (2013); Wang et al. (2011); Wang et al. (2013); Zhao et al. (2012).

4 LITERATURE REVIEW/BACKGROUND

Risk is a variable present in the workplaces, thereby each occupation, activity and human being hold a particular level of risk, commonly linked to concrete tasks. Therefore, occupational risk is the possibility of that some element included in a specific process and workplace may cause damage to health, through accidents or diseases, and to induce physical and psychological repercussions; hence the prevention or minimization of the severity must be health and goals in the companies (García-Herrero et al., 2012a, Wang et al., 2013).

Several factors may contribute to the exposure of occupational risk, and all of them are correlated, hence is necessary to consider their interactions when analyzed (Zhao et al., 2012; Akhtar & Utne, 2014). In order to develop strategies of prevention, the risk analysis determines the factors involved and the risk level which is acceptable to a particular activity (García-Herrero et al., 2012b; Aneziris et al.,2010; Martín et al., 2009).

Therefore, to try to write a literature review about identification and analysis of the occupational risk, modern theories have been developed it, one of them is the Theory of Three Types of Hazard (Fig. 1). It identifies occupational risks as been originated from three sources: (1) resulting from physical and chemical magnitudes dispersed in the environment where the task is performed; (2) related to unsafe or defective elements during task performing; (3) resulting from organizational and individual factors (Zhu-Wu et al., 2011). To analyze of occupational risk in a holistic way and based in these three investigation areas is essential to use methods that allow to prevent with accuracy the cause-effect relationship among elements this complex system (Martins & Maturana, 2013; Leu & Chang, 2013).

One of the methods gradually used for risk to analyze of occupational accidents are BN. It is a statistical method that provides accurately the probability of occurrence of a specific event regarding the set of the variables and its dependencies,

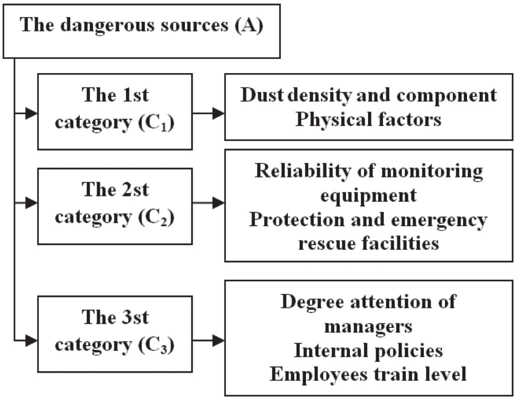

Figure 1. Origin of occupational hazards.
Source: Zhu-Wu et al. (2011) (Adapted).

generating quantitative informations about the exposure to the risk (Delcroix et al., 2013; Abdat et al., 2014; Tighe et al. 2013; Wang et al., 2012). This is only possible, considering García-Herrero et al. (2013b), because this method allow integrating two or more hypotheses to determine the probability of an event.

Therefore, RB allow identifying of the dependence relationships among different causes of accidents and occupational disorders. These information—usually are not provided by conventional statisc methods applied in the occupational risk area—allow to develop an more realistic causal model (Martin et al., 2009).

Several current studies indicate BN as robust tools to analyze occupational risk, for example: Wang et al. (2011) developed a model based on BN to assess how human and organizational factors contribute to the occupational accidents. From this study was possible to identify that the action "do not run security norms" was the main risk factor for the accident occurrences. Zhao et al. (2012) characterized the factors that influence hazardous material transportation accidents with the use of the RB. It could find that the human factors were the most important direct causes of occupational accidents; García-Herrero et al. (2012a) used BN tools to analyze the influence of working conditions on occupational accidents. For this, was used datas related to higienic conditions, ergonomic, job demands, physical and psychological symtoms. Their results showed strong relationship between occupational accidents and global set of the hygienic and ergonomic conditions. Khakzad et al. (2013) performed an analysis of accident risk in drilling operation on the high sea using BN. Probablitites were calculated from occurence of precursors of accidents during five weeks. Their findings suggest that the RB provide reliable results by considering common causes of failure and conditional dependencies, besides promote the sequential learning of the common precursors of accidents. Abdat et al. (2014) develop a RB to evaluate occupational accidents where identified eight recurring accident scenarios and its risk probabilities.

These probabilistic networks have ability to provide monitoring data as new informations are added or removed from its structure, it is also possible to embody categorical variables; this feature adds a great advantage over others methods (García-Herrero et al., 2013b; García-Herrero et al., 2013a; Valdés et al, 2011). In this sense, information generated can be used as input to a occupational risk management model (Martin et al., 2009).

Therefore, it is possible to understand that the risk analyze through BN may be used as a tool of decision making, because through it were identify what factors of risk of specific activity and how each factor may influence on occurrence of accidents and occupational disorders, providing subsidies to mitigate its common assumptions (Zhao et al., 2012; Martín et al., 2009; Tighe et al. 2013).

Therefore, it is observed that BN is a good tool to analyze the relations of independence between variables that, according García-Herrero et al. (2012a), it can aid in investigating the causes of accidents and occupational disorders, once it provides flexibility and probabilistic reasoning. Thus, the use of the BN in the area of risk analyze inherent in the work appears as a tool that includes causal probabilistic calculations whose focus is on helping and improving of the identification, analyze and management of such risks, it is important for diagnostic and decision making process (Arlinghaus et al., 2012; Martins & Maturana, 2013).

5 CONCLUSIONS

Occupational risks are elements inherent in the systematic of the work; to identify and quantify these risks provide subsides for an effective action to try to prevent accidents and/or mitigate its effects. In this perspective, RB may become robust tools to analyze occupational risks to present the following characteristics: (1) Considers dependence relationships among variables allowing the identification of a causal model; (2) Considers a sequential of harmful events and its repercussion about accidents and occupational disorders; (3) Uses qualitative and quantitative data, covering all the complexity of the system; (4) Allows to integrate several hypotheses to determine the probability of a risk event. These characteristics make RB a reliable and efficient modeling tool of the occupational risks.

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Dentist health and its ergonomic risks: Literature review

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ABSTRACT: The occupational health of the individual is affected by numerous factors and risks that are becoming increasingly commonplace in many industries. The objective of this study was to review the literature addressing the main occupational risks to which dentists are exposed, with emphasis on ergonomic risks and diseases related to it. The main risks to which dentists are exposed, are related to physical, chemical, biological, mechanical and ergonomic agents, and are the focus of the work. It was concluded that dentists have a high frequency of musculoskeletal disorders, probably caused by poor posture and stress arising from professional practice. Prevention through regular exercise helps to minimize these problems.

1 INTRODUCTION

A little over two centuries ago, through the studies of Ramazzini, Occupational Health—a branch of Preventive Medicine—came into being. The possibility of damage or loss involving the presence of an adverse event is characterized as an occupational risk (Brasil, 2006). In addition, it may be a condition or set of circumstances that have the potential to cause harmful effects such as death, injury, illness, or damage to health, property or the environment (Neves, 2007).

Occupational risks can be classified as physical, chemical, biological, mechanical, ergonomic and psychological (Mehta et al., 2013). Exposure to ergonomic risks can create musculoskeletal disorders which are situations to which dental professionals are commonly exposed (Fasunloro & Owotade, 2004). Repetitive movements, poor positioning, genetic predisposition, prolonged static posture, suboptimal lighting, mental stress, physical fitness and age are risk factors linked to musculoskeletal disorders (Valachi & Valachi, 2003a).

It is necessary to conduct literary research on the health of dental field workers, because there is constant concern about eliminating or minimizing their occupational risks (Santos & Peloggia, 2002).

For this literature review, Pubmed, Scopus and BIREME databases were used. Descriptors related to the issue were included in the databases and relevant articles published after 2000, written in English and Portuguese were selected.

2 OBJECTIVES

Therefore the objective of this study was to review the literature addressing the main occupational risks to which dentists are exposed, with emphasis on ergonomic risks and diseases related to it.

3 REVIEW OF THE LITERATURE

The advancement of health in the pursuit of new knowledge of etiopathogenesis, participation of professionals and users, and awareness of the multiple causes of diseases have originated the so-called risk map, which is a graphical representation of a set of risk factors present in the work environment. It is important to be aware of these factors, because the majority of risks are inherent to professional practice.

Since the eighteenth century the occupational diseases have been described in the literature and by 1946, in the United States, published a study reporting a large percentage of dentists with a problem of occupational origin (Lulamandier et al., 2001). Dentists are faced with all of them, because the atmosphere of dental office is propitious to development issues related to physical health, resulting in infection from bio-aerosols, infectious body fluid exposure, and respiratory or other communicable illnesses; working with chemical or other environmental agents; factors such as ionizing and nonionizing radiation injuries, noise-induced hearing loss, and peripheral neuropathy; and poor ergonomic working conditions (Leggat & Kedjarune, 2001). Chemical risk is defined as professional exposure to chemical agents such as, for example, dusts, mists, fumes, gases, mercury, and chemical products in general. In a dental office the main causes of this risk are: amalgamators, chemical disinfectants (alcohol, glutaraldehyde, sodium hypochlorite, chlorhexidine) and medical gases (nitrous oxide and others) (Brasil, 2006). Exposure to substances with high volatility of resin cleaners and x-ray developers and fixers, including procaine, soaps, eugenol, formalin, phenol and other disinfectants, can cause irritation to the eyes and respiratory system.

However, physical risk is characterized by professionals' exposure to physical agents such as noise, vibration, ionizing and non-ionizing radiation, extreme temperatures, inadequate or excessive light and humidity. Dental equipment such as high speed pens, air compressors, laser equipment, curing units, autoclaves, air conditioners, X-ray equipment may be the cause of these risks (Brasil, 2006). Search conducted with dentists who work with speed hand pieces have demonstrated moderate hearing loss. Aggression is gradual, progressive and painless and is not noticed in the early stages of the disorder. With continuous exposure, the perception and understanding of a conversation, for example, may be compromised.

As regards biological risk, the probability of this can be considered an adverse event, such as the presence of a biological agent (Brasil, 2006). From this aspect the dentist is exposed, resulting from their work activity, to biological agents causing sites for infection by pathogens, is considered a very significant risk environment (Brasil, 2005). Transmission in the dental environment can occur through direct contact with the injury, blood or secretions or aerosols, needles or scalpels and even improperly sterilized instruments (Nogueira et al., 2010). However the correct use of Personal Protective Equipment (PPE) and safety measures are able to minimize contagion and transmission.

The mechanical risk consists of exposure of dental personnel to mechanical agents that provide damages, or accidents while using defective instruments, or those unfit for the procedure; danger of fire or explosion; building defects; improvisations in the plumbing and electrical network installations; lack of PPE (Brasil, 2006). Dental clinics with larger numbers of employees are necessary in order to implement the Program of Environmental Risk Prevention—PPRA, in accordance with the NR 94 Standard.

Ergonomic risks are related to agents such as incorrect posture; absence of professional help, or lack of training in this area; lack of planning; pace of overwork; repetitive acts; among others (Brasil, 2006). Ergonomic risks are covered by Regulatory Standard NR17 provided in Administrative Ruling No. 3,751, of November 23, 1990, which is responsible for man's relationship with his work, equipment and environment, with the aim of preventing occupational diseases.

According to the "Committee on Ergonomics of the FDI—World Dental Federation" (quoted by Alexandre Barros—PUC-MG), construction and installation of the dental office, advance planning of the installation of equipment, hydraulic and electrical systems and furniture should be done, in compliance with criteria that seek to prevent strain and fatigue, simplify work and the handling of equipment, and provide comfort and security. The simplification of the physical space when well planned, can allow the reduction of time and motion in performing clinical tasks as an important element in productivity. This will reflect in the planning and execution of dental work by minimizing the effort-vices, exhaustion and stress in the short, medium and long term. In preventing more serious compromise of health, such as MSDs, circulatory system disorders (varicose veins), nervous system disorders or heart problems. There is concern about the increase in the quality of life of the entire dental team. There is increasing evidence that the unique working conditions in dentistry can significantly affect the health of dentists (Harshid et al., 2012). A variety of risk factors in the dental workplace can affect the professional's physical health, or aggravate pre-existing problems (Puriene et al., 2007). Studies have shown that dentists often report more health problems (Szymanska, 2002) related to musculoskeletal pain (Crawford et al., 2005).

The basic ergonomic principles for dentist work objective the rationalization of care, allowing professional produce more and better avoiding fatigue and unnecessary wear and at the same time providing safety and patient comfort (Rio & Rio, 2000). These principles guide the biomechanics of work, which we can mention: the best work positioning professional/patient, according to the procedure to be performed, the arrangement and use of equipment, the appointment time, and others. But the professionals did not follow these principles when working (Garbin et al., 2008) and it brings consequences. The basic operating posture is considered a major occupational health risk for clinical oral health professionals. The occurrence of cumulative trauma, since the professional often assumes static positions that are uncomfortable and asymmetric, such as sitting or standing for long periods and keeping the head, neck and shoulders in a fixed position without intervals. Inadequate work habits, inconvenient posture and repetitive tasks may be potential drawbacks for the musculoskeletal system, leading to psychological stress, and fatigue (Valachi & Valachi, 2003b).

Each year, about 2 million workers of different professions suffer from musculoskeletal injuries, and this problem occurs mainly due to postures and repetitive movements. To refer specifically to dental professionals the risk of developing these disorders is increased (Hayes et al., 2009b) and generally the prevalence is about 65% (Nals Saraji et al., 2005; Garbin et al., 2011), whereas back pain (36.3–60.1%) and neck (19.8–85%) are the most frequently reported by dentists (Hayes et al., 2009a).

The Musculoskeletal disorders more commonly seen in dental surgeons are: Carpal Tunnel Syndrome; Ulnar Nerve Entrapment; Pronator Syndrome; Tendinitis; Tenosynovitis; Extensor Wad Strain; Thoracic Outlet Syndrome; Rotator Cuff Tendonitis (Nield-Gehrig, 2008).

Most dentists do not seek any treatment for pain, which may adversely affect the condition and increase the severity of injury. Regular exercise and physical therapy would be a possibility to reduce the prevalence and severity of these diseases (Shrestha et al., 2008), but some dentists prefer take painkillers, and very few seek medical treatment (Harshid et al., 2012). However, the most important advice is the dentist should pay attention to their movements, which must be rationalized within the basic ergonomics principles to provide higher performance and lower prejudice (Garbin et al., 2008).

4 DISCUSSION

This literature review provided an overview of the health problems suffered by dentists, especially those resulting from limited or poor ergonomic work habits. The restricted and prolonged flexion of the spine or neck position, may result in a risk factor for musculoskeletal injury. The symptoms of musculoskeletal injuries increase with the number of years worked (Kierklo et al., 2011; Ruijter et al., 2014).

Studies have shown that dentists have a high frequency of work-related musculoskeletal disorders (Kierklo et al., 2011; Shrestha et al., 2008), that worsen with age (Purine et al., 2008), wherein backache, in the neck and shoulders are musculoskeletal complaints job-specific in dentists (Hjalmers et al., 2003; Alexandre et al., 2011).

There is evidence that dental professionals who have poor mental states could affect your physical state, or vice versa (Pandis et al., 2007; Ruijter et al., 2014). Thus the pain suffered by dentists can lead to decreased productivity, due to the time absent from work or reduction in working hours, and can also lead to inefficient movements, causing an increase in time spent per patient.

Musculoskeletal pain may be diminished by adopting the so-called neutral positions, which involve the ideal positioning of the body while performing work activities, and is associated with decreased risk of musculoskeletal injuries. It is believed that the more the position deviates from the neutral position, the higher the risk of injury (Nield-Gehrig, 2008). However, in spite of musculoskeletal complaints being common among dentists, they are not of a serious nature. There is a possibility of further decreasing the prevalence and severity of these diseases by performing specific exercises regularly. However, the study by Shrestha (2008) showed that the majority of dentists did not perform specific exercises to prevent or decrease pain in the back, neck and shoulders (Shrestha et al., 2008).

To avoid these problems the advice is follow the basic ergonomic principles. And also to alleviate or to prevent injury the recommendation is to practice stretching before starting the workday. This will cause increased blood flow to the muscles, increased production of synovial joint fluid, reduction in trigger point formation, maintenance of the normal movement range of motion, increased supply of nutrients to the vertebral disks by creating a relaxation response by the central nervous system, warming the muscles before starting work, and identifying tight structures that may be predisposed to injury.

5 CONCLUSION

The literature showed that dentists have a high frequency of musculoskeletal disorders and these are probably caused by bad posture and stress resulting from professional practice. Prevention is still the best alternative, because essentially it will enhance the professional's performance and this is directly related to the quality of life and work.

The multifactorial nature of the problem must be understood in order to encourage education, extension and research in the area.

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Comparison of different medical clothing used in Operating Rooms (OR's)—the importance of thermal comfort at work

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ABSTRACT: In operating room, the health professionals are exposed to stress situations that can influence their physical and psychological performance. The thermal properties are an important requirement for the best performance of OR medical clothing, that plays a crucial role in thermal comfort of the user, that involve the regulation of heat and mass transfer between a clothed body and the environment. In this way, the aim of this work was comparison of thermal properties between scrub and clean air suits. The test was performed on a thermal manikin, tri-dimensional test that simulates the use of clothing measuring clothing insulation and to evaluate the thermal comfort. The test provides a good estimate of total dry heat loss from the body, between body surface and textile materials, and esteem the comfort level of this work wear.

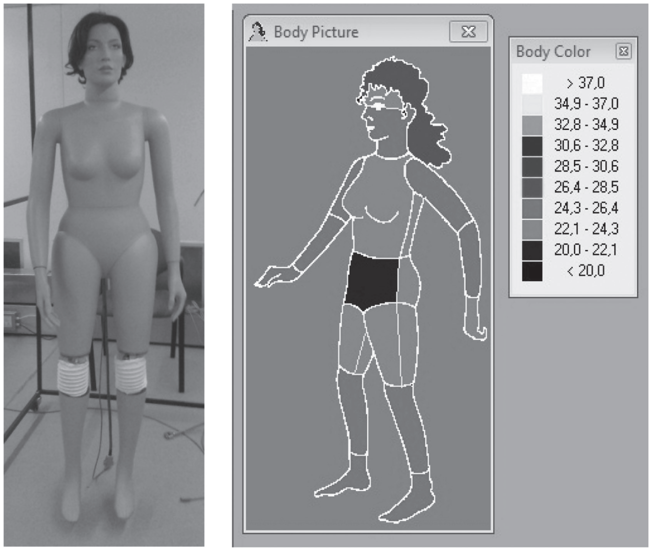
1 INTRODUCTION

Over the last years, surgical Scrub Suits (SS) have been worn by health care workers in the Operation Room (OR) and for many other applications in healthcare outside the OR. They are used by health professionals as uniform. However, scrub suits are not considered a medical device, so there is no defined regulation nether scientific studies support the practice of using scrub suits as a means for preventing transmission of infection (Abreu, 2012, Abreu, 2014). On the other hand, Clean Air Suits (CAS) are considered Class I medical devices according to the definition and classification rules of the Medical Devices Directive 93/42/EEC, amended by 2007/47/EC (Council Directive 93/42/EEC) [3] [3]. Clean air suit is defined as a "suit intended and shown to minimize contamination of the operating wound by the wearer's skin scales carrying infective agents via the operating room air thereby reducing the risk of wound infection" by EN 13795:2011+A1:2013 (CEN, 2011). In Figure 1 can be seen the appearance of a scrub suit and a clean air suit. The standard EN 13795 presents general performance requirements concerning properties which require assessment in CAS like resistance to microbial penetration, microbial and particle matter cleanliness, linting, bursting strength and tensile strength (CEN, 2011). As further characteristic of medical clothing, EN 13795 takes in consideration the comfort of the users.

Inside of OR, thermal comfort of medical clothing apparel is a very important parameter, since the lack of comfort can lead to thermal stress that influence the physic and psychological conditions of the surgeon, as the ability to maintain constant vigilance and concentration, which the correct surgical procedure is dependent. Thermal comfort of the user of medical apparel depends on thermal properties and its adjustment to the environmental conditions in the OR during the surgery, among many other factors like design, size and fabric characteristics (Cho et al., 1997). Extremely insulating and low absorbent medical apparel will results in an increase of skin temperature, leading to a greater moisture accumulation between professional skin and clothing. To overcome this situation, surgical clothing needs to satisfy some requirements; they should be comfortable, breathable, loose fitting, keep the user in cool conditions and allow heat exchange changes between the body and environment (Fanger, 1973).

The mean skin temperature of, approximately, 33 °C and non-occurrence of sweating or chills are the general condition for a health professional experience thermal comfort. Studies have determined that surgeons experience thermal comfort when OR temperature is between 20 °C and 24 °C and if their clothing system were consisted by shoes, cotton socks, nonwoven surgical clothing with viscose fiber and good air and water vapor permeability (Bogdan et al., 2011).

In this way, the aim of the presented study was to compare thermal properties between scrub and clean air suits.



a b

Figure 1. Thermal manikin: photo of nude thermal manikin used on tests (a) and software body picture of thermal manikin and color legend of body segments temperature (b).

2 MATERIAL AND METHODS

2.1 *Clothing system*

Disposable and reusable scrub and clean air suits were used in this study, Table 1. The clothing was stabilized in an adiabatic chamber before each test.

2.2 *Thermal manikin*

The thermal insulation of clothing ensemble was measured using a thermal manikin, Figure 1, with controlled skin surface temperature that simulates the wear. This thermal manikin, called "Maria", has a woman's body; its size and configurations are similar to an adult woman. It is divided in 20 thermally independent sections and only sense dry heat transfer. Thermal manikin, positioned 0.1 m from the floor, was kept standing with their legs and arms held in vertical position without any motion. The skin temperature of all body was set, and during the test period maintained at 33 ± 0.1 °C. The tests were conducted in a climatic chamber where ambient conditions characteristic of an operating theatre were simulated, 20 °C ± 2 °C and 60% Rh. The climatic chamber can achieve temperatures around 15 °C to 35 °C and relative humidity around 35% to 85%.

Data acquisition started after achieving stationary conditions and did not take more than 60 min. During the acquisition period, the heat flux and the skin temperature of each body part record every minute. Thermal insulation (I_T) was calculated according to global method, Equation 1, where T_{sk} [°C] is the mean skin temperature, T_0 [°C] is the room temperature, $\dot{Q}_s$ [W/m^2] the sensible heat flux of the manikin and fi the relationship between the surface area of segment *i* of the manikin (ISO 9920:2007) [8] [8]. This is the general formula for defining the whole body resistance and the one that best fits the definition of thermal insulation expressed (Oliveira et al., 2008). Furthermore, global method is less susceptible to significant variations to calculate thermal insulation.

$$I_T = \frac{\sum_i (f_i \times \overline{T}_{sk,i}) - T_0}{\sum_i (f_i \times \dot{Q}_{s,i})} \tag{1}$$

The effective clothing insulation (I_{cle}), consisting of the difference between I_T and Ia are calculated by the Equation 2, considering Ia is measured by operating the manikin nude:

$$I_{cle} = I_T - I_a \tag{2}$$

3 RESULTS

3.1 *Thermal manikin*

Figure 2 shows the heat loss from manikin body segments. According to Hensel cited in (Song,

Table 1. Description of clothing system tested.

Reference	Clothing system	Composition	Thickness (mm)	Air permeability (l/m²/s)
A	Single-use scrub suit	Non-woven SMS	0.52	1824
B	Reusable scrub suit	67% PES/33% cotton	0.43	411.2
C	Single use clean air suit	Non-woven SMS	0.35	464.8
D	Reusable clean air suit	99% PES/1% carbon fiber	0.30	291.8

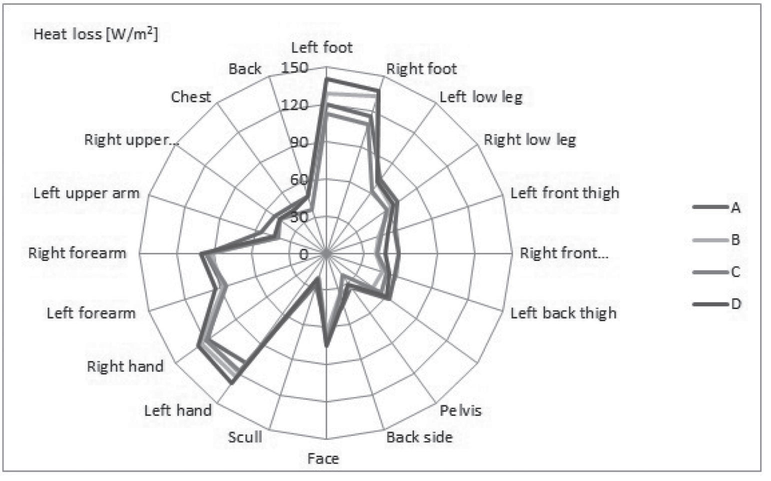


Figure 2. Heat loss from body section of manikin dressed with CAS (a) and SS (b).

2011), the higher is the heat loss from the skin to the environment, the faster the temperature will drops and more intense is the freshness feeling. So, as said earlier, the material that could absorb and conduct heat well, will remove heat from the skin and give the sensation of being a "coolest" garment. Hence, heat loss is closely related to thermal insulation, they are inversely proportional parameters. In this particular case, as expected, unclothed parts like feet, hands, forearms and face have higher heat loss.

Through heat loss values, total (I_T) and effective clothing thermal insulation (I_{cle}) can be calculated. In Figure 3 can be seen that SS A have the lower thermal insulation, the difference between single use SS and CAS (A and C) is around 0,032 m^2.°C/W and for disposable ones (B and D) it is around 0,012 m^2.°C/W. However, the difference between SS and CAS is significant when we compare SS A with CAS C, and there is also a significant difference between scrub suits A and B. Despite of SS A being the scrub suit with higher thickness value, 0.33 mm (Table 1), its lower thermal insulations can be explained by higher value of air permeability, 1824 l/m^2/s (Table 1) that allow a better heat exchanges between body surface and environment.

In spite of being made of same fabric, disposable SS and CAS (A and C), its different insulation behaviour can be also possible due to the design and lining of CAS. CAS openings for head, arms, waist and feet are closed by tightly fitting cuffs and the heat loss through these openings is lower and the thermal insulation increases. Moreover, this CAS has lining in upper part of shirt and trousers, which can also result in increased insulation.

When the effect of air layer thermal insulation is removed (I_{cle}), clothing thermal insulation decreases but show the same behaviour. For A suit, can be observed a decrease around 73%, about 58% and 57% for B and C, respectively, and 61% for D.

Thermal insulation of clothing can also be expressed in clo, Figure 4a. The higher the value of clo, the greater is thermal insulation. Clo value of 1 is defined as the amount of clothing required to a human being at rest to be comfortable at room temperature of 21 °C [10]. The differences between clothing clo values are statistically significant (p-value < 0,05), except between scrubs B and C (p-value > 0,05), Figure 4b. So, the differences of

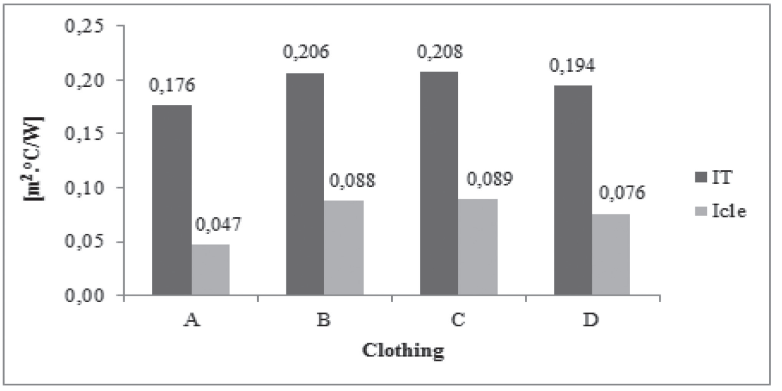
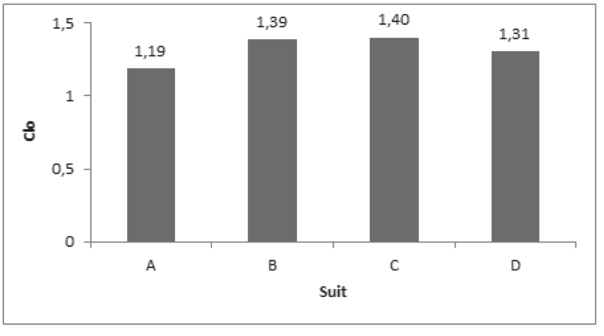


Figure 3. Total thermal insulation and effective clothing insulation of scrub and clean air suits.



a

Clothing systems	p-value
A-B	0.073
A-C	0.044
A-D	0.006
B-C	0.816
B-D	0.318
C-D	0.443

Figure 4. Clo value of total thermal insulation of scrub and clean air suits (a) and statistically differences between clothing systems (b).

wear scrub suit B or wear clean air suit C can't be perceived and A suit has the closer clo value from being thermal comfortable.

4 CONCLUSION

This study was performed to compare thermal properties between scrub suits and clean air suits made of woven and nonwoven fabric. Thermal manikins provide a good estimate of the total dry heat loss from the body and the distribution of heat flow over the body surface; these measures were used to describe the thermal characteristics of clothing. Clothing thermal insulation differences are statistically significant ($p < 0.5$) which means the user will perceive thermal differences between scrub suits. Regarding to fabric thermal properties there is no suit with all ideal properties.

Thermal insulation of clothing, it is dependent upon their specific design, size and fabric characteristics, particularly air permeability that allows heat exchange between skin surface and environment.

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Companies' OHS internal structures: A characterization based on the literature review

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ABSTRACT: By integrating the Safety, Health, Environment and Ergonomics (SHEE) occupational factors into its management programs and/or systems, an organization can regulate, standardize and optimize their operations, prioritizing the aspects associated with health and safety. In order to propose a guideline for the evaluation of Companies' Occupational Health and Safety Internal Structures (COHSIS) allowing to create and threaten safety, COHSIS and its representative concepts that are similar, i.e. coincident between structural combinations, were reviewed and characterized based on a literature review, based both on papers published in journals and on works made available by selected organizations. Nineteen similar concepts were identified for comparison between the four possible combinations (e.g. intersection relations) of COHSIS, enabling propose the mentioned guideline through six macro sequential procedures.

1 INTRODUCTION

The integrated SHEE system introduces a systematic mechanism, which integrates the structure of the human and organizational systems with a conventional Safety, Health and Environment (SHE) system and is utilized to enhance team-work, reliability, availability and maintainability; placing health and safety first (Asadzadeh et al. 2013).

In order to propose a guideline for evaluation of COHSIS allowing to create and threaten safety ("leading and lagging indicators" e.g. the so-called "dual-assurance" approach) (Øien et al. 2011a, b, HSE & CIA 2006), COHSIS and its similar concepts were reviewed and characterized. These similar concepts were based on a structural study (i.e. studying structure parts and their relationships) developed for comparison between COHSIS through a literature review, based both on papers published in journals and on works made available by selected organizations with mature culture in these structures (Bergh & Sundh 2010).

The main objectives of this study were: (i) to identify the COHSIS; (ii) to define the most adequate terminologies for COHSIS; (iii) to describe or define the key elements (e.g. justified intervention measures) that are effective and cited in the COHSIS, without repetition of its references assigned for each structure; (iv) to include key elements as the representative concepts for comparison between COHSIS; and (v) to identify the similar concepts between the possible combinations of COHSIS.

2 LITERATURE REVIEW: COMPARISON BETWEEN COHSIS

A structural study was developed for the identification and characterization of COHSIS, and for the comparison between these structures in a timeline based on a literature review.

By assigning references, the priority was given to objective evidence of one or more words, and/or contexts strongly associated between (i) definitions of the key elements cited in this section, and (ii) key elements to be included as concepts in the section 3.1. Additionally, it was used a lot more references (50 found references) than the ones included in the reference list of this paper, since only those most important were selected for this purpose.

The different definitions of the main key elements of COHSIS are related to 3 criteria included in this section: (1st) to identify terminologies of COHSIS allowing to define the most appropriate one; (2nd) to find organizations with mature culture in COHSIS or its individualized structures allowing to select as "benchmark" some of these main organizations; and (3rd) to reveal different definitions of the main key elements allowing a common configuration (e.g. that exhibits similar characteristics) of these definitions between the COHSIS.

The COHSIS investigated on this paper were described in relation to the 3 criteria above for each of these structures as follows:

– *Internal Structure 1 (IS1)*

  HFE—Human Factors/Ergonomics studied based on Dul et al. (2012).

  Review of safety indicators development in the past and its recent discussions made based on Øien et al. (2011a, b), Hopkins (2009), HSE & CIA (2006) and Reason (1997): (i) two dimensions of safety indicators—personal versus process safety, and "leading versus lagging indicators"; (ii) performance indicators are not a replacement for an audit program, but is a complementary activity contributing to more frequent and supplementary information on system performance; (iii) "leading and lagging indicators" may be illustrated using Reason's accident model, in which accidents are explained as a series of failings (i.e. holes) in the layers of defenses/barriers/safeguards (the "Swiss Cheese Model"); (iv) all development of indicators is context specific; (v) there is no such thing as an universal model or method for the development of indicators and perhaps the use of several different methods will provide the best result—the most appropriate set of indicators; and (vi) complementary triangulation of methods—"incident-based approach"/"resilience-based approach" (resilience based indicators may be an aid in situations of incomplete knowledge, about what may go wrong, since the people focus on being prepared for the unexpected)/"safety performance-based approach (barrier performance)"—in which both negative events (e.g. failures, incidents, etc.) and positive factors are utilized i.e. factors that create safety in contrast to factors that threaten safety (in this way, one can avoid the so-called "controller dilemma", the problem with lack of data).

  To reach a holistic safety control within an organization, all different aspects including culture need to be considered (Knegtering & Pasman 2009). Implementing SHE culture will have positive effects on the HFE in the workplace, and the benefits of SHE culture suit the HFE primary goal (AviationKnowledge 2012).

  Awareness, communication and cooperation among responsible groups are considered as crucial factors to achieve an effective HFE program (AviationKnowledge 2012). Focusing on HFE and human behaviour, as the main contributor of the system, is a need to reach a safer situation (Shahriari 2013).

– *Internal Structure 2 (IS2)*

  HES—Health, Environment and Safety (Saksvik & Nytr 1996) or SHE—Safety, Health and Ergonomics (Munck-Ulfsfält et al. 2003); Safety, Health and Environment (Shahriari 2013, Dodsworth et al. 2007); Safety, Health and Environmental (Hassim & Hurme 2010) or HSE—Health, Safety and Environment (Asadzadeh et al. 2013).

  Specific definitions of the key elements are referenced according to DuPont (2014), Wood Group (2012), and Executive Committee of the Shell International Limited (2009).

  Consider the same key elements included in the IS1.

– *Internal Structure 3 (IS3)*

  HSEE—study on Health, Safety, Environment and Ergonomics done based on Asadzadeh et al. (2013).

  Consider the same key elements included in the IS1.

3 RESULTS

The terminologies of COHSIS adopted in this paper, and to help on its usability, were: HFE, SHE, and SHEE. The main selected organizations with mature culture in COHSIS or its individualized structures, in the temporal sequence of the reference list, were: DuPont, Wood Group, Shell International Limited, and Volvo Car Corporation.

The references assigned to definitions of the key elements cited in the section 2 exhibited a consistent configuration between these key elements included as concepts, however, without repetition of such references for the COHSIS. The same 19 concepts were implemented for HFE, SHE, SHEE, and its integrated version; resulting in a coincident configuration of 9 adopted references (in spite of 12 found) between these concepts to the 4 possible combinations of COHSIS.

The 19 concepts that were presented on the Tables 1 and 2 (three of these concepts are included in the 1st, 2nd and 4th macro procedures to be presented in the discussion) are: (i) Ergonomics-based design; (ii) Leadership commitment; (iii) Employee involvement in decision making; (iv) Risk assessment and communication; (v) Events reporting and investigation; (vi) "Job Hazard Analysis (JHA)"; (vii) Health problem management;

Table 1. Number of found references and its different definitions cited in key elements included as concepts.

COHSIS and its integrated version	(Concepts): number of found references/number of different definitions cited in key elements included as concepts
HFE	(i): 10/22; (ii): 3/4; (iii): 9/12; (iv): 6/9; (v): 6/9; (vi): 1/1; (vii): 3/5; (viii): 4/7; (ix): 8/27; (x): 5/7; (xi): 7/9; (xii): 3/3; (xiii): 3/3; (xiv): 4/7; (xv): 3/4; (xvi): 2/2; (xvii): 9/16; (xviii): 10/19; and (xix): 4/8.
SHE	(i): 6/10; (ii): 6/12; (iii): 8/19; (iv): 13/29; (v): 10/22; (vi): 7/13; (vii): 11/20; (viii): 10/21; (ix): 8/27; (x): 9/17; (xi): 3/4; (xii): 12/22; (xiii): 7/8; (xiv): 11/24; (xv): 13/31; (xvi): 12/17; (xvii): 10/17; (xviii): 15/54; and (xix): 13/38.
SHEE	(i): 13/21; (ii): 8/10; (iii): 11/16; (iv): 11/17; (v): 10/15; (vi): 1/1; (vii): 8/11; (viii): 11/17; (ix): 8/27; (x): 10/14; (xi): 6/7; (xii): 5/5; (xiii): 5/6; (xiv): 11/17; (xv): 7/8; (xvi): 8/9; (xvii): 11/17; (xviii): 13/21; and (xix): 13/21.
HFE ∪ SHE ∪ SHEE (integrated version, in which "∪" indicates union relation)	(i): 19/37; (ii): 13/20; (iii): 21/37; (iv): 22/43; (v): 21/38; (vi): 7/13; (vii): 18/30; (viii): 19/33; (ix): 8/27; (x): 16/28; (xi): 12/18; (xii): 13/24; (xiii): 12/15; (xiv): 19/36; (xv): 16/35; (xvi): 19/26; (xvii): 22/38; (xviii): 28/78; and (xix): 21/51.

Table 2. Number of found references and its different definitions cited in similar concepts between the possible combinations of COHSIS.

Possible combinations of COHSIS	(Concepts): number of found references/number of different definitions cited in similar concepts
HFE ∩ SHE ∩ SHEE = HFE ∩ SHE = HFE ∩ SHEE = SHE ∩ SHEE	(i): 4/8; (ii): 2/3; (iii): 3/5; (iv): 3/6; (v): 2/4; (vi): 1/1; (vii): 2/3; (viii): 3/6; (ix): 8/27; (x): 3/5; (xi): 1/1; (xii): 3/3; (xiii): 1/1; (xiv): 3/6; (xv): 3/4; (xvi): 1/1; (xvii): 3/6; (xviii): 4/8; and (xix): 4/8.

(viii) Safety culture; (ix) Evaluation of workplace safety with complementary approaches based on incident, resilience and safety performance ("leading and lagging indicators"); (x) Training; (xi) Task analysis; (xii) Standards (ISO); (xiii) Legislations; (xiv) Human behaviour; (xv) Emergency planning and responses; (xvi) Environmental management; (xvii) Man-machine interaction (sociotechnical approach); (xviii) Feedback and control; and (xix) Change management.

3.1 *Key elements included as the concepts for comparison between COHSIS*

The key elements extracted from the section 2 were included as the 19 concepts for comparison between COHSIS and its integrated version. The number of found references and its different definitions cited in these key elements included as concepts is presented in Table 1.

3.2 *Similar concepts between the possible combinations of COHSIS*

The same 19 similar concepts extracted from the section 3.1 were compared between the possible combinations of COHSIS. The number of found references and its different definitions cited in these similar concepts is presented in Table 2.

4 DISCUSSION AND CONCLUSION

Based on the results of this study, including key elements of COHSIS, similar concepts were identified for comparison between the possible combinations of COHSIS. These new findings enabling propose a guideline for evaluation of COHSIS allowing to create and threaten safety through the following macro procedures:

(1st): Identification of integrated concepts (e.g. originated from the integrated version of COHSIS) and its references that characterize these mature organizations in safety culture (Knegtering & Pasman 2009), excluding concepts strongly associated with the phases of evaluation of the proposed guideline. For example: Concepts included in "HFE ∪ SHE ∪ SHEE" and its references allow the exclusion of the concepts (ix), (xii) and (xiii).

(2nd): Characterization of a company at different steps of HFE, SHE and/or SHEE culture ladder (or ladders). For example: Each of the steps describes the concepts and its references (contextualized by definitions of these references) in the sections 2 and 3; excluding the concepts (ix), (xii) and (xiii). The "Hearts and Minds" educational program aiming to help the organizations to improve their HFE, SHE and/or SHEE culture and to help employees to do the right thing naturally and because they want to, and not because they

are forced to. This culture ladder is divided into 5 steps: pathological, reactive, calculative, proactive and generative; and it describes the way to reach a high reliable organization (Bergh & Sundh 2010).

(3rd): The improvement is described showing employees their current level in the "safety culture ladder" (or ladders) and, if necessary, how they can change their habits and improve their behaviour/attitudes (Shahriari 2013).

(4th): Based on the concepts (ix), (xii) and (xiii), the evaluation of workplace safety with complementary approaches should consider: incident, resilience and safety performance (i.e. "barrier performance"—established before and after the occurrence of an incident). As well as, standards (ISO) and legislations are the fundamental bibliographic bases to carry out an audit program (Øien et al. 2011a, b).

(5th): "Leading indicators" identify the failings in the risk control system during routine checks, whereas the "lagging indicators" reveal the holes in the barriers as a result of an incident (the so-called "dual-assurance" approach; in which incident does not have to cause injuries or damages, but may be a near miss or a precursor event), avoiding the problem with lack of data (Øien et al. 2011a, b, HSE & CIA 2006, Reason 1997). The indicators need to be identified as relevant for the group for which the performance is measured being possible to influence by their management, and should show responses within a convenient timeframe; motivating the necessary actions (Hale 2009). An alternative is selecting "leading indicators" based on "underlying safety models", which will help to identify emergent patterns leading to expected and unexpected outcomes (Wreathall 2009).

(6th): According to authors knowledge, there is not an universal model or method for the development of risk or safety indicators and perhaps the use of several different methods will provide the most appropriate set of indicators (Øien et al. 2011a).

A structural study was developed to identify and characterize COHSIS, and to make a comparison between these structures through a literature review.

To improve the usability, the terminologies of COHSIS adopted were HFE, SHE and SHEE; and the main selected organizations with mature culture in COHSIS were DuPont, Wood Group, Shell International Limited and Volvo Car Corporation. The same 19 similar concepts were identified in a coincident configuration of 9 adopted references (in spite of 12 found) for comparison among 4 possible combinations of COHSIS: HFE ∩ SHE ∩ SHEE, HFE ∩ SHE, HFE ∩ SHEE, and SHE ∩ SHEE.

With the intention of improving the operationalization of the proposed guideline, a strategy for assigning the identification for the references of the terminologies, fundamentals, key elements and key elements included as concepts of COHSIS should be investigated. After the definition of the most adequate methodology for developing the mentioned indicators, further work will be developed and a framework (or model) for the guideline will be proposed.

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The presence of radon in thermal spas and their occupational implications—a review

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ABSTRACT: Radon gas, produced by the decay of radium, is recognized as the most significant natural source of human exposure and the leading cause of lung cancer incidence, with the exception of tobacco. Radon can be found in various concentrations in soil, air and in different kinds of water like lakes, springs, wells and groundwater. The presence of radon in thermal and in mineral waters may result in an additional exposure to natural radiation. In fact, the European Union has identified thermal spas as one the professional activities with higher exposure to radon. Several studies have been conducted worldwide to measure the concentration of radon in water and in air of thermal spas in order to estimate the exposure doses both for workers and for users. The results of some of these studies showed that radon concentrations in indoor air of thermal spas can lead to intense exposure and consequently result in a short-term impact for users but in a long-term for workers who have longer and continuous exposure periods. The purpose of this work was to perform a review on the occupational exposure to radon in thermal spas considering the factors that may lead to an increasing exposure in occupational environments and the consequents evidences on health effects.

1 INTRODUCTION

Radon (222Rn) is a radioactive gas generated by the decay of radium (226Ra), being both members of the uranium decay chain. Radon has a half-life of 3.82 days and it decays into a series of short half-life products that are hazardous if inhaled. Human exposure to radon is mainly due to radon or more precisely its progeny, recognized as the natural source of most significant human exposure and the leading cause of lung cancer incidence, with the exception of tobacco (Alberigi et al., 2011, Yarar et al., 2006, Erdogan et al., 2013, Santos et al., 2014, Nikolopoulos et al., 2010, Vaupotic et al., 2013). People are exposed to radon as member of the public in dwellings or as workers in workplaces (Nikolov et al., 2014). Radon is also present outdoor in the open air only in lower levels due to the dilution and the continued dispersion by the wind, but is found in higher concentrations in confined spaces such as underground places and caves (Alberigi et al., 2011, Yarar et al., 2006, Vaupotic et al., 2013, Koray et al., 2013, Aykamis et al., 2013, WHO, 1986).

In 1924, the high mortality rate among miners in central Europe was suggest attributed to radon exposure (Ludewig and Lorenser, 1924 in Nikolov et al., 2014). Since the 1970's, there has been a growing evidence that radon can also represent a danger for non-mining environments (Koray et al., 2013). In 1986, radon was formalized as a cause of lung cancer with the identification by the World Health Organization as a human lung carcinogen (IARC, 1988, ICPR, 2011).

The main workplaces where worker's exposure to radon may be considered as occupational exposures are mines (independent of the mined substance), other underground workplaces such as caves and galleries (which accumulates high radon concentration), spas (using radon in care process or just the exposure through water usage), desalinization of underground brines and operations involving naturally occurring radioactive substances (NORM in the extraction of gas and oil, phosphate industry, etc.) (Nikolov et al., 2014). Thermal establishments, in particular, were identified by the European Union as one of the professional activities with higher exposure to radon.

Radon concentration in groundwater varies considerably (1 to 10 000 Bq/L) depending mostly on the uranium concentration in the surrounding rock and on the water circulation (Nikolov et al., 2014). Radon's solubility in water increases with decreasing temperatures and therefore much attention has been given to water sources due to the potential risk to the public health. Moreover, radon concentration levels in groundwater are generally higher than in surface waters (Erdogan et al., 2013).

Human exposure to 222Rn and its decay products in water supplies can occur in two ways: by ingestion (drinking water) or by inhalation (due to the release or radon into the air when using thermal waters in health purposes) (Koray et al., 2013). The risk of radon exposure is mostly associated with high radon concentrations in confined environments and the subsequent inhalation increasing the risk of damaging the organ cells, where radon short-life products are deposited.

Several studies have been conducted to determine the occupational exposure to radon in thermal spas. One of these studies carried out in the USA has showed a correlation between the exposure to radon and the incidence of thyroid cancer and a high probability between this type of exposure and the incidence of both stomach and lung cancers resulting from ingestion and inhalation, respectively (Jalili-Majareshin et al., 2012). It is estimated that radon inhalation in confined environments contributes to about 20 000 deaths per year in the USA and between 2 000 and 3 000 deaths in the United Kingdom, caused by lung cancer (Ferreira, 2009).

In recent years, some recommendations have been published with the purpose of protecting the workers and the general public against adverse health effects arising from the exposure to natural radiation. The recommendation of the European Commission (2001/928/EURATOM), in what concerns to the protection of the public against exposure to radon in drinking water, establishes that for concentrations above 1 000 Bq/L a remedial action should be made based on the radiation protection principles. However, it is assumed that mineral waters are not consumed on a regular basis and because of this no reference value has been established yet as a threshold for the concentration of radon. With regard to radon concentrations in air, the European Commission (90/143/EURATOM) recommends that the annual average concentrations do not exceed 400 Bq/m3 for the existing buildings and 200 Bq/m3 for new constructions (Nikolov et al., 2014). The Directive 96/29/EURATOM establishes the basic safety standards for the protection of workers and for the general public against the dangers arising from ionizing radiation. In this way, the effective dose limit for workers is 100 mSv over a period of five consecutive years, as long as this value does not exceed a maximum effective dose of 50 mSv in one year. The effective dose limit for members of the public is 1 mSv/y.

In Europe, the average annual effective dose from all sources of radiation in the environment is estimated in 3.3 mSv with indoor doses from radon, thoron and their short-lived progeny accounting for 1.6 mSv of this value (Koray et al., 2013).

The purpose of this work was to perform a review on the occupational exposure to radon in thermal spas considering the factors that may lead to an increasing exposure in occupational environments and the consequents evidences on health effects. Although there are several studies at international level focusing on radon concentration measurements in well waters, ground waters and thermal waters, in Portugal, the occupational exposure to radon in thermal establishments has not been approached yet.

2 METHODOLOGY

A systematic review was conducted in multiple databases with Metalib tool. The research was done using a combination of a couple of keywords: radon and occupational exposure refined with thermal spas, geology, ventilation and cancer. Thirty two articles were selected from 2001 to 2014. The methodology adopted in this work focused on a few issues: i) identify the possible sources of radon exposure; ii) correlate the geological context with the indoor radon concentration levels; iii) identify the parameters affecting radon concentration iv) disseminate the results of studies about the occupational exposure to radon in thermal spas and v) make some conclusions based on the evidence of occupational exposure to radon in thermal spas.

3 PARAMETERS AFFECTING RADON CONCENTRATION

3.1 *Geology*

Many natural rocks contain terrestrial radionuclides of the 238U and 232Th decay series and 40 K. The activity concentrations of these radionuclides are related to the types of rocks: higher radiation levels are associated with igneous rocks and lower levels with sedimentary rocks. However, there are a few exceptions, as some shale and phosphate rocks have relatively high content of radionuclides (UNSCER, 2000).

Radon is produced by radium decay in ore bodies and by recoil emanating from the solid matrix of the material into the air- or water-filled pore space, or into fractures in rocks. In underground mines radon is transported from the rocks to the galleries by diffusion and convection through water or air circulation. The importance of each one of these processes depends on the geological and tectonic fractures of the formation and the hydrologic behavior of the aquifer.

Radon concentrations vary substantially in the atmosphere of underground mines depending on the type of mine, the geological formation, the porosity, the moisture, the radon exhalation rate, which varies due to alterations in the differential air pressure (naturally or mechanically), the uranium and radium levels, the working conditions and the degree of ventilation (Santos et al., 2014).

Building materials can also be a potential source of radon emanation such as concrete, bricks, natural building stones (mostly granite), natural gypsum and industrial raw materials (such as phosphogypsum), fly ash, etc. (WHO, 1986). Granite tile is one of the most common building materials and has been used throughout thousands of years for both interior and exterior applications.

The composition of geological formations is known to critically affect the concentrations of radon in water sources near those formations, and the natural ventilation is likely to reduce radon concentrations (Tarim, et al., 2012). The faults existing in geological formations are means for the transport of liquids and during such transport radon gas escapes from rocks. The amount of radon present in rocks and soil will depend on the concentration of uranium and will be significantly affected by the occurrence of moisture or water in pores (Abo-Elmagd et al., 2010).

Radon is also transported by the groundwater flow. The concentration of 222Rn in groundwater depends largely on the concentration of 226Ra in the underlying rock: groundwater in uranium-rich crystalline rocks often has an elevated radon concentration in relation to the radon concentration of the surrounding rock. This is due to the uranium leaching from the rock with the subsequent precipitation together with its decay products (like radium) on the surface of the fractures in the rock. Radon is released into groundwater and transported farther away by groundwater flow. In this way, groundwater with a high radon concentration can then be found in natural springs with different geological environments (Knutss et al., 2002).

Several studies have been carried out correlating the occurrence of high radon concentration in thermal waters with geologic and hydrogeological factors. One of these studies was carried out in the south-eastern part of Serbia where there are several occurrences of thermal waters originating from igneous and metamorphic rocks (Koray et al., 2013). Niska Banja spa was identified as a high natural radiation area and radon concentration in water and in air were both measured in this study; water with high level of 222Rn concentration is often a good indicator of an elevated radon level in the surrounding air as radon can easily be transferred from water to air (Koray et al., 2013).

According to Koray et al. (2013) the emanation of radon from groundwater and soil is controlled by the geological formation and by the tectonic structure of the area. The migration of radon through a porous material or fractured rock occurs primarily by advective transport. The migration and concentration of radon in an anisotropic medium, such as bedrock, is highly variable and dependent upon the rock type, the physical condition of the rock (i.e. fractures, porosity), the aquifer parameters and the aquifer geochemistry (Campos et al., 2010).

Tarim et al. (2012) observed that the highest radon concentration corresponds to areas predominantly composed by granite and schist formations. High levels of radiation are associated with igneous rocks, such as granite, and lower levels with sedimentary rocks (Tarim, et al., 2012) although there are a few exceptions.

3.2 *Ventilation*

The most common indoor radon sources are natural soils and rocks under the buildings. Radon that enters in buildings may reach high concentrations in some circumstances. The construction method and the ventilation rate will influence radon levels in individual buildings. The exposure to radon will also vary according to how particular buildings and spaces are used as radon that emanates from rocks and soils tends to concentrate in enclosed spaces (WHO, 1986).

Ziane et al. (2014) carried out a study to measure the concentration of radon in workplaces of Algeria and found that a general trend of decreasing radon concentration was observed from the basement towards upper floors except for buildings where radon is due to the presence of radium in the construction materials. It was also observed that these high concentrations can be greatly reduced through ventilation devices. An important conclusion from this study was that the average radon in the winter is higher than in the other seasons because of the closed atmosphere in the buildings during the cold season. Average indoor radon concentrations are lower in summer, while the average radon concentrations in autumn and in spring are very similar (Ziane et al., 2014).

Kavasi et al. (2011) conducted a study in the old new buildings of the Turkish bath of Eger, Hungary, having checked that during the night hours, radon concentration in air was typically around 2 000 Bq/m3 (the maximum registered value was 2 720 Bq/m3) but much lower during working hours. The average value during working hours in one pool room was 631 Bq/m3 (range 297–1616 Bq/m3), while in another pool room, tangentor and dressing rooms the average values were 404 Bq/m3 (range 1390–126 Bq/m3), 143 Bq/m3 (range 171–62 Bq/m3) and 64 Bq/m3 (range 85–32 Bq/m3), respectively. A sudden decrease of radon concentration in the morning time indicated that the ventilation was switched on and an increase in the evening time indicated that it was switched off (Kavasi et al., 2011).

Nikolov et al. (2012) referred that there is a clear evidence that the annual dose of workers depends directly on indoor radon activity, however, this situation can be solved or minimized by improving the ventilation system in confined spaces (particularly around the pool tank) (Koray et al., 2013).

In Portugal, a study conducted in Caldas da Felgueira confirmed the importance of ventilation in the decrease of radon concentration in air and consequently in the reduction of dose for values below the permissible limit (Pereira et al., 2001). In the same study, radon concentration was continuously monitored in the area of the jet shower during a period of 150 minutes, with the permanent presence of a worker. Under these conditions radon concentration was very high leading to the operating of the ventilation system. After this, radon concentration decreased close to zero values (Pereira et al., 2001).

4 REFLECTIONS ON OCCUPATIONAL EXPOSURE TO RADON IN THERMAL SPAS

Several studies have been conducted in order to measure the concentration of radon in air and in water of thermal spas in Croatia, Greece, Turkey, Serbia, Spain, China, Austria, Brazil, Hungary and Algeria, estimating the radiation doses received by workers. The relevant results and conclusions extracted from some of these studies are presented below.

In Turkey, in the city of Bursa, a study was carried out to assess the concentration of radon in 27 wells (mineral water) and 19 public supplies (tap water). It was observed that only 7 of the 27 wells exceeded the safety value recommended by the USEPA for drinking water (1 000 Bq/L) (Tarim et al., 2012) and for the others 20 wells the values ranged between 0.91 and 53.64 Bq/L. As expected, the results showed that tap water had lower radon concentration than the well water. In addition, the results from this study showed a correlation between radon concentration and the geological structure of this region (Tarim et al., 2012).

In a study conducted by Erdogan (2013) in another region of Turkey, Konya, the concentration levels of radon in thermal water samples varied from 0.60 ± 0.11 to 70.34 ± 3.55 kBq/m3 in the spring and from 0.67 ± 0.03 to 36.53 ± 4.68 kBq/m3 in the summer. The calculated effective doses due to radon inhalation ranged between 0.09 and 10.13 nSv in spring and between 0.10 and 5.26 nSv in the summer, considering a radon equilibrium factor of 0.4, an indoor occupancy factor of 0.8 through an exposure period of 30 minutes during the thermal treatments and 9 nSv/h per Bq/m3 for the conversion factor (effective dose received by adults per unit of 222Rn activity per unit of air volume) (Erdogan et al., 2013, UNSCER, 2000).

In Spain, the concentration of radon was measured in 82 spas (Abo-Elmagd et al., 2010) and as there is no specific regulation for radon concentration in thermal waters the limit value of radon concentration in drinking water was considered as the reference level. In this study, it was found that this limit was exceeded in 16 thermal spas with radon concentrations above 100 Bq/L (Abo-Elmagd et al., 2010).

Also, in a few thermal hotels in China, radon concentrations measured in air were higher than the limit established by the EU (200 Bq/m3), representing a potential risk for the workers (Abbasi et al., 2013).

Although thermal spas are classified by the EU as a professional activity exposed to natural radiation, in Greece, thermal therapy is well accepted by the National Health System (Nikolopoulos et al., 2010). Nevertheless, the exposure to radon in thermal spas was studied for both users and workers in the Island of Lesvos, Greece. The doses for spa users were very low and for the workers it did not exceed the value of 5 mSv/y (Datye et al., 1997). Also, the concentrations of radon in thermal water were significantly lower than the limit value with the exception of the thermal waters from Polichnitos and Eftalou spas, where high levels of radon concentration were registered. In the thermal spa of Peak there were elevated levels of radon also during the filling of bathtubs. Considering that a bather goes through 30 treatments per year, each one with a duration of 30 minutes, the staff works 260 days per year, 8 hours per day, i.e. 2 hours in the treatment room and 6 hours of the rest room, the exposure dose was calculated both for workers and bathers. The obtained values for users were 0.15, 0.03 and 0.07 mSv/y for the spa of Eftalou, Polichnitos and Thermi, respectively. The staff doses were 4.55, 2.09 and 0.76 mSv in the thermal spas of Eftalou, Polichnitos and Thermi, respectively. Users' doses are much lower than those for the staff, however, both workers and users are exposed to higher doses than those usually received at home; the doses found in the treatment rooms and rest rooms are two to thirteen times higher than those received through indoor exposure at home (Datye et al., 1997).

Radolic et al. (2005) studied the exposure to radon in 9 spas from Croatia. Radon concentrations were measured in indoor air and pools, obtaining values in the range of 11–109 Bq/m3 (average 40.3 Bq/m3) and 0.73–18.6 kBq/m3 (average 4.5 kBq/m3) respectively. Radon concentrations in water catchments ranged between 2.02 and

93.79 kBq/m3, with an average value of 19.6 kBq/m3 (Radolic et al., 2005). Nevertheless, the highest concentration of radon (93.79 kBq/m3) was observed in the spring mainly due to its geological structure. The fact that the concentration of radon in the water was lower than the uptake may be explained mainly by two factors: i) the pool water is not daily changed accumulating radon's progeny products and ii) the natural mineral water is mixed with water from the public network, without any radon concentration or in the worst case with lower concentration levels. The dose received by workers during 1 year (2 000 hours exposure) was 0.27 mSv/y, below the threshold dose of 6 mSv/y for workplaces in Croatia (as well as below the limit for the public of 1 mSv/y for members of the public or visitors) (Radolic et al., 2005).

High levels of radon concentration in air were registered in the basement of Niska Banja spa in Serbia with an average concentration of 22.90 ± 0.57 kBq/m3. The thermal water of this spa also presented high levels of radon, and in this way it cannot be used for internal treatments. The annual effective dose that these workers are exposed at home and through water supply system would have been important to study adding some conclusions to the incremental dose in the non-occupational environment (Koray et al., 2013). Elevated radon levels in air and water have also been found in spa facilities of several hotels in Niska Banja spa town. The annual effective doses of employees working at the pools, or at therapeutic baths using thermal water, may reach up to 18 mSv (Vaupotic et al., 2013). There is an evidence that the exposure to a common user submitted to radon therapy, for example in the form of baths, is lower than the annual exposure resulting from the environmental radiation. On the other hand, the doses resulting from the inhalation treatment or thermal water consumption are considerably higher than the doses resulting from the bath treatment (Koray et al., 2013). Indoor radon concentrations are variable, but they are always higher than outdoors concentrations (Alberigi et al., 2011). Individuals spend 80% of their lifetime indoors, exposed to internal and external radiation, resulting in prolonged exposure situations (Abbasi et al., 2013 Louro et al., 2010).

Ringer et al. (2008), conducted a study to determine the occupational radiation exposure in Upper Austrian water supplies and spas, having concluded that radon exposure is directly linked to the working time within the facilities of a water supply and that high radon exposure occurs if high radon concentrations are generated in the water-treatment techniques like vaporizer, cascade, etc., and/or prolonged working times within the facilities of a water supply, as offices are usually situated within the water storage building (Ringer et al., 2008).

In the region of Araxá spa (Minas Gerais, Brazil), the committed effective dose due to 222Rn and 212Pb inhalation was evaluated for workers and users. High levels of radon were detected, especially at the emanatory collective swimming pool which presented the highest concentrations in all spa. Doses received by the spa workers are below 20 mSv/y. The radiation doses for the users are also below the average of the effective dose due to the exposure to radiation from natural sources, estimated in 2.4 mSv/y (Aykamis et al., 2013).

In Portugal, the monitoring of radon exposure is mandatory only in buildings built in granitic areas, particularly in the districts of Braga, Porto, Vila Real, Guarda, Viseu, Castelo Branco, due to the geological nature of these regions. In what concerns to Portuguese thermal establishments only one study was carried out in Caldas da Felgueira Spa. Several measurements of radon concentration were performed by Pereira et al. (2001) both in thermal water and in the air of the building. It was observed that the lowest concentrations occurred predominantly on the first floor (although exceeding 100 Bq/m3 a few times) and that the highest values occurred on the second and third floors (with values in the order of 200 values Bq/m3). This situation is opposite to what would be expected due to the dominant contribution of radon in soils beneath the first floor. One of the conclusions of this study was that the main source of radon comes from water given by a positive correlation between the volume of water used and the values of radon concentration in the air. This may be explained by the fact that depending on the therapeutic techniques used in thermal spas, up to 30% of radon content present in water may be transferred into the surrounding air. Nevertheless, the annual effective dose was estimated in 1.2 mSv and therefore does not exceed the legal limit for occupational exposure. This was mainly achieved with the efficient ventilation system present in this thermal establishment (Pereira et al., 2001).

5 EVIDENCE ON HEALTH EFFECTS

Prolonged exposure to radon can cause a negative effect on health, causing lung cancer and bronchial tissue damage (Alberigi et al., 2011, Campos et al., 2010, Oner et al., 2013, Correia„ 2010). High levels of radon can cause problems to the health of workers, and in this way, radon exposure should be monitored (Alberigi et al., 2011, Tarim et al., 2012, Radolic et al., 2005). Radon is well known as a radiation hazard being the main cause of lung cancer in underground miners. The evidence that radon exposure can result in similar effects in others environments rather than mining activities, started to be the focus of attention in the seventies. Several studies indicate that radon is the cause of about 20 000 deaths from lung cancer each year, representing about 9% of the total of deaths from cancer in the world and about 2% of cancer deaths in the European Union (Koray et al., 2013). The intake of radon through the water ingestion can give rise to an additional exposure dose to the stomach. For users and workers in spas with low ventilation conditions, an increase in chromosome aberrations has also been observed (Koray et al., 2013). Zhukovky et al. (2014) verified that the risk of radon-induced lung cancer incidence is considerably for people with the diagnosis of "chronic lung disease" or "chronic bronchitis" in medical history. Epidemiological studies have also revealed a strong correlation between lung cancer and exposure to radon (Zhukovky et al., 2014).

Radon was recognized as a human lung carcinogen in 1986 by the World Health Organization (WHO) (Santos et al., 2014). Cothern et al. (1986), estimated that approximately 1 to 7% of lung cancer fatalities in the USA are related to indoor radon levels derived from groundwater use (Cothern et al. in Campos et al., 2010).

6 CONCLUSIONS

High concentrations of radon were observed in several thermal spas (Aykamis et al., 2013, Tarim et al., 2012, Radolic et al., 2005, Bonotto et al., 2007), causing an additional increment of radiation both for users and workers (Erdogan et al., 2013, Nikolopoulos et al., 2010). Radon is considered a dangerous carcinogen, however, is deliberately used in thermal establishments as medical treatment both in children and adults. Thus, doctors, nurses and technical maintenance workers may be subjected to increased levels of radon in the performance of their duties.

Several studies have been conducted specifically in thermal spas in different countries such as Croatia, Greece, Turkey, Serbia, Spain, China, Austria, Brazil, Hungary, Algeria and Portugal, noticing that in some of these studies radon concentration exceeded the limits and/or reference values. On the other hand, some of these studies were further and calculated the dose of exposure to radon for workers, stressing that whenever the limit and/or the reference values are exceeded this implies damage to the health of workers. In Portugal there was only one published study in this context until now but limited to radon concentration measurements in air and in water.

The results of some studies showed that radon concentrations in indoor air of thermal spas can lead to an intense exposure and consequently result in a short-term impact for users but in a long-term for workers who have longer and continuous exposure periods. In this way, this additional exposure may become extremely significant to the workers group.

Finally, radon is still a big concern for public health, and by the results and conclusions of the studies carried out to evaluate radon concentration in the occupational exposure of thermal spas, these studies should be extended both to different countries and different professional sectors, with potential risk of radon generation, as Portugal.

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Contribution of BIM for hazards' prevention through design

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ABSTRACT: Construction still remains a sector with high level of occupational risks. Several research studies point out the importance of the Prevention-through-Design in the construction sector as one of the most effective means of preventing hazards. So, through the reduction of causal factors during design phase, which can affect safety at work during the execution and the use phase, the risk level can be effectively reduced. The Building Information Modeling (BIM) creates a 3D model that integrates reliable and multidisciplinary information and leads at design optimization. A literature review through more than 50 articles was performed, but only few comply with the research requirements. This paper aims to assess the BIM use in occupational risk prevention during the design phase.

The analysis points out the increasing importance of BIM to achieve safety in construction through design and the need to integrate relevant safety information in the models.

1 INTRODUCTION

Over the last years the number and rate of occupational injuries have been significantly reduced in the Construction sector. Nevertheless, construction remains a high risk industry as depicted by the number of serious and fatal accidents that occur in this sector. According to the current statistical data, the principal causes of worker fatalities still remain: falls, be struck by a falling or moving object, by a collapsing element or in overturn, be hit by a moving vehicle, and electricity (HSE 2013; ACT 2014; Eurostat 2014). Several studies regarding the causes of accidents taking place in construction sites indicate that the main causes responsible for those occurrences can arise from design until the execution phase (Haslam et al. 2005), highlighting the importance of the design phase on safety performance in later phases (Rodrigues et al., in press).

To achieve reliable results of hazards' Prevention through Design (PtD) designs have to be highly detailed, optimized and compatible each other (without conflicts). Building Information Modeling (BIM) is a modeling technology and associated set of processes to produce, communicate, and analyse building models (Eastman et al. 2011). According to ISO 29481-1:2010 is a "*Shared digital representation of physical and functional characteristics of any built object (including buildings, bridges, roads, etc.), which forms a reliable basis for decisions*". So, permits a building be represented by intelligent objects carrying detailed information about them, and also the understanding of their relationship with other objects in the building model (Eastman et al. 2011). BIM application is growing in the design and engineering fields as fundamental methodology that enables the creation of digital 3D models of buildings with embedded information about a project from design through construction and operation phase (Kamardeen 2010). These models are a digital representation of the physical and functional characteristics of a building being more than just a 3D virtual model. Really is an intelligent repository of building's objects with attributes and relationships, making it an effective vehicle for automated decision-making in all phases of a Project. The model can integrate information from different disciplines (such as value analysis, constructability, sustainability, site layout, facilities management) but, according to Kamardeen (2010) the potential of BIM for PtD is not still being fully explored. So, the aim of this paper is to show the viability and the use of BIM for PtD.

2 METHODOLOGY

Literature review from 2010 to 2014 through keywords search was made. The main keywords 'BIM', 'occupational risk', 'prevention', 'construction', 'safety at work', were used in research databases (Scopus and web of science). Articles were included if they focused on the contribution of BIM for the hazards prevention during the design phase leading to a project without or with controlled hazards. Over 50 papers were collected, but only three aim the use of BIM during the design phase to achieve safety.

3 HAZARD'S PREVENTION THROUGH BIM

The design phase, from its first moment, is the ideal moment to influence construction results.

Figure 1 show that studies conducted at the early stages of a project are more effective than those conducted later on. This is justified because the opportunity and facility to make changes is progressively reduced as the project progresses in the sense of construction phase, and the cost also increases in the same direction. Similarly according to Furst (2009) and Mroszczyk (2008) cited by Kamardeen (2010) and according to time–influence curve formulated by Szymberski (1997), the ideal opportunity to influence construction safety is during the inception, concept design and detailed design phases during which designers can influence safety through their design options (Fig. 2).

So, as BIM can produce beyond the 3D model a 4D (planning process), a 5D (costs and financial representations), a 6D (facilities management) and a 7D (sustainability) models, it is also possible to integrate elements that really enable identify hazards and consequently implement preventive or control measures and do an accurate Prevention through Design.

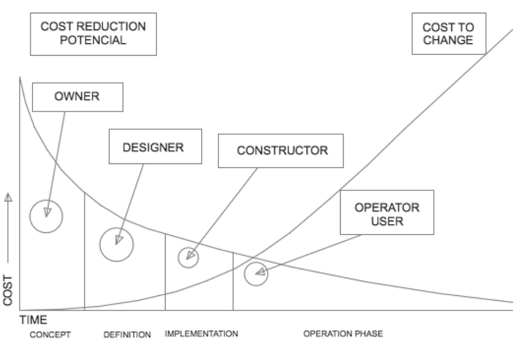

Figure 1. Stakeholders' impact on project cost (Source: ICE 1996. cited by Potts 2008: 93).

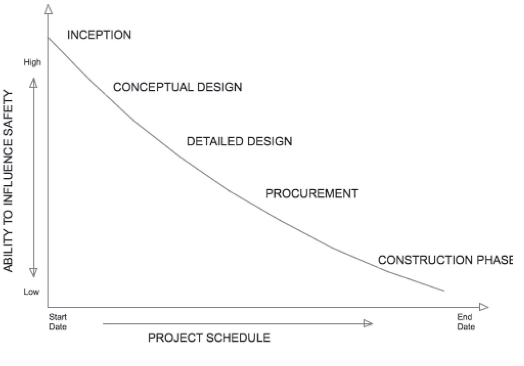

Figure 2. Project schedule vs safety influence (Source: Furst 2009 and Mroszczyk 2008 cited by Kamardeen 2010).

Kamardeen (2010) proposed a conceptual 8D modeling tool for PtD that consists on the following three steps:

- Make the hazard profiles of the 3D BIM model elements using and completing a PtD database according to three risk levels (critical, moderate and low).
- Identify high hazard elements and produce the correspondent safety solutions. This solution will generate design revisions and automatically a safety BIM model (3D model + safety).
- Generate new hazard profiles of the 3D BIM model elements and on-site control measures of hazards that could not be eliminated through design.

According to Kamardeen (2010) this conceptual model contains the methodology of safety integration during the design phase but need to be developed, create a prototype of the proposed system and do its validation.

Zhou et al. (2012) made a literature review exploring the relations between safety in construction and digital design practices. They highlight that "*digital approaches to construction safety in the design phase are less mature than those in the construction phase*" and comparing with the number of digital applications existing for safety in construction phase they realized that are few to support the design aiming construction safety. From the analysis of these digital applications to support construction safety through the different phases of a project it is underlined that BIM can be used to get information from the design phase to clarify construction safety concerns.

Zhang et al. (2013) developed an automated rule-checker for BIM based on safety checking for protections against falls. This rule-based safety checking system on BIM platform allows:

"1—*Automatically checks the model and detects holes in slabs and walls, and edges of slabs;*
2—*Install guardrail systems at floor edges/slab opening/wall openings and cover slab opening;*
3—*Take-off the quantity and type (leading to an estimate) of the protection safety system to be installed;*
4—*Provide an update schedule of when and what safety protective system needs to be installed; and*
5—*Create 4D visualization and 3D virtual environment to visualize the protective system and how to it fits in the construction schedule sequence.*"

In spite of being supported by a BIM model this tool does not implements the PtD according with hazards' identification, with risks' assessment and with the introduction of preventive measures that led to the design revision to obtain a higher safety level. It is a specific tool that from the 3D model identifies in all the constructive elements the holes that need to be protected according to safety rules (legal or technical rules). According to this identification, a model with the location and characterization of the safety systems is produced. This model will provide elements to obtain a 4D model that gives the planning process (sequence of construction and safety systems installation) and also elements to take-off the safety equipments' quantities and the respective budget (that can lead to a 5D model).

4 CONCLUSIONS

According to several research works published in the scope of construction safety management, integrating building information modeling, it is clear that safety issues strongly benefit with BIM methodologies. The intelligent BIM models and the virtual reality generation of construction sites, have great potential to achieve accurate risks assessment, to define and plan the consequent safety measures, to specify the workers' safety training, and to facilitate all safety management matters.

Although the existence of several research works that use BIM for safety in the construction site there are few about safety integration during the design phase taking advantage from the potentialities' of 3D and 4D models. It is essential that designers and safety supervisors include all the safety information in the BIM model and learn how this model must be developed to permit to do an integrated and accurate safety management since the first moment of the design phase. This process will benefit from the potentialities of BIM models especially from the virtual visualization of the models, and from the compatibility checker of the different designs (architecture, structures, Mechanical, Electrical, and Plumbing (MEP) systems). Also temporary structures designs can be integrated in the model being very important elements for hazards prevention during the design and the construction phase. So, more research and developments on this subject are required.

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Production targets consistent with ergonomic factors of forestry activities

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ABSTRACT: The objective was to determine production targets for forestry activities (alignment and marking, semi-mechanized tillage, planting and felling trees), taking into account the ergonomic factors related to the activities, in order to prevent damage to workers' health. Ergonomic factors were evaluated using the validated methodology for ergonomic analysis in scientific circles. Work organization was assessed according to the methodology of systems analysis and studies of times. The results indicated that the WBGT index, the total level of vibration, noise, cardiovascular load and the repeatability factors were higher than the recommended limits for a workday. All factors required breaks for recovery and rest. Only the activity of semi-mechanized tillage had its production target reduced, in other activities the target can be increased by rearranging the workday.

1 INTRODUCTION

Manual activities of forest implementation require strong physical exertion at work and are not always organized and implemented so that the works are adapted to the physical and mental conditions of human beings. Exposure to dust, sun, rain and moving heavy loads are all factors that can harm the health of workers during forestry activities (Souza et al., 2012).

One of the problems related to the work organization in the forest sector is the definition of efficient production targets consistent with the ergonomic factors associated with the work and the workers, such as: thermal environment of the workplace, exposure to noise and vibration, physical load required and repetitive use of the upper limbs. The production targets, historically, has always been determined by motion and time studies, and measures of production (Stanton et al., 2004). However, the definition of production targets humanly sustainable must also be taken into account human factors and those affecting its limitations.

The aim of this study was to analyze the ergonomic factors involved in forestry activities and determine production levels efficient and compatible with the maintenance of health and safety conditions of work.

2 MATERIALS AND METHODS

2.1 *Research site and sampling*

This study was conducted in Eucalyptus spp. forests, belonged to a forestry company located in Guanhães (42°58'W and 18°38'S), in the state of Minas Gerais, Brazil. The land where the activities of forest implementation were performed had above average 15° slope, with irregular surface. The sampled population corresponded to four teams of six workers who performed forestry activities, totaling 24 employees. All workers had more than one year of experience in the activity. The activities contemplated in this study were alignment and marking, the semi-mechanized tillage, planting seedlings with hydrogel application and harvesting of trees with chainsaws. These activities were carried out by groups of workers who did not engage in rotation tasks, ie, each group only performed the same task every day.

2.2 *Ergonomic evaluation*

2.2.1 *Thermal environment*

The thermometer WBGT Index (Wet Bulb Globe Thermometer) was used to evaluate the thermal conditions in the workplace. It was installed in the environment in which the task was performed. Data were collected between the months of September and October, 2012. After stabilizing the equipment for 25 minutes WBGT data were recorded every 5 minutes and obtained an average value for each hour of the working day. The evaluation methodology and the limits of tolerance to heat exposure considered for determination of break times needed were regulated by the Brazilian legislation NR-15, Appendix 3.

2.2.2 *Noise exposure*

Workers involved in the activity of semi-mechanized tillage were exposed to continuous or intermittent noise. Measurements were performed with dosimeters brand 0.1 dB, Wed007 model, operating in compensation "A" and slow response circuit. Readings were made near the ear of the worker. The reference criteria that supports daily exposure limits adopted for continuous noise corresponds to a dose of 100% for 8 hours exposure to a level of 85 dB (A), according NR-15, Appendix 1.

2.2.3 *Vibration exposure*

Workers involved in the activity of semi-mechanized tillage were exposed to hands and arms vibration. For vibration analysis the MAESTRO instrument manufactured by 01dB coupled to a triaxial accelerometer was fixed at the point where energy was transmitted to the hands. This instrument provides the values of the magnitude of acceleration in ms-2 in the weighted frequencies from 6.3 to 1250 Hz. Digging holes machines brand Stihl BT 121 model were evaluated using the Directive 2002/44/EC the European Community (EUROPEAN PARLIAMENT AND OF THE COUNCIL, 2002). The values set by the Directive for hand and arm are: 2.5 m s^{-2} to alert level and 5.0 m s^{-2} to threshold level.

2.2.4 *Physical workload*

The analysis of cardiovascular load with heart rate measurement establishes the maximum time within the workday that the employee may be exposed to the observed frequency. The cardiovascular load and rest periods were determined for each activity according to methodology developed by APUD (1989). The physical workload was evaluated in workers throughout their work shift using the heart rate monitor Garmin Forerunner 305 model. The cardiovascular load and resting pauses were determined utilizing the Equations 1, 2, and 3 below:

$$CCV = ((FCT - FCR) \times 100)/(FCM - FCR) \quad (1)$$

$$FCL = 0.40 \times (FCM - FCR) + FCR \quad (2)$$

$$Tr = (Ht \times (FCT - FCL))/(FCT - FCR) \quad (3)$$

where: CCV = Cardiovascular Load, %; FCT = Working Heart Rate (bpm); FCR = Resting Heart Rate, bpm; FCM = Maximum Heart Rate (220—age), bpm; FCL = Heart Rate Limit, bpm; Tr = Time of Resting Pauses, min and Ht = Duration of the work shift, min.

2.2.5 *Repetitiveness*

The Repetitiveness factor was analyzed according to the methodology developed by Couto (2006). The time for fatigue compensation pauses was determined based on the analysis of the following factors: number of repetitive movements accomplished in a work shift; task diversity; existence of very short breaks; and work cycle time. These factors were obtained by detailed task analysis utilizing video recorded from the operation. The analysis was done through videos obtained during the data collection.

2.3 *Motion and time study*

The motion and time study was conducted with the objective of understanding the organization of work and identifying the steps in each silviculture activity analyzed. Workers were followed from the moment they arrive to the workplace until the end of the workday. The analysis of time spent in each stage of the activity was performed by the method of continuous time (Barnes, 2001) using a digital stopwatch. Data were recorded in a standard spreadsheet and processed later. The steps of working were: Effective Work (TE)—time in which the worker remains effectively performing its activity; Ergonomic Regular Breaks (ERB)—breaks prescribed by the company; Low Ergonomic Requirement activities (LERA)—activities that are part of the cycle, such as dislocations, supply and maintenance tool; Time Not Worked (TNW): time elapsed between the end of the prescribed activities and the end of the workday.

2.4 *Productivity and production targets*

The actual worker productivity was obtained by the ratio between the average production and average effective work time of the workers evaluated. The production targets of each activity was determined according to the product of the actual productivity of workers and the proportion between the new effective working time recommended taking into account the requirements of breaks related to ergonomic factors and the effective working time found.

3 RESULTS AND DISCUSSION

To determine the production target the factors mentioned above were analyzed separately and then we identified which required a longer break. This time was considered in the determination of the new effective work time and to recommend the production target for each activity.

3.1 *Ergonomic evaluation*

In the semi-mechanized operation moving the Earth Auger from pit to pit, 99% of workers presented risk of injury to the elbow joint and the L_5-S_1 spinal disc and 89% of workers presented risk of injury to the knees. In all body joints evaluated the recommended load limit was exceeded.

3.1.1 *Thermal environment*

The highest WBGT average for the interval of 60 minutes during the workday, was 28.8°. The weighted WBGT, which was done by considering the resting place with equal 25.0° WBGT is 27.8°. Whereas the activities analyzed as moderate (rate of metabolism = 300 kcal h-1) and the rate of metabolism of the rest period equal to 100 kcal h-1, the weighted metabolic rate for an hour is equal to 250 kcal h-1. In this case the maximum WBGT allowed by the NR-15 is 28.5°.

As the weighted WBGT not exceeded the maximum it can be stated that the system breaks of 15 minutes for every hour worked is adequate and there is no need for additional rest times due to this factor.

3.1.2 *Noise exposure*

The equivalent level (Leq) of noise found for the evaluated chainsaws was 94 dB (A). The digging hole machines presented Leq = 98 dB(A). As proposed in the methodology of TOR-TOM Couto (2006), the percentage of aimed pauses for recovery due to noise exposure is 5% of the workday. Furthermore, the use of hearing protection should be required to perform the function.

3.1.3 *Vibration exposure*

The equivalent vibration level of the evaluated chainsaws was 5.8 $m \cdot s^{-2}$, while digging hole machines presented equivalent vibration level equal to 7.92 $m \cdot s^{-2}$. The pauses recommended for the workers recovery from exposure to vibration should be equivalent to 25.6% of the working day for chainsaw operators and 60% of the journey to the digging hole machines operators.

3.1.4 *Physical workload*

The assessment of heart rate of workers indicated that the rest time needed due to this factor was equal to 114 minutes, which corresponds to 23.75% of the workday. This value corresponds to the highest cardiovascular load found, which was 53%, for a 33 years old worker, with heart rate at rest equal to 75 bpm and during work equal to 134 bpm.

3.1.5 *Repetitiveness*

In the alignment and marking activity the rest time due to this factor was 30.5% of the working day, in the semi-mechanized tillage activity, this time was 47.0% of the journey, in the planting activity the rest time was 20% of journey and in the harvesting with chainsaw, 25% of the journey.

3.2 *Motion and time study*

The motion and time analysis in the forestry work provided the following average values according to Table 1. According to this work organization, in alignment and marking activity, each employee was able to perform, on average, 1200 marks by day. In semi-mechanized tillage activity, each worker performed 800 holes per day. In planting activity each worker was able to plant and irrigate 594 seedlings per day. In harvesting with chainsaw activity, each worker was able to cut down 132 trees a day. As the volume considered was 0,25 m^3 per tree, worker productivity was 33 m^3 per workday.

3.3 *Production targets*

Compliance with the recommended limits of exposure throughout the working day and the percentage of recovery pauses required for the activities studied for each ergonomic factors analyzed are presented in Table 2. The recommended effective work time, the recommended rest time, the worker productivity and the targets production recommended for each activity are presented in Table 3.

Table 1. Time of each step of working day of forest activities, in minutes and percentage the journey.

	Alignment and marking		Semi-mechanized tillage		Planting		Harvesting with chainsaw	
Activity	Time (min)	(%)	Time (min)	(%)	Time (min)	(%)	Time (min)	(%)
Effective work time	231.7	48.3	228.8	47.7	194.4	40.5	292.0	60.8
Ergonomic breaks	33.3	6.9	52.9	11.0	0.0	0.0	59.0	12.3
Low Ergonomic Requirement Activities (LERA):	182	3.8	8.6	1.8	88.5	18.5	129.0	26.9
Time Not Worked (TNW)	196.8	41.0	189.7	39.5	197.1	41.1	0.0	0.0
Total	480.0	100.0	480.0	100.0	480.0	100.0	480.0	100.0

Table 2. Compliance with the ergonomic factors and percentage of breaks required by each one.

Activity	Alignment and marking		Semi-mechanized tillage		Planting		Harvesting with chainsaw	
Ergonomic factor	Compliance	% of breaks	Compliance	% of breaks	Compliance	% of breaks	Compliance	% of breaks
Thermal environment	No	25.00	No	25.00	No	50.00	No	25.00%
Noise	–	–	No	5.00	–	–	No	5.00%
Vibration (Directive 2002/44/EC)	–	–	No	60.00	–	–	No	25.63%
PW	No	10.00	No	20.60	No	13.50	No	23.75%
Rep	No	30.50	No	47.00	No	20.00	No	20.00%
Critical factor	Rep	30.50	Vb	60.00	TE	50.00	Vb	25.63%

PW: Physical workload; Rep: Repetitiveness; Vb: Vibration; TE: Thermal environment.

Table 3. Recommended Rest Time (RRT. %); Recommended Effective Work Time (REWT. min); Average productivity of workers (Pt); and Recommended Production Target (RPT) to forestry activities.

Activity	RRT (%)	REWT (min)	Pt	RPT
Alignment and marking	30.50	334	5.1 marks/min	1725 marks/day
Semi-mechanized tillage	60.00	192	3.5 holes/min	671 holes/day
Planting	50.00	240	3.0 seedlings/min	731 seedlings/day
Harvesting with chainsaw	25.63	357	0.11 m^3/min	40 m^3

4 CONCLUSIONS

None of the analyzed factors were in accordance with the ergonomic parameters adopted, requiring inclusion of recovery breaks during the workday.

Only in the semi-mechanized tillage activity, the production target had to be reduced compared to what was practiced during the study period, due to the high level of vibration of the machines used. The use of new and well maintained machinery could expose workers to lower vibration levels, allowing more effective work time and increasing the productivity. In other activities, increasing daily production could be achieved by reorganizing work and distributing the working time with the inclusion of breaks and using all available time of the journey.

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Proposed improvements for work performance and comfort in the perspective of Cognitive Ergonomics: A case study in the release sector of maintenance orders

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ABSTRACT: Improvements based on knowledge of cognitive ergonomics are quite efficient when you want to optimize comfort and performance at work. Knowing that, this article is designed with the objective of proposing changes in the release of maintenance orders in a sugarcane mill sector in order to reduce the cognitive efforts and complaints from employees. Methodologically, a structured questionnaire, spontaneous conversations and verbalization, and in situ observations, in order to find opportunities for improvement, were used. The results show that this sector has many problems, mainly related to poor work organization and workplace's layout. To solve these problems, ten improvements are proposed that can contribute to the reduction of cognitive effort, complaints and resignations.

1 INTRODUCTION

As a consequence of globalization and the rapid expansion of technology, highlights the equivalence in terms of technical capacity among firms and the search for lower costs and higher production efficiency. This situation caused the worsening of business competition added to the growing demands of consumers by imposing the imminence of new management models that prioritize the incessant search for competitive advantage for firms.

In this context, to optimize the work and eliminate waste, organizations are bothering to offer your employees a healthy environment with activities adapted to their physical and psychological limitations. To improve the work in this perspective, companies are performing based on knowledge from Cognitive Ergonomics (CE) studies. Thus, we seek to reduce cognitive efforts that labor activity requires, minimizing the mental fatigue factor.

To Ismália and Samuel (2014) the CE is concerned with mental processes such as perception, memory, reasoning, and motor response, and how all these variables affect interactions among humans and other elements that constitute the system. To Karwowisk (2000) and Saldanha (2004) cognition is linked to human functioning in terms of information processing, decision making, perception, memory, attention, feedback and response processes.

According to Hollnagel (2012) cognitive systems engineering was first proposed in 1980 The cognitive system was defined as an adaptive system, which works by using the knowledge of itself and the environment it is in, both for planning, as for the modification and completion of actions (Hollnagel and Woods, 1983).

Currently, the focus of the CE has been the performance of individual users, in understanding their cognitive abilities, needs and preferences to interact with machines and computers (Dittmar and Forbrig, 2013). To Vidal (1999) the CE considers the capabilities and limits, both physiological and cognitive nature of human beings and, in this way can often explain the genesis of errors and incidents attributed to human error.

When it comes to maintenance, Kim *et al.* (2009) summarizes the errors into four types:

- By failure in planning, even existing work procedures;

– By failure in planning, with no work procedures;
– Human errors due to failure during the execution of planned actions;
– Violation of rules and mismanagement of unplanned events.

From the explicit representations and the identification of relevant elements of the work situation, it is possible to structure more effective and efficient computerized systems, since from them systems that provide the user with clear cues can be designed indicating the most appropriate possibilities for action.

In this sense, the objective of this work is to use the knowledge of the CE to propose improvements to the workplace responsible for the release of orders for corrective and preventive maintenance (SOS), which is located in the garage of processing plant sugar cane, in order to minimize cognitive efforts and improve employee performance.

2 METHODOLOGY

This work is qualitative, and it is a case study. Initially, a survey was conducted in the literature for academic papers on the subject CE. Research sources were the Emerald Insight, Springer Link, Science Direct, Scopus and the Group of Ergonomics and New Technology (GENTE). The keywords and their crosses in databases to find references were used. Articles and theses found were chosen for their alignment with the topic. Reviewed the title, then the abstract, and finally, the content of articles and theses to see which would give better information base for this article.

Then a pre-structured questionnaire was developed, and through conversation, spontaneous verbalizations and on-site observations, we sought possible improvement opportunities for the sector under study.

The questionnaire contains seven closed questions and one open. The questionnaire was designed to detect the salient points in the study of the EC, which according to Vidal (1999) are the stress level of employees, cognitive ability, level of motivation, level of competence and the influence of shifts. All these points shown by Vidal (1999) were raised through the seven closed questions. On the other hand an open question aims to get advice through spontaneous verbalization of employees, on the grounds that cause them to wear at work. The questionnaire was applied individually to the three collaborators of the sector during the working hours in an air conditioned room, away from the noise and work place, and with the consent of the supervisors.

There were twenty systematic in situ observations to observe the structure of the task performed, including six in the morning shift (8:00 to 16:00), seven in the afternoon (16:00 to 12:00 hours) and seven in the evening (0:00 to 8:00). What was observed was previously established. It was observed the way that occurred the communication in the workplace, decisions made by employees, use of equipment and devices industry, tensions and difficulties encountered in performing the work, and the feedback process of the work. Through in situ monitoring of employees in their respective work shifts, we attempted to detect the existence of variables that caused dissatisfaction, stress and discomfort. The recordings were made by a group of six people divided into two groups of three people. Informations were recorded through photos, videos and notes that were subsequently analyzed by the group of six people.

The study was conducted during the period January 8 to March 22 in 2014, which encompasses the period of idealization (25 days), understanding of the functioning of the sector (20 days) and formulation of proposed improvements (28 days). The plant is located in the state of Pernambuco, Brazil. It has a vehicle fleet 755 machines, working in 34 000 hectares.

In the SOS sector, there are three individuals working in alternating times in order to maintain the operating sector. The importance of the sector during the harvest is so great that when employees need time to use the toilet, they have to ask for support from another sector to cover them, even if it takes at most 10 minutes of their journey. The three employees are supervised by a supervisor on the night shift and by another one on the morning shift, which quite often charge higher interest and efficiency of the sector.

The job of SOS consists of a bureau, a chair, a computer, two radios, a printer, field maps, warnings and the container. Radios, the computer and the printer are connected continuously, as they are sources of information for employees. One of these radios provides information of machines in the field that are in need of some mechanical intervention in order to operate. The second radio has the function of internal communication with the garage, as well as serving to make requisition of material with other sectors, ask questions and learn about equipment entering and exiting the garage.

On the computer that information is entered with the help of a software, and then print work orders generated by the information provided in the software, which are delivered to the mechanics with their respective paths and orders to repair machines.

Figure 1 shows one of the research participants in their workplace.

For the opening of the work order are requested some information, such as: the machine fleet

Figure 1. Sector SOS.

number, hour meter/odometer, registration of the operator/driver, the equipment's location with a reference point, prognosis, those requesting the order and opening the machine status (working or stopped). The order is delivered to a mechanic who performs maintenance. When completed maintenance, work order is returned to the SOS sector to lower the service.

3 RESULTS AND DISCUSSION

The female operators were named as F1 and F2, while M1 is the male operator. M1 is working in the industry for three months, and F1 and F2 are working for 8 months to 14 months.

The first question aims at the detection of stress in employees. Table 1 shows the responses submitted and the percentage of symptoms appearance.

The F1 and F2 operators had lower amounts of symptoms, probably because they had already worked on similar activities in other sectors. The operator F1 works in part of the night shift, something that justifies the difference of their answers, when compared to the responses of F2. M1 has a higher number of symptoms, something justified by their short time in the role, work shift (from 0 hours to 8 hours), lack of logistical support and information.

Days off were another issue addressed in the research. To receive a day off, two employees have to work 12 hours straight, sometimes even changing shift to cover that day resting. When asked if this change of schedule was an aggravating factor for the symptoms presented, the answer was affirmative and unanimous. The fatigue was so significant that generated these periods, especially near the end of the work shift, criticism increased.

The third issue is related to leisure time of individuals, asking if any of them had any social life during the day off. In this case the answer was not to all. When asked the whys, all said that fatigue was so great that the day off in the week was used to rest, and when some rare recreational program were done, the time still short.

Table 1. Responses to the question regarding which deals the stress symptoms.

Stress symptoms	Operator F1	F2	M1	Percentage (%)
Excessive tiredness	X	X	X	100.00
Tingling	X		X	66.66
Headache	X		X	66.66
Lack of memory			X	33.33
Excessive irritability		X		33.33
Inattention	X		X	66.66

Table 2. Data relating to training to operate equipment/tools of the job.

Training	Operator F1	F2	M1	Percentage (%)
Operate the radio				0.00
Field		X		33.33
Software used	X	X	X	100.00
Computer				0.00
Mechanics			X	33.33

Questions 5 and 6 of the questionnaire had the purpose of seeking mechanisms used by the company to increase the level of satisfaction of respondents. F1 said to have received no increase or promotion office. F2 claimed to have received a pay increase. M1 already said that when she came to work in S.O.S. improved its ranking in the work papers, but hears no salary increase.

The seventh question was to assess the character of training offered by the company to help them to do the job efficiently, with the competency required by his superiors. Table 2 shows the responses presented.

The training which occurred, for some it was made so dysfunctional by a tutor (oldest employee), who also had learned the same way with another employee. Thus, if the tutor learned something wrong, wrong passes this knowledge forward. Thus, there is no fixed and standardized teaching method. For situations that do not listen to training, proper use of tools was learned empirically observable that the M1 operator, still has difficulties to the use and handling of these, even with three months of activities in the sector.

Finally the last questions are subjective, where the goal was to hear all the reasons to wear at work. All told at this point that the disrespect of other employees was frequent, so little time to perform all activities requested was a stress factor, the charges were excessive, even higher knowing that there were limitations in the workplace. These factors negatively influenced during periods of rest and play. When asked if the two connected radios constantly were a factor to make the work more exhausting, all said they were accustomed. However, during the observations, all passed by moments of anger when they were using one radio and were required in the other one at the same time, not to mention that the noise generated by the two radios is high, making it impossible to dismiss them as a source of psychological stress.

4 CONCLUSION

It was evident that the job does not present basic conditions to minimize the cognitive load during the workday. In addition to negatively influence the work, factors such as stress extend beyond working hours, affecting the rest until in day off moments. Thus, changes are necessary for the work to be less painful in a cognitive point of view. Thus, based on the results obtained, some changes were suggested in the S.O.S. sector:

- Take the M1 operator in the evening and put it to work in the morning with the supervisor supporting this;
- Place a new supervisor in the night shift to support the industry during the night;
- Provide skills training to all employees of SOS, for proper use of the devices work and to show how to proceed in the face of variability that can occur in the workplace;
- Place field maps in A0 format in the room to serve as a consulting services;
- Arrange an easier way mechanical catalogs;
- Opening a specific radio channel for the sector, so that no relevant information from other industry do not interfere negatively in the workplace;
- Remove one of the radios, so that the employee receives a piece of information at one time;
- Train supervisors to make them aware, so that the collection, are proportionate the working conditions offered;
- Hire three more employees in order to have two employees during the work shift and so it is not necessary to request to another sector for short breaks; and
- Implement a program of awards and salary enhancements to improve motivation levels;

Suggestions for number 1, 4, 5 and 6 were implanted immediately. Suggestions for number 2, 3, 8, 9 and 10, were well regarded by company managers and should be fully implemented in two months. To implement the suggestion 7, managers will conduct experiences to verify if a single radio per employee meets the demand of requests for maintenance services.

The suggestions were chosen to minimize the cognitive effort, stress and demotivation. Certainly, each of the suggestions will contribute to improvements in employees performance and productivity in the SOS sector, something that will reflect positively in employees work and health. In addition, the company will show that valorize their human capital, and the sector as a whole, as this is critical to the properly mill function in the currently sector that has high level of absenteeism and turnover. Unfortunately the number of collaborators in the sector is small, which is a limitation of this study because makes unfeasible the statistical analysis of data collected.

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A method for accident analysis oriented to the identification of areas of intervention for public safety policies

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ABSTRACT: Analysis of accident reports has been a useful tool in occupational safety research. Important variables related to main circumstances of accidents are being gathered in Europe according to European Statistics on Accidents at Work framework (ESAW). This paper present a method for the identification of possible public safety programs based on the application of Multiple Correspondence Analyses (MCA) and the introduction of the concepts of task and accident mechanism. The method is presented using the accidents notified in the manufacturing sector of Andalusia. This method can help policy makers in the identification of areas of public intervention.

1 INTRODUCTION

1.1 *Accident analysis*

Analysis of accident reports have been a useful tool in occupational safety research (Khanzode et al., 2012). Governments have also understood the importance of the quality of accident reports data. At the end of the last century, a serious improvement took place in Europe with the development of the project denominated European Statistics on Accidents at Work (ESAW hereinafter), launched in 1990. The main purpose of ESAW is to harmonize data on accidents at work and also to incorporate meaningful variables of the accident scenarios.

Regulation (EC) No 1338/2008 of the European Parliament and of the Council of 16 December 2008 on Community statistics on public health and health and safety at work sets out obligations to supply statistics on accidents at work to the European Commission according to the third phase of ESAW (ESAW-III). With the third phase of ESAW (European Commission, 2012), the harmonized and common microdata set to be provided on accidents at work cover new characteristics of the accident, including the sequence of event characterizing the causes and circumstances of the accident.

Analysis of the ESAW microdata need to be done with a clear differentiation between the circumstances related to risk exposure and the circumstances related to the accident occurrence (Hale et al., 2007). All circumstances coded according to ESAW are sequentially linked as a flow of events, but some are related to the exposure, such as working process or physical activity, and others capture the accident itself such as deviation and mode of contact.

In the last decades, most researchers have used statistical analysis to discover the relationships between circumstances and accident occurrence. Accident circumstances are usually structured as a flow of events (Rajala & Väyrynen, 2010) and then analyzed with contingency tables. Also, exploratory techniques (Chi & Chen, 2003) and clustering tools (Palamara et al., 2011) have been used to identify sequences of events and their prevalence. Finally, correspondence methods have been applied to explore relationships among certain variables, as between deviations and type of injury of the accidents (Conte et al., 2011).

All these methods are useful for identifying relationships between the variables of accident circumstances; nevertheless, from the perspective of prevention and risk assessment, the key factor is to analyze the relationships between the categories of these variables and not just the between-variable relations (Silva & Jacinto, 2012).

An important issue is that accidents need to be analyzed considering their different etiology. A group of accidents from the same scenario share a common internal structure in terms of the exposure and circumstances leading to the accident occurrence. In Europe, as harmonized variables and classifications of the circumstances of accidents at work establishing the situation and conditions prevailing at the time of the accident are coded using ESAW, the identification of the accident scenarios of accident reports should be done using the taxonomy of ESAW.

The purpose of this paper is to present a method for analysis of accident databases coded according to ESAW that considers the implicit conceptual relationship between exposure variables and accident variables in order to identify main areas of public policies intervention. This method is presented using a dataset of the accidents reported in the manufacturing sector of Andalusia in a ten years period.

2 MATERIALS AND METHOD

2.1 *Data*

In order to present the method, we have gathered all accidents with at least one day of absence in the manufacturing sector of Andalusia, from 2003 to 2012.

The manufacturing sector is defined as using NACE economic classification according to Eurostat. Manufacturing is the sector with the highest number of annual days of absence because of accidents in Europe (European Commission, 2012). In order to limit the analysis to accidents occurring in industrial sites we used the ESAW variable *Working environment*.

To show the importance of the manufacturing sector accidents, for accidents with more than three days of absence in the European Union and Norway in 2007, the latest incidence rate of the manufacturing sector published by Eurostat is 3,097 accidents per 100,000 workers.

It is important to add that Andalusia is one of the biggest regions of Europe, and represents approximately 12% of the Spanish manufacturing sector and employs on average more than 200,000 workers.

In Spain, accident reports are electronically collected in "Official Workplace Incident Notification Forms". All accidents that result in an absence from work of one or more days must be notified. Medical criteria are applied by the physicians of the Mutual Insurance System for Occupational Injuries and Illnesses to classify the accident as slight or severe, depending on the injuries and the expected period of recovery.

For each accident, variables related to main circumstances are gathered according to ESAW: *Working process, Specific physical activity, Deviation and Mode of injury.*

2.2 *Implicit structure of the accident circumstances*

Another important issue is that in-depth analyses of the circumstances of accidents should only be carried out for accidents classified as fitting the same scenario (Hale et al, 2007). The accident scenario is identified by the combination of accident circumstances.

According to the findings of previous researchers, and regarding ESAW variables meaningful concepts underlie the structure of accident reports (Carrillo-Castrillo et al., 2014). In particular, two main concepts are directly linked with flow of events that lead to the accident: *Task* and *Accident Mechanism*.

The *Task* is what the worker was doing. This concept can be used to identify the risk exposure. Tasks are identified through the ESAW variables *Working Process* and *Physical Activity*.

According to ESAW, *Working Process* is the "main type of work or task (general activity) being performed by the victim at the time of the accident" and *Physical Activity* is "the victim's exact specific physical activity at the instant of the accident".

The *Accident Mechanism* is what happened leading from normal work to the accident occurrence. The accident mechanism is used to identify each central event of bow-ties and it is defined by the combination of the ESAW variables *Deviation* and a *Mode of Injury* (Hale et al., 2007). According to ESAW, *Deviation* is "the event that triggers the accident" and *Mode of Injury* is "the contact that injured the victim".

2.3 *Method*

The relationships between the variables and their categories in ESAW can be identified using Multiple Correspondence Analysis (MCA hereinafter). MCA analysis, as an exploratory technique, provides an intuitive representation of how certain categories are close enough to intuit an association (Conte et al., 2011). MCA is also a useful method for presentation purposes because the plots are very intuitive (Pérez-Alonso et al., 2012).

MCA is a multivariate statistical technique. Conceptually similar to principal component analysis, but applies to categorical rather than continuous data. In a similar manner to principal component analysis, it provides a means of displaying or summarizing a set of data in two-dimensional graphical form. The nearest two modalities are in the plot, the stronger is the evidence of the relationship between them. It must be considered that in the center of the correspondence plot very little can be said, as it represents the average of profiles.

For the possible associations identified, it is possible to assess after if the association is significant, for instance using Phi coefficient (Chi et al., 2004).

3 RESULTS

3.1 *Correspondence analysis for task and accident mechanism*

The most prevalent *Task* are presented in Table 1 and the most prevalent *Accident mechanism* are presented in Table 2.

In Figure 1 there is a representation of the categories with reduction to two-dimension after correspondence analysis. When two or more categories are close enough, an area of intervention can be identified. In terms of accident prevention that association identifies an accident scenario. Main associations according to Figure 1 are the following generic accident scenarios:

- Scenario A—Tasks of "*Movements*" (T3) are associated with accident mechanisms with "*Loss of control*" that lead to being "*Struck by*" (M3) and also accident mechanisms with "*Body movements*" that lead to an "*Impact with/or fall*" (M8).
- Scenario B—"Manual handling" (T1) and "Manual transport" (T4) are associated with "Body movement under/with physical stress" that lead to "Physical or mental stress (includes stress on the musculoskeletal system)" (M1).
- Scenario C—Tasks such as "*Operating machines*" (T2) and "*Working with tools*" (T5) are associated with accidents mechanisms of "*Loss of control*" that leads to "*Contact with hazardous elements*" (M2).

4 DISCUSSION AND CONCLUSIONS

Using as example the first of the areas identified (Scenario A), where tasks related to "*Movements*" are associated with accidents with "*Loss of control*" that lead to being "*Struck by*" and accidents with "*Body movements*" that lead to an "*Impact with/falls*" suggest interventions that are focussed in reducing losses of control and falls. To complete this initial identification, analysis of the relationships between these accident mechanisms and their more usual causes can provide a better insight in possible designs of the programs (Carrillo-Castrillo et al., 2013).

Therefore the combination of this method and the results of the analysis of the most prevalent

Table 1. Most prevalent *task*.

(ESAW code) *Working Process*	(ESAW code) *Specific Physical Activity*	*Task*	Nº cases
(10) Production, manuf., processing, storing	(40) Handling of objects (manually)	T1	41,527
	(20) Working with hand-held tools	T2	19,801
	(60) Movement (walking, getting in/out, jumping, etc.)	T3	18,665
	(50) Carrying by hand, transporting	T4	14,170
	(10) Operating machine	T5	14,119

Table 2. Most prevalent *accident mechanism* (within the five tasks identified in Table 1).

(ESAW code) *Deviation*	(ESAW code) *Contact-Mode of Injury*	*Accident mechanism*	Nº cases
(70) Body movement under/with physical stress	(70) Physical or mental stress (includes stress on the musculoskeletal system)	M1	14,271
(40) Loss of control (total or partial)	(50) Contact with sharp, pointed, rough, coarse Material Agent	M2	7,543
(40) Loss of control (total or partial)	(40) Struck by object in motion, collision with	M3	6,160
(50) Slipping—Stumbling and falling —Fall of persons	(30) Impact with or against a stationary object (the victim is in motion; resulting from a fall)	M4	5,824
(60) Body movement without any physical stress	(70) Physical or mental stress (includes stress on the musculoskeletal system)	M5	5,448
(30) Breakage, bursting, splitting, (…) of Material Agent	(40) Struck by object in motion, collision with	M6	4,542
(60) Body movement without any physical stress	(50) Contact with sharp, pointed, rough, coarse Material Agent	M7	4,185
(60) Body movement without any physical stress	(30) Impact with or against a stationary object (the victim is in motion; resulting from a fall)	M8	3,047
(30) Breakage, bursting, splitting, (…) of Material Agent	(50) Contact with sharp, pointed, rough, coarse Material Agent	M9	3,000

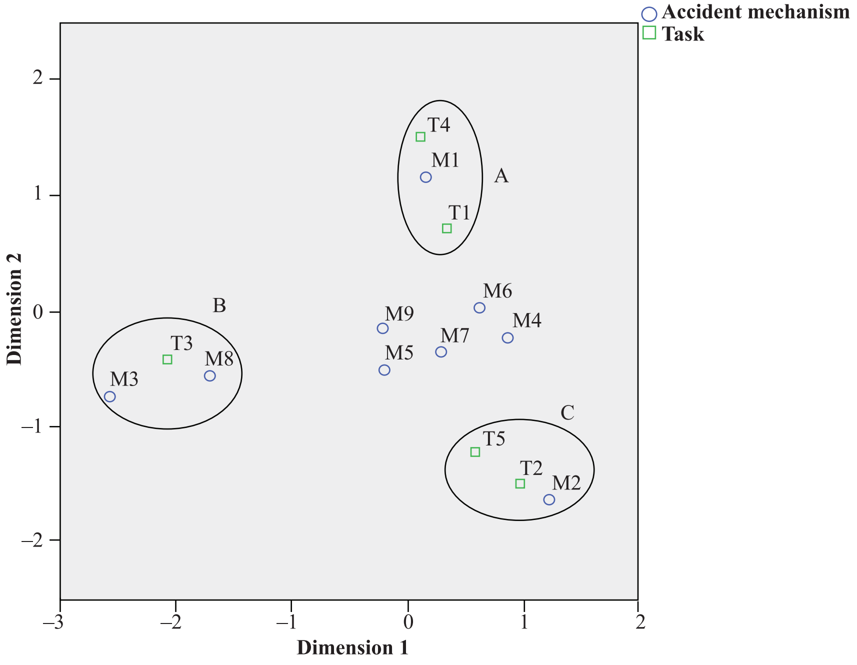

Figure 1. Correspondence analysis: Two-dimension representation of the most prevalent *Task* and *Accident mechanism*.

causes of each of the accident mechanisms can be used in a more effective design of the public safety programs. As an improvement to the criterion of relative frequency of each combination of variables (Silva & Jacinto, 2012), this method used the implicit structure in the data.

Although difficult to interpret the meaning of the dimensions in MCA, each scenario is formed by accidents that are alike in the transformed space and the preventive activities should be effective considering the flow of events.

The method presented allowed an easy identification of the main associations candidates for public intervention programs. Each of them can be object of further detailed research before designing the intervention program.

As any multivariate statistical technique, multiple correspondence analyses enable to identify associations incorporating as many meaningful variables as possible. It must be remarked that this identification of the accident scenarios is only based on some variables of the technological subsystem. Other subsystems, such as human factor and organization, unfortunately are not yet developed with the same level of detail in the coding system of ESAW. If available the new variables could lead to most sophisticated identifications of the accident scenarios (Jacinto et al., 2009).

In our analysis we only used first level of codification (first digit of ESAW codes). Task and accident mechanisms can be different within the same first digit ESAW codes, the analysis can be done with two digit level ESAW that with lead to more detailed definition of the associations.

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The new regulatory norm nº 12: The criticisms and difficulties in the applying this norm

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ABSTRACT: Changes in the safety standards that address machinery protection incorporate obligations often controversial. In Brazil, occurs the same situation in the Regulatory Norm nº 12 (NR 12). Thus, this article, which it aims to discuss the changes in the NR 12 to understand the reason of the criticisms of entrepreneurs and how difficult is for Brazilian companies to apply this norm. As this is an explanatory research, the methodology was based in a information collection through databases and sites and inspection agencies of safety at work in order to explain why companies have problems applying this standard. The results show eight major difficulties, ranging from the absence of certification of equipment to correctly signal difficulty of the machines and cognitive limitations of the employees. Finally, some solutions are given to solve these difficulties identified.

1 INTRODUCTION

In Brazil, National Institute of Social Security (INSS) accounts, among others informations, occupational accidents, showing sectors of the economy that generate accidents. Thus, for the INSS (2013), were accounted over 55 thousand accidents in machinery, representing 10% of the total of accidents in the Brazil in 2013.

This reality of accidents does not occur only in Brazil. Data collected by NIOSH (1999), between the years 1980–1998, showed that in the United States injures caused by machinery are rated as third place among the causes of accidents, representing 13% of the total. National Union of the Labor Fiscal Auditors (SINAIT), through document analysis of Notices of Occupational Accidents issued between the years 2011 and 2013, completed 172.115 accidents, where 10.710 are amputations, 26.010 are fractures and 358 deaths (SINAIT, 2014).

RN 12 is the Brazilian norm that establishes obligations for machinery and equipment. It undergoes few changes during years, but the report of the Ordinance SIT n.º 197/2010, were added requirements leading to 340 requirements.

Reality is that until then does not occurred consensus of government, entrepreneurs and machine operators with respect to technical and financial feasibility. Thereby, arises critical, especially from entrepreneurs.

Thus, this article aims to discuss the changes in the NR 12 to understand the reason of the criticisms of entrepreneurs and how difficult is to Brazilian companies to apply this norm.

2 METHOD

The research is the explanatory type. This study is a starting point to understand the difficulties of applying NR 12. Therefore, we sought in the literature, papers, about machinery and equipment protection. The main databases used were Science Direct, Springer Link, Emerald Insight and CAPES Portal of Electronic Journals. Searched data, opinions and informations in websites as Ministry of Labor and Employment, INSS and SINAIT, among others databases as the international norms Directive 2006/42/CE and International Labor Office which deals with security and health in the use of machinery.

To perform the search were used the following keywords: "machinery protection", "safety in machine"; "accidents in machinery and equipment"; "protective devices in machinery"; "risk in machines". Searched the same keywords in Portuguese: "proteção em máquinas"; "segurança em máquinas"; "acidentes em máquinas e equipamentos"; "dispositivos de proteção em máquinas"; "Riscos em máquinas". The search selected articles published since 1990 until 2014. Science Direct database presented the larger amount of researches about the subject through keywords above. The data were systematized in: machinery protection; accident statistics in machinery; safety devices; critical and controversial issues about NR 12.

3 DISCUSSION

3.1 *Machinery protection*

As occurred in Brazil and others countries, through NR 12 legislations are modified and directed to improve the safety of machinery and equipment for labor purposes. Caputo, Pelagagge e Salini (2012), claim that strict norms were imposed in most countries to determine specific security requirements for new machines or for oldest one that keep working.

Hale et al. (1990) claim that there is a increasing detail in the norms to ensure that they contain information about machinery, security needs of users to facilitate the application of the safety obligations, left to the discretion of the company if the saving time, money and effort are worth the risk of being caught out of the laws.

In Europe the norms contain various obligations. To clarity and to promote substantial reformulations related to machinery safety, Directive 98/37/CE was repealed and emerged the Directive 2006/42/CE that bring reformulations related to the issue. This Directive sets only general health and safety requirements, added for various specific requirements for particular kind of machineries (Directive 2006/42/CE).

However, in Brazil not only the NR12 cares these issues related to machinery protection. Section XI Consolidation of Labor Laws (CLT) addresses the machineries and equipments, among articles 184, its sole paragraph and article 186 (BRASIL, 1977):

- Article 184: Machineries and equipments should be equipped with necessary devices to prevent occupational accidents.
- Sole paragraph: It is prohibited to manufacture, import, sale, lease and use of machineries and equipments that do not answer the provisions of this article.
- Article 186: Ministry of Labor shall establish additional standards about protection and safety measures in the machinery and equipment operations, specially the protection of moving parts, distance between them, access routes to large machineries and equipments, use of tools, adequacy and protection measures required when motorized and electric.

In some countries, subsidies and incentives are targeted to companies to improve occupational safety issues. For example, Hale et al. (2010) claim that between 2004 and 2008 the Dutch Ministry of Social and Labor Affairs provided subsidies around €100.000 to the companies perform changes in order to reduce accidents and modify as a whole the organization culture.

To ensure effective safety in machinery is necessary to prevent risks since conception of these equipments. Even early in the life of the machines, tools and equipments, a number of initiatives related to professional policies are created to minimize or eliminate risks (Schulte et al., 2008). To the Directive 2006/42/CE (2006), it is allowed the exposure in markets and events of machines and almost machines that are the risk during operation and maintenance, however, this norm requires that is necessary to inform stakeholders about risks in these equipments, through visible panel to show risk circumstances. Norm of International Workshop of Labor (2013) that address safety and health issues in the using machines process, points that every machine intended to be used to the labor must be dimensioned and constructed to eliminate or reduce to the minimum the dangerous situations related to use.

In Brazil, creating machineries and tools must satisfy the principle of fail-safe (BRASIL, 2011). Thus, in case of emergency or any failure, the machine does not necessarily need to stop, but it must operate without risk, ensuring the integrity of employees. Thereby, the machine does not must offer risk in any situation, even if it shows failure in its normal running.

3.2 *Accident statistics in machinery*

Accidents involving machineries and equipments increase the causes of fatal accidents due to great strength necessary to transformation and change of materials. Bulzacchelli et al. (2008) collected data on fatal accidents in the United States in 2005, they verify that among 5700 employees fatally injured, 18% were injured due to contact with equipments, considerably high number in the industries involving production activities, with 38% deaths due to contact with machineries and equipments.

Support teams are, in many cases, victims of accidents caused by machinery. Studies conducted in Norway by Bull et al (2001) show increases of the accidents during services of adjustment, cleaning, tools and machine lubrication, or during ordinary operations in machines or tools, showing rates of 1,0 in 1991 and 3,7 in 1996 for 100 thousand stakeholders.

Validating the high risk to the responsible stakeholders by maintenance services Bulzacchelli et al. (2008) compared rates of fatal accidents for 100 thousand stakeholders, finding 7,6 for maintenance workers, 2,9 for production workers, 4,0 for workers in general. Automatically Controlled machines do not necessarily mean safety, since Backstrom e Doos (1995) e Backstrom e Doos (1997) performed studies in two Swedish automotive industries and their findings reveal 12% and 17% of accidents caused for this kind of machine.

3.3 *Safety devices in machines*

Several devices can be used to increase the safety in machines, although standard choices used in specifics machines not always are admissible or suitable (Caputo, Pelagagge e Salini, 2012), making difficult to choice the right device, because a device implemented in a wrong way can increase the risk for the employees, this, the designer can be responsible for any damage caused for improper selection of safety devices (BARAM, 2007).

NR 12 divides the devices in two categories, for fixed protection and for mobile protection. For this, NR 12 norm (Brazil, 2011) cites:

- Electrical controls or safety interfaces: devices responsible to perform the monitoring, verify interconnection, position and operation of others devices as security relays, configurable security controllers and programmable logic controller security;
- Interlock devices: electromechanical security keys, with positive action and rupture, magnetic and electronic coded, optoelectronic, inductive safety sensors;
- Safety sensors: sensing devices of mechanical and non-mechanical presence that send signal to interrupt or prevent the onset of dangerous functions, as light curtains, optoelectronic motion detectors, laser multi-beam, optical barriers, area monitors, or scanners, stops, carpets and position sensors;
- Valves and safety blocks or pneumatic and hydraulic systems of the same effectiveness;
- Mechanical devices, as retention devices, limiters, separators, pushers, inhibitors, deflectors and retractable; and
- Validation devices: additional control devices manually operated as lockable selector keys and lockable devices.

Factors as cost, reliability, efficiency, risk of neutralization or creating new hazards, directly influence the designers during the choice of which safety devices may be used in machines and tools (Caputo, Pelagagge e Salini, 2012).

Studies as Fadier e De la Garza (2006) found methods, models and recommendations used in the projects of safer machines, concluding that the safety devices are complements of an original project, such that safety issues are not considered before product, but when it is idealized.

3.4 *Controversial and critical issues about NR 12*

This norm is responsible for various prohibitions. SINAIT interdicted 174 machines only in a sisal company in Bahia (SINAIT, 2012). Interdictions occur mainly due to changes in the NR 12. Some of these controversial issues are:

- The installation of stationary machines must respect the necessary requirements provided by manufacturers or, in its absence, the project must be elaborate for professional legally qualified (BRASIL, 2010). Something hampered by the large number of machines built by homemade by many Brazilian companies;
- Requirement of synchrony on driving of bimanual controls, light indication during operation, selector switch with lock, operator interface with extra low voltage with maximum 25 V, contactors with mechanically guided contacts (BRASIL, 2010). These aspects are hard to fit in machines, because require changes of electrical parts;
- Danger zones of the machinery and equipments must have fixed protections, mobile protections, devices of mobile protections and safety devices interconnected (BRASIL, 2011). Something extremely hard in some kind of eccentric presses, for example, that have tools that are not suitable to electrical systems and nor fixed protections;
- Security systems must be under technique responsibility of professional legally qualified (BRASIL, 2011). This requires hiring professionals or consultants;
- Protections, devices and systems security must integrate machineries and equipments, and can not be considered optional items to any purpose (BRASIL, 2011). This is extremely imposing, does not being a suggestion to use.
- Machineries and equipments must have permanently fixed and safe access for all the operation points as ramps, walkways and stairs (BRASIL, 2011). This obligation requires several changes in old machinery;
- Machineries and equipments must have instruction manual provided by manufacturer or importer, provided in Portuguese language (BRASIL, 2011). These obligations are hard to perform, specially in old equipments;
- Interventions in machinery must be performed for skilled, trained and qualified professionals (BRASIL, 2011), something that creates unemployment stakeholders of maintenance;
- Machinery must be submitted to corrective and preventive maintenance, the form and timing of the manufacturer (BRASIL, 2011). This information not always is provided by manufacturers;
- Safety signs must be present throughout life of the maquineries and should be easy to

understand (BRASIL, 2011). Something considered subjective;

- It is prohibited the machinery and equipment exposure that do not answer this Norm (BRASIL, 2011), making norm more rigid that the Directive 2006/42/CE.

Several these points above are criticized, mainly of the entrepreneurs who claim that the norm is hard and extremely technique, harder than norms practiced in others countries that guide and force elements in machines that there is no lack of differential treatment with respect to company size, missing support of State with policies to facilitate compliance with the norm, missing certifying bodies to validate machines, forcing companies to look for consultants, and changes have high costs.

4 CONCLUSION

It is possible to observe it is an important issue, because it refers to increasing number of machinery accidents. Observed that RN 12 is harder than other international norms that dealing of machinery protection. However, companies have had enough time to get fit, because since 1977 the section XI of CLT prohibits the use of machineries and equipments that do not have necessary devices to prevent occupational accidents.

It was found a difficulty related to deployment of the security devices in the old machines, due to slow turnover of Brazilian industrial parks. It was clear that even in modern machines the safety devices are complements, something that shows that requirements of NR 12 are necessary.

Moreover, perceives that majority of criticism related to changes arise from entrepreneurs who are hard to change and do not see benefits that the norm offers related to safety and reduction of accidents.

Was observed that the main difficulties for the application of the NR 12 are related to: (1) machines without the technical certification of a competent professional; (2) machines without signaling, electronic sensors mandatory safety since the design and evaluated for qualified professionals; (3) tools and molds without fit protection exposing the dangerous points of the machines; (4) poor machines in access to its important places, mainly for maintenance services; (5) companies that are not worried with information manuals, not leading to preserve it; (6) companies that do not follow plans of preventive maintenance; and (7) machines without fit signaling for cognitive limitations of employees.

As a solution for these problems is necessary for companies to seek certification of their equipment, reviewing the design of new machines and adapting those that are in use. Furthermore, companies need to give more attention to handbooks because they are sources of information and help in maintenance. Companies must also empower their maintenance employees and manufacturing shop floors so to that the norm has positive effect on the job.

It is necessary more dialogue between government and entrepreneurs, because NR 12 is important and it is not wrong. Norm is complete and brings clear and directed requirements, something different from what is found in part of Brazilian legislation.

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Innovative protective insoles for safety footwear: A balance between protection and comfort

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ABSTRACT: The use of adequate protective footwear and other Personal Protective Equipment (PPE) has become a necessity in view of the number of accidents at work occurred in the past years.

This paper presents a project developed at University of Minho which main goal was the improvement of the existent inserts in terms of comfort. A detailed analysis of the penetration resistant inserts available in the market was made. Chemical, metrological and destructive tests were performed to the normally used materials allowing us to obtain the necessary information about the inserts and select new materials to be applied in this component. The comfort properties (air permeability, mass per unit of area and frictional properties) of the selected materials were tested and compared with the aramid based materials properties to see if the replacement of aramid for any of these materials is profitable in terms of comfort.

1 INTRODUCTION

In the European Union (EU) almost 3 million workers were victims of accidents at work every year, resulting in 500 deaths and an absence from work of approximately 3 days (Communities, 2004). In 2010, nearly 2 634 196 accidents at work occurred in Europe, of which 707 292 affected the lower extremities. These facts led the EU and the member states for the creation of strategies aiming the increase of the use of PPE and consequently the decreasing of the number of accidents at work (Eurostat, 2013).

The safety shoe industry has suffered improvements in order to increase the level of the user's comfort and at the same time decrease the manufacturing costs of the safety shoes and it's components. Despite the fact that safety shoes are getting more comfortable, a large number of employees still neglect the use of this kind of protection because they are uncomfortable, have excessive weight, lack of flexibility, models are unsuited to the morphology of some feet, lack of aesthetic/ergonomics or have inadequate ventilation (Goldcher and Acker, 2005). The legislation define protective footwear as footwear including protective structures (toecaps and penetration resistant inserts) to protect the user from injuries which could arise through accidents. There are three types of protective footwear classified according to the protection that they offer: safety shoes, protection shoes and occupational shoes. The main difference between these three types of shoes is the toecap protection. In the case of safety shoes, toecaps must resist to a mechanical impact of 200 J, while the impact supported by the protective shoes should be 100 J. In the case of the occupational shoes, toecap protection is not required.

The penetration resistant inserts are one of the most important components of the safety shoes and its main goal is to prevent the penetration of sharp objects. This component suffered a big evolution in the last years. Nowadays, there are mainly available two types of resistant penetration inserts, metallic or made of aramid fibers. The first ones have a thickness of ≈0.5 mm and due to their low cost production are the most used by the safety shoes producers. The ones made of aramid fiber are very flexible, making the shoe more comfortable, however, their cost is superior to the metallic inserts. Some inserts were patented: In 1991, Kenji Okayasu (Okayasu, 1991) developed a new penetration resistant insert using small metal plates joined together allowing the insert to bend in the front part, the metal plates are involved in an involcro from plastic or rubber in order to prevent the insert damaging in the sole of the shoe. In 2003, Luigi Bettaglia (Bettaglia, 2003) presented an improvement of the simple metallic inserts by applying longitudinal ribs in the back part of the insert. These longitudinal ribs form grooved ribs on the upper surface of the sole that are going to stiffen the area of the arch of the foot. In 2008, Leo Sartor and his colleagues (Sartor et al., 2007) developed an insert with two distinct parts. The front part of the insert is comprised of multiple layers of aramid fiber conferring a good flexibility. The back part of the insert is made of a composite material and acts like a structural element and prevents the heel torsion and therefore heel injuries.

The present work aims the development of a new and innovative penetration resistant insert for safety shoes, regarding the standards, with an improved behavior than the ones already available in the market. For that, we are trying to develop a penetration resistant insert using new and innovative materials that are not being applied in safety footwear. Aiming to improve the comfort of safety footwear, we pretend a decrease of thickness and weight, without sacrificing the physical protection offered by the same. With the decreasing of the insert weight, the shoe weight will also decrease. Moreover, we are considering the incorporation of comfort components on the penetration resistant insert and with that purpose, we compared several new materials with the material already used in the safety footwear industry to see if it replacement would be vantageous in terms of comfort.

2 MATERIALS AND METHODS

2.1 *Materials*

The materials selected used for this work are based in polypropylene (A), an Ultra-High Molecular Weight Polyethylene (UHMWPE) (B, C, D) and an aramid fibre (E, F, G, H, I, J, K). The UHMWPE based materials B and C are made by the same manufacturer; the main difference between them is their weight. The material based on aramid fibres (K) is from a different manufacturer than the materials E, F, G, H, I and J. The difference between them (E, F, G, H, I and J) is the number of layers.

2.2 *Methods*

2.2.1 *Penetration resistance test*

The penetration resistant inserts are footwear components placed in the sole complex in order to provide protection against mechanical penetration. The penetration resistance tests were performed according to the standard EN ISO 12568—"Foot and leg protectors—Requirements and test methods for toecaps and penetration resistant inserts". When tested accorded to the mentioned standard, using a force of at least 1 100 N, the tip of the test nail shall not penetrate through the test piece. A "pass" result requires that the tip of the test nail does not protrude from the rear side of the test piece to be checked by visual, cinematographic or electrical detection. This test was performed for the new materials alone and for the materials combinations.

2.2.2 *Comfort tests*

2.2.2.1 Air permeability

The air permeability is the ability of a fabric to be crossed by the air through the pores or interstice which rate depends mainly on the size and distribution of pores or interstices between the fibres. The air permeability is determined by measuring the velocity of air flow perpendicularly crosses a specimen under specified conditions, (area and pressure). In this work the test has been performed with an area of 20 cm^2 and a pressure of 200 Pa for non-woven materials. The air permeability test has been carried out following the standard NP EN 9237-1997—"Determination of the air permeability of textiles" with the air permeability tester TEXTEST FX 3300.

2.2.2.2 Mass per unit of area

The mass per unit area has been performed according to the standard NP EN 12127:1999—"Determination of mass per unit area in samples of small dimensions". It was calculated the mass per unit of area of five samples of each material.

2.2.2.3 Frictional properties

The Frictorq method consists of characterising the coeficiente of friction between two flat surfaces based on torque evaluation (Lima et al., 2008). The frictional properties of the materials were tested using the Frictorq II. Samples with 84 mm diameter were tested under a conditioned atmosphere.

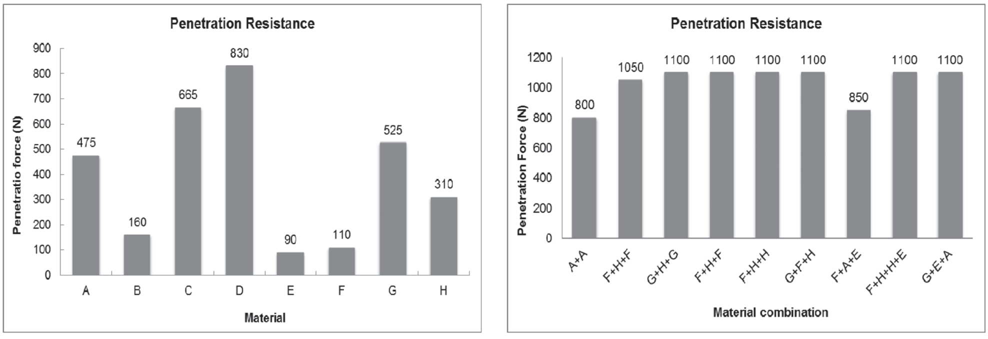
3 NEW PROTECTIVE INSOLE

The anti-penetration inserts available still have several flaws that undermine the comfort and reliability of safety shoes.

The starting point of this study was a detailed analysis of the inserts available in the market, whose results allowed us to understand what the most important characteristics of the inserts are. Chemical, metrological and destructive tests were performed to the normally used materials (steel and aramid) allowing us to acquire the necessary information about the inserts tensile strength, thickness and chemical composition and therefore to select new materials to be applied in this component.

3.1 *Penetration tests*

Due to properties like flexibility, light weight and good mechanical properties aramid fiber, polypropylene and ultra-high molecular weight polyethylene based materials were selected and tested according to the safety shoes standards. The results of these tests were helpful to see if these materials were suitable options for the new insert. The results



(a) (b)

Figure 1. Penetration resistance of the selected materials. (a) selected materials, (b) combinations of the selected materials.

shown in Figure 1a allowed us to conclude that the use any of these materials alone would not be an option due to their penetration resistance forces, hence combinations of these materials according to their prices and availability were made. Materials A, E, F, G and H were combined and tested to penetration (Figure 1b).

3.2 *Comfort tests*

The comfort properties of the selected materials were tested in order to find a new material that induces better comfort than the standard material. The properties of the new materials were compared with the properties of the aramid material already used in the market to see if the replacement of aramid for any of these materials is profitable in terms of comfort.

3.2.1 *Air permeability*

The air permeability of the present materials used and the selected materials were compared (Figure 2. Through the values presented in Figure 2 it is possible to assume that only the replacement of the existing aramid insole with material A is not advantageous for the foot breathability.

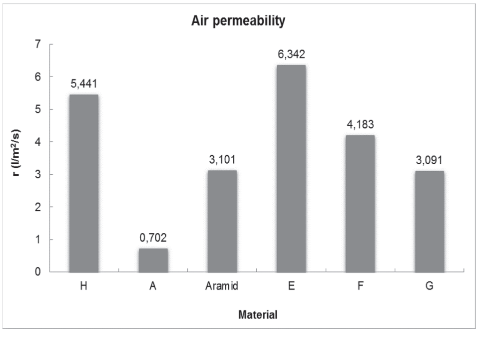


Figure 2. Air permeability of the tested materials.

3.2.2 *Mass per unit of area*

Since the weight of the shoes is an important factor to the user comfort and one of the goals of this project is the decrease of the shoe weight, the mass per unit of area of the new materials was tested and compared with the materials normally used in penetration resistant inserts (Figure 3). The results show us that the replacement of the traditional inserts available in the market for inserts made of any of the new materials would be advantageous in terms of weight.

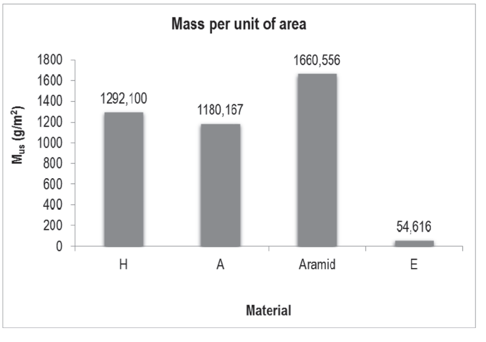


Figure 3. Mass per unit of area of the tested materials.

3.2.3 *Frictional properties*

The frictional properties of the materials were tested in the Frictorq II. This equipment measures the kinetic or dynamical coefficient of friction between the surface of the sample and the standard metal surface contact element. A relation between the friction coefficient and how soft the material is can

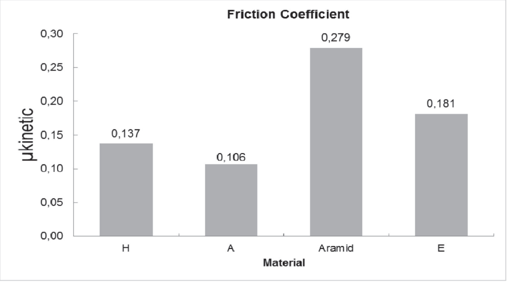


Figure 4. Friction coefficient of the tested materials.

be achieved testing the materials by this method. The results can be seen in Figure 4. The materials with higher friction coefficient are the aramid. Therefore, it can be said that the replacement of the aramid for any of the new materials would be advantageous once they all are softer to the user touch and consequently more comfortable.

4 CONCLUSIONS

The main goal of this work was the increase of comfort and safety of the existing safety footwear. Initially, an analysis of this type of footwear and of the penetration resistant inserts was made. This analysis allowed concluding that there are some failures that could be solved if this component was more comfortable and lightweight, but at the same time more resistant. With the selected innovative materials based in polypropylene, in ultra-high molecular weight polyethylene and in aramid fibre, a new insert with increased comfort and lower thickness and weight can be made. Despite the increase of the comfort of the new resistant penetration insert, the safety and reliability of safety shoes would not be neglected.

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Analysis of the causes of work accidents in Romania in the period 2011–2013

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ABSTRACT: Occupational health and safety is very important for any organization. The development of optimal working conditions contributes to the development of sustainable organizations that are aligned with European standards. This paper presents an analysis of the causes of accidents at work in Romania divided into groups of causes. After analyzing these factors, the authors present a model of causes that affect the seriousness and fatality of work accidents. In the initial part of the paper it is presented the legal framework of occupational health and safety, followed by the European directives. The research ends with the conclusions and future research directions.

1 INTRODUCTION

Occupational health and safety is very important for organizations, being approached and evaluated differently depending on the management of each organization. Work accidents occur most often on the basis of budgetary difficulties of organizations. Given the current economic situation, organizations are trying to cut costs or invest small amounts in preventing accidents. Another problem reported in various studies (Probst et al, 2008; Lopez et al, 2011; Fuente et al., 2014) is that in different countries, work accidents are not fully recorded. Most work accidents are recorded in the construction organization (Joao, 2012, Costa et al., 2012; Suarez-Cebador, 2014). Basically, the published results are relative and not actual reality. In this research, the authors present, the relative reality of Romania based on data from the Labour Inspection in Romania.

The present paper is divided into two main areas: current status, laws of Romania and OHS (Occupational Health and Safety) European directions, on one hand, and analyzing the causes of work accidents in Romania and the model of influence, on the other hand. By analyzing the data and presenting a model, a presentation of future directions and proposed improvement of the current situation is required in the end.

2 THE IMPLICATION OF WORK ACCIDENT

2.1 *The legal framework in Romania*

According to the Law on health and safety no. 319/2006 (published in Official Gazette no. 646/26.07.2006):

- Work accident represents "body injury and occupational acute poisoning that occur during the process of doing the work or service and which causes temporary inability to work for at least three days, disability or death";
- Event represents "the accident that led to death or injury to the body, produced during or in performing official duties, missing person or the case of accident of traffic or route, while involving people employed, dangerous incident and the case of likely occupational disease or work-related".

In Romania, the legal system in the OHS is established by the Constitution of Romania. Creating a controlled work environment involves improving knowledge on the causes of risk production by all actors. This means developing an approach both global and preventive focused on promoting sustainable jobs, beyond the mere prevention of specific risks. To develop a controlled environment

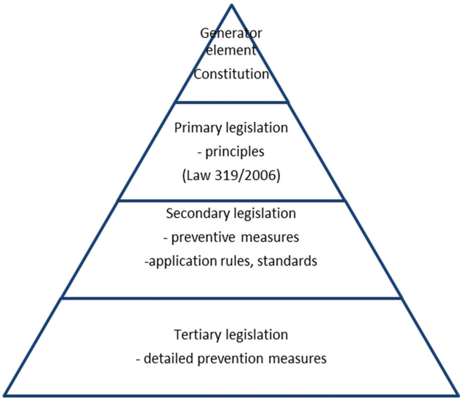

Figure 1. The structure of the legal system of Romania in the OHS (European agency for OHS).

there must be analyzed three mutually reinforcing components: education, awareness training and treatment of causes. Causes of accidents also show an uncertain component, since at any moment a new hazard of the job can be developed. Lago et al. 2012 reported that the human is easily adaptable to various environments. Therefore, by analyzing the history of the organization the present causes of work accidents can be analyzed. Their evaluation and presentation is made in the next section. The legislative, sometimes difficult, helps prevent accidents declaring and the implementation of accident prevention models. Based on the legislative framework the causes of accidents nationwide are presented.

2.2 *The OHS European directives*

EU priorities regarding occupational risks are formulated in OSHA report (European Agency for Safety and Health at Work) of January 2014. The report's objective was to identify priorities for OHS research in the coming years in accordance with the Europe 2020 strategy and the Horizon 2020 programme. These priorities are:

- Occupational health and safety communication and risk communication: investigating the use of new technologies in OHS and developing good communication;
- Intervention research: evaluate the OSH interventions at all levels and risk communication;
- Globalization and the changing world of work: Changing organizations, new employment and work patterns, and new environmental, and OHS in small enterprises;
- Occupational health and safety research for safe new technologies: risk in new technologies and information and communication technology: opportunities and risks in the working environment.

Table 1. Number of accidents in Europe in 2011*.

	Number of accidents 2011		Accident per 100.000 workers	
Country	Serious	Fatal	Serious	Fatal
Belgium	55.315	66	502,86	0,6
Germany	747.560	469	915	0,57
Spain	363.510	336	785	0,72
France	483.476	501	748	0,77
Portugal	81.730	180	778	1,26
Slovenia	12.449	19	622	0,95
Romania	28.100	273	127	1,24

*Source: Eurostatt, online data code hsw_mi01, demo_gind.

Aligning the organizations in Romania to the European directives would lead to improved working conditions and reducing work accidents. Accident situation in Europe (by selecting the relevant countries to this research) in 2011 is shown in Table 1.

From the analysis of above data, we can see that the situation of Romania is an acceptable one, there are 28,100 serious accidents and 273 fatal accidents in the year 2011. The most worrying situation is recorded in Germany, where the number of serious injuries/accidents per 100,000 workers was 915. The number of these accidents is recorded at the European level.

3 ANALYSIS OF WORK ACCIDENTS CAUSES IN ROMANIA

3.1 *Data presentation*

The data used in this research are obtained from Romanian Labour Inspection, they are real data that shows the reality in the field. The authors use recent and actual data from 2011–2013. In the last years, the number of work accidents occurred in Romania fluctuated slightly from year to year, the peak being in 2008, with 5,110 cases, while in 2013 the authorities registered 3,627 cases.

The work process is a complex system, structured on the following mutually interacting elements (Romanian Labour Inspection):

- The performers—workers involved in the execution of work tasks;
- The workload—all actions to be performed by means of production and under certain conditions, to achieve the aim of the work;
- Means of production—all the instruments of labor (plant, equipment, machinery, apparatus, tools, etc.) and objects of labor (raw materials, etc.) used in the workplace;
- Work environment—all physical, chemical, biological and psychological conditions in which one or more performers achieve their tasks.

The causes of accidents are analyzed by the work system elements, considering that an accident may occur by combining several causes. Data presentation is done by group of causes dependent of: work environment, work load, means of production and execution. Taking to the analysis the period 2011–2013, the authors present the evolution of work accidents causes in Table 2.

In 2013 there were 3,627 work accidents, 14% fewer than in 2012. The year before, in 2012 there was a total of 4,187 people injured, 8% less than in 2011, when there were 4,010 people injured. Analyzing this trend is observed as the number of accidents experienced a decrease, the slope of decline is increasing. At present, the Romanian Labour Inspection statutory controls are numerous, increasing by 21% compared to the previous year. Basically, the organizations realize the importance of this field and also pushed by the national legislation they improve their working conditions and invest in occupational risk.

3.2 *Data analysis*

From the analysis of the above data it results that the main causes of work accidents presented on the elements of work system are:

- Performer: Performing improper work operations and omissions;
- Production: Physical causes;
- Workload: Omissions in operations preset and supervision work, control
- Labor: Causes of physical nature.

It is noted that the main causes of accident at work are dependent on the work operations, which are incomplete implemented or present a number of difficulties in practice. The causes of physical

Table 2. The evolution of work accidents causes in Romania.

		Total accidents (%)			Fatal accidents (%)		
Group of causes	Causal elements	2011	2012	2013	2011	2012	2013
Causes dependent of the performer	Performing improper work operations	37.7	37	40.4	36.2	29.4	35.1
	Fall from height or same level	27.5	29	27.2	15.2	14.4	10.5
	Omissions (failure to use protection means et al.)	17.4	16.9	16.3	18.1	23.9	20.5
	Exposure, outside work load, to hazardous or noxious factors	6.9	5.9	5.5	14.3	12.8	14
	Performing, outside work load, of hazardous operations	1.7	1.7	1.4	2.9	2.8	4.1
	Presence at work in poor psycho physiological conditions	0.9	0.8	0.9	3.8	6.7	2.3
	Other causes	7.9	8.7	8.3	9.5	10	13.5
Causes dependent of production	Physical causes	62.1	59	58.6	67.1	65.1	63.7
	Chemical causes	1.4	1.7	1.0	2.8	3.3	1.6
	Biological causes	0.1	0.5	0.3	0.0	0.7	0.0
	Other causes (static effort, forced positions, monotony of work)	36.4	38.8	40.1	31.1	30.9	34.7
Causes dependent on workload	Supervision, control	17.3	14.6	14.3	22.4	22.0	21.7
	Errors in preset work operations	13.3	11.7	12.4	10.6	9.9	10.8
	Omissions in preset work operations	11.4	10.8	12.1	18.0	7.1	6.7
	Shortcomings in working conditions	6.3	6.2	6.6	3.7	8.5	10.8
	Inadequate distribution of performers on workplaces	4.1	5.0	4.2	9.9	12.1	11.7
	Other causes	47.6	51.7	50.4	35.4	40.4	38.3
Causes dependent on work environment	Other causes	6.5	9.2	6.7	13.2	22.6	10.7
	Physical causes	2.2	1.4	1.5	6.1	3.2	1.3
	The special nature of the environment	1.8	1.4	1.2	0.9	3.2	1.3
	Psychosocial climate	1.0	1.1	0.9	2.6	1.1	4.0
	Chemical causes	88.5	86.9	89.7	77.2	69.9	82.7

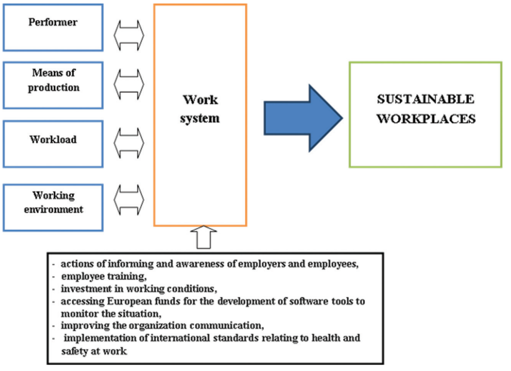

Figure 2. The conceptual model.

nature prevail on the elements: labor and production. Work operations and physical causes are interrelated, being causes that trigger each other in a real job. To reduce occupational accidents, the organizations need to invest in facilities and equipment to ensure optimal working conditions.

3.3 *The conceptual model*

Considering the causes dependent of the labor system presented in Table 2, it can outline a conceptual model for improving the current situation. It can be seen that the work accident situation improved from one year to another. Based on the improvement shown nationally, the Figure 2 systematizes the conceptual model of continuous improvement and of the development of sustainable workplaces.

Based on the causes of the elements of the work system (causes dependent on the performer, the means of production, the workload and working environment) a series of measures are imposed to reduce work accidents (actions of informing and awareness of employers and employees, employee training, investment in working conditions, accessing European funds for the development of software tools to monitor the situation, improving the organization communication, implementation of international standards relating to health and safety at work). By adopting such measures in the system of work for sure the path to sustainable and healthy workplaces is created.

4 CONCLUSIONS AND FUTURE DIRECTIONS

Detailed, the causes dependent on the performer, the means of production, the work load and work environment, Table 1, there were variations in the analyzed period. Given the structure of the causes of the accidents we must emphasize the implementation of actual measures that contribute to the improvement of the current situation (actions of informing and awareness of employers and employees, employee training, investment in working conditions, et al.). The future directions of work include: analysis of cases in other EU member countries and the development of a comprehensive database that contributes to the implementation of a procedure for cause's reduction.

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Human body thermoregulation: Test and validation of a computer program

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ABSTRACT: This study aims to validate and to test a program that simulates the behavior of human thermoregulatory systems. Depending on the physical characteristics of the person, the amount of clothing, the activity level and the environmental thermal conditions, the program provides several parameters, namely the deep body temperature, skin and clothing temperatures, sensible and latent heat flow and global thermal state of each area of the human body. The present contribution gathers two simulations with and without changes in the thermal environment, both considering a low activity level. The results show that the experimental data and the values predicted by the program are in good agreement, namely in the case of the rectal temperature. Therefore, we might conclude that, for the conditions tested, the thermo-physiological response of humans is well predicted by the program.

1 INTRODUCTION

Simulation programs of the human thermo-physiological behavior have been increasing its importance over the years. Indoor air quality, heating, ventilation and air-conditioning systems and any other device that aims to improve thermal comfort inside buildings are becoming more and more important. In developed countries people spent most of their time indoors. Therefore, the concern about the living environment indoors is greatly increased. Thermal comfort of occupants not only enhances the subjective feeling of satisfaction with the thermal environment but also increases productivity. Another matter in which the simulation of human thermo-physiological response is important refers to the design of several activities (industry, sports, military, firefighters, …) by improving efficiency in order to avoid collapse or heat/cold stress conditions (Oliveira et al., 2014a; Oliveira et al., 2014b; Abreu et al., 2014). Considering that industrial workers are often exposed to hot and cold environments, anticipating the human behavior is essential to achieve success and productivity. The role of this kind of simulations is also significant in the design of the protocol of certain activities being also useful in medical activities and research, namely when high metabolic rates are involved. It is also important to emphasize that with this kind of simulations individuals are never at risk.

The objective of this work is to test and validate a program named Huthereg that simulates the human thermo-physiological behavior.

2 MATERIALS AND METHODS

The program is composed by several modules, namely for the calculation of the thermo-physiological response, the heat and water transport through clothing, the heat and mass exchange between the external surface of clothing (or skin) and the environment, the start and evolution of skin injuries (pain and burn) and the detection of specific incidents within the individual. Due to its interdependency, all modules are run iteratively in each time step until a specific convergence criterion is reached. The module for simulation of human's thermo-physiological response is based on the Stolwijk (1971) thermoregulation model, improved with recent knowledge (e.g. Tanabe et al., 2002; Raimundo and Figueiredo, 2009; Raimundo et al., 2012). This enhanced 89-node model considers the human body divided in 22 segments (face, scalp, neck, chest, abdomen, upper back, lower back, pelvis, left shoulder, right shoulder, left arm, right arm, left forearm, right forearm, left hand, right hand, left thigh, right thigh, left leg, right leg, left foot and right foot). Each body segment is composed of 4 layers (core, muscle, fat and skin) and the 89th node is the central blood compartment. The model was implemented for an average man with 74.43 kg of body weight, 1.72 m of height and 14% of body fat (1.869 m^2 of skin). For an individual with other anthropometric data, the appropriated coefficients are proportionally changed as a function of its body weight and skin area.

The present work represents only a very small part of a recent extensive research (Pereira, 2014). Despite the wide set of cases simulated, they can be gathered in 3 different scenarios: (i) without changes in the thermal environment, (ii) with changes in the thermal environment and (iii) particular cases. Due to space restrictions it is not possible to address them all. Therefore, for the present work only simulations within the two first conditions were selected.

In order to ensure that the "*virtual individuals*" considered in the program have the same thermal state as the "*real persons*" that participate in the research studies used to validate the actual program, an initial period was assumed in the simulation prior to the first real phase of each experiment. This preliminary period is not included in the comparison between the experimental results and the ones obtained with the present program. Unfortunately, this initial period is not always described with enough detail in the literature. In such cases, it was assumed that the duration of the preliminary period was 60 minutes, that the individual is resting, laying in a portable sleeping frame (M = 0.8 met), dressed with shorts and exposed to an environment with an air temperature (T_a) of 29 ºC, a Mean Radiant Temperature (MRT) of 29 ºC, a Relative Humidity (RH) of 60% and an air velocity (v_{ar}) of 0.2 m/s. These values were adopted because they correspond to the most commonly considered. Even though, in some cases, it was necessary to both increase and decrease some of these values in order to achieve the required thermal state. Moreover, it was also realized that the literature seldom presents a complete description of the tests, condition that is required to accurately validate mathematical models (Liu et al., 2014; Liu et al., 2011). The lack of detail is particularly felt in the case of the thermal insulation of clothing. Usually, only the overall intrinsic thermal insulation of the ensemble ($I_{cl,\ global}$) is given, sometimes complemented with a general description of the garments used. However, this is not enough for the Huthereg program which requires that the characteristics of the clothing in each body part is known, namely the local intrinsic thermal insulation (I_{cl}), the mass (m_{clo}), the specific heat (cp_{clo}), the water vapour permeability (ivp) and the radiative emissivity (ε). Thus, it was necessary to distribute the insulation over the 22 body parts as well as to specify the corresponding thermo-physical properties. In the case of the distribution of insulation over the body, the works of Oliveira et al. (2008c) and Raimundo & Figueiredo (2009) were considered. For the weight of the clothing (m_{clo}) no reference was found, so realistic values were assumed. For the remaining properties the values suggested by Raimundo & Figueiredo (2009) were adopted, namely cp_{clo} = 1 000 J/(kg.ºC), ivp = 1 for nude body parts, ivp = 0 for the body parts dressed with impermeable clothing, ivp = 0.15 for boots and shoes, ivp = 0.35 for "*normal*" clothing, $\varepsilon = 0.90$ for the exterior layer of clothing and $\varepsilon = 0.93$ for human skin.

In the case of thermal environments with changes the simulation considers the preliminary period and at least two phases, each one corresponding to a different thermal environment. The preliminary period is firstly performed followed by a test that lasts for a given period. Next, a sudden change to another thermal environment is considered, corresponding to a second test phase. From this point additional simulations can be carried out or not. In each case, the individual performs a given activity, is nude or dressed with a given ensemble and exposed to a given thermal environment. Experimental results with enough detail were found only for the case of nude individuals performing an activity characterized by a low metabolism. Finally, a comparison between experimental data of several research studies and the results predicted by the present program is carried out to validate the Huthereg program. In addition, in order to improve the analysis of the results use was made of statistical tools, namely averages of mean relative differences (δ) and respective standard deviation (σ), mean square deviation (DQM) and Pearson coefficient (r).

3 RESULTS AND DISCUSSION

3.1 *Thermal environment without changes*

Figure 1 shows the experimental results and the ones predicted by the program. The mean skin temperature (T_{skin}), the rectal temperature (T_{rectal}), the hypothalamus temperature (T_{hypot}) and the heat production (Q_{prod}) by individuals exposed to a thermal environment with a RH value of 50% and with a v_{ar} value of 0.2 m/s are depicted. In this case, the values predicted are compared with the experimental ones measured after an exposure period of one hour to a thermal environment with T_a and MRT values that ranged between 0 and 50ºC. For instance, for an air temperature of 5º C, the shown values correspond to the thermal state attained after one hour of exposure. The experimental results were obtained by Wyndham et al. (1964) considering 44 individuals and by Werner & Reents (1980) involving 88 persons with $h = 1.72$ m,

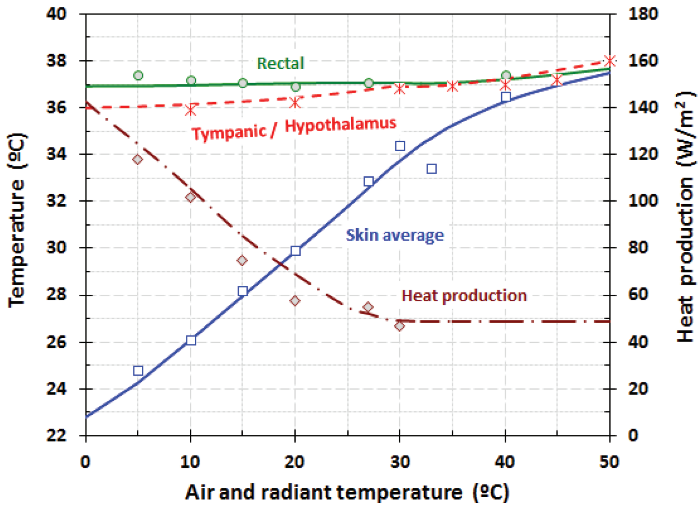

Figure 1. Measured values (points) and predicted values (lines) for the thermal state reached by nude individuals after the exposure of one hour to the specified environmental conditions.

w = 74.43 kg, $I_{cl,global}$ = 0.1 clo, M = 0.8 met and B_f = 17%. Table 1 shows the comparison between the experimental and predicted values in terms of the statistical parameters δ, σ, DQM and r.

Figure 1 shows that the evolution of the rectal (T_{rectal}), hypothalamus (T_{hypot}) and skin (T_{skin}) temperatures and of the heat production (Q_{prod}) is globally similar in both experimental and predicted values, despite being particularly close in the case of T_{hypot} and T_{rectal}. This scenario becomes more clear in Table 1 which shows high values of the Pearson coefficient (r) for the forehead ($T_{forehead}$), forearms ($T_{forearms}$), hands (T_{hands}), skin (T_{skin}), thighs (T_{thighs}), legs (T_{legs}), feet (T_{feet}), arms (T_{arms}) and hypothalamus (T_{hypot}) temperatures and for the heat production (Q_{prod}). For the rectal temperature (T_{rectal}) the r value is lower but even though the linear relationship between the experimental and predicted values is moderate. The ability of the program to predict accurately $T_{forehead}$, $T_{forearms}$, T_{hands}, T_{skin}, T_{thighs}, T_{legs}, T_{feet}, T_{arms}, T_{hypot} and T_{rectal} values is thus high. However, in the case of the Q_{prod} the statistical parameters δ, σ, and DQM present values that are too high. Nevertheless, the program shows a good capability to predict the thermo-physiological response.

3.2 *Thermal environment with changes*

Figure 2 shows the comparison between the experimental results and the ones predicted by the program for T_{skin}, T_{rectal}, T_{hypot} Q_{prod} and for the heat stored (Q_{stored}). In this scenario the individuals are firstly exposed to an environment characterized by $T_a = MRT = 28$ºC, RH = 60% and v_{ar} = 0.7 m/s (these last two values were assumed because they were unknown), and then changed to a cold environment characterized by $T_a = MRT = 10$ºC, RH = 40% and v_{ar} = 0.17 m/s. The experimental results were obtained by Bittel (1987) taking into account 9 persons with h = 1.75 m, w = 71.34 kg, B_f = 15.92%, dressed only with shorts, $I_{cl,global}$ = 0.1 clo, lying in a nylon net and M = 0.8 met. The experimental values were obtained after t = 80 minutes and the persons were exposed 90 minutes to a moderate environment and then 120 minutes to a cold environment. Table 2 shows the comparison between the experimental and predicted values in terms of the statistical parameters δ, σ, DQM and r.

Table 1. Change from a cold to a hot thermal environment: comparative analysis.

	δ	σ	DQM	r
$T_{forehead}$ (ºC)	−0.5825	0.7612	0.2596	0.9947
T_{arms} (ºC)	0.1587	0.8663	0.2919	0.9901
$T_{forearms}$ (ºC)	−0.6775	2.9220	0.9956	0.9002
T_{hands} (ºC)	−0.9950	1.6982	0.6627	0.9926
T_{thighs} (ºC)	0.3513	0.5644	0.2242	0.9943
T_{legs} (ºC)	0.7500	0.9310	0.4318	0.9974
T_{feet} (ºC)	−0.5125	0.6994	0.2938	0.9976
T_{skin} (ºC)	0.3283	0.2556	0.1644	0.9985
T_{hypot} (ºC)	−0.1157	0.1279	0.0626	0.9808
T_{rectal} (ºC)	0.0417	0.2088	0.0797	0.5445
Q_{prod} (W/m²)	−16.7418	10.9745	7.9651	0.9872

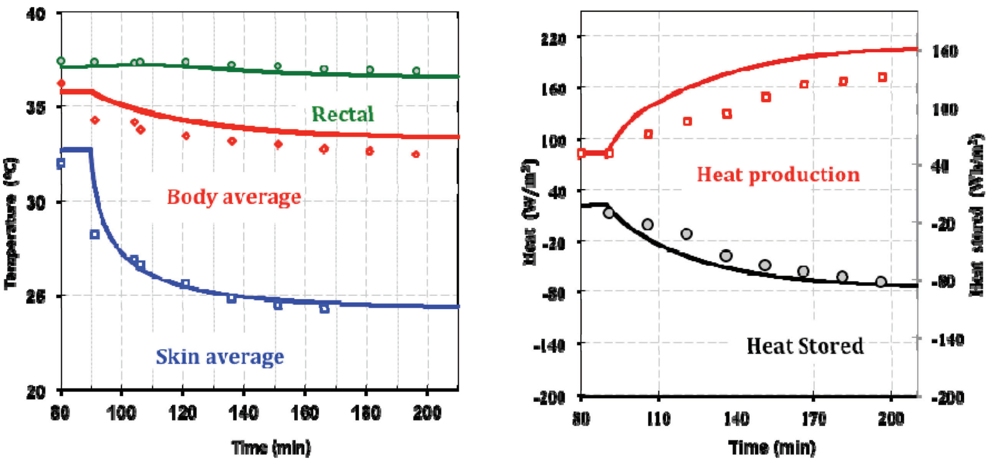

Figure 2. Measured values (points) and predicted values (lines) for the rectal, body and skin temperatures, and heat production and heat stored for nude individuals changing from a neutral to a very cold environment.

Table 2. Change from a moderate to a cold thermal environment: comparative analysis.

	T_{skin} (ºC)	T_{rectal} (ºC)	T_{body} (ºC)	Q_{prod} (W/m^2)	Q_{stored} (kJ/kg)
δ	–0.4973	0.2555	–0.7182	–6.3285	8.1984
σ	0.9118	0.0696	0.4450	68.4278	7.5958
DQM	0.2912	0.0796	0.2515	20.6257	3.4517
r	0.9569	0.9626	0.9213	0.9616	0.9681

Figure 2 shows that the evolution of the measured and predicted values of all the parameters is identical. The above comment on the rectal temperature is reproduced once again given the agreement between the experimental and predicted values. In addition, it is important to underline that in the case of T_{skin}, T_{body} and Q_{prod} the mean value of the differences between the experimental and predicted values is negative, which means that for these parameters the values predicted by the program are higher than the measured ones. Table 2 also puts in evidence that the Pearson coefficient is higher than 0.96 for T_{rectal}, Q_{prod} and Q_{stored}.

4 CONCLUSIONS

Within the range of situations analyzed in the present work no limitations in the software were found. Therefore, the usefulness, the applicability and the reliability of the Huthereg program in the simulation of the thermo-physiological response of the human body is highlighted. It is expected that this program will continue to be used in the future in many different research studies and in technological developments to evaluate thermal situations that may entail risks or simply to improve performance at work.

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Occupational Safety and Hygiene III – Arezes et al. (Eds)

Exposure of agricultural pilots to noise

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ABSTRACT: Noise exposure can cause undesirable effects on both health and safety. In agricultural aviation, noise exposure is one of many factors that can affect operation safety. The aim of this study is to measure noise dose during the most common work situations. The identified noise dose levels appear far above the recommended limits, even for modern aircraft equipped with closed cockpits and air conditioning systems. These results showed that additional measures are necessary, both in noise reduction and regulation of working time. Besides, the proper use of personal protective equipment, including their regular inspection can be an important short-term measure.

1 INTRODUCTION

The negative influence of noise on humans includes problems in both health and safety. Noise above 75 dB(A) can cause loss of concentration, difficult work release and reduced efficiency (Engel et al. 2001). These effects can affect the performance needed to fly. Hearing is the second most important physiological sensory mechanism to obtain critical information during an aircraft operation (Federal Aviation Administration—FAA). Auditory effects such as Noise Induced Hearing Loss (Foltz et al. 2010), well as temporary loss threshold, can hide warning signs, thus increasing hazardous situations. In addition, the noise does not allow the use of information technologies based on auditory stimuli, as well as better equipment for communication.

The exposure depends on both the noise intensity and the exposure time. It is necessary to consider that pilots need to use Personal Protective Equipment (PPE) that plays an important role in decreasing exposure (Foltz et al. 2010). On the other hand, the losses caused by noise occur along an exposure time (Guimarães et al. 2004). Thus, the pressure for deadlines and intense work rhythm, common to the agricultural pilots (Barach & Baruch 1970; Billings 1963; Gordon & Hirsch 1986; Perry 1969; Richter et al. 1981) can increase the exposure time while decrease recovery time.

In the agricultural aircrafts, power system generates the main noise source that comes to the cockpit from the aircraft's nose through their structure and fuselage at high intensities (Foltz et al. 2010). Other noise sources include the friction of the fuselage and other mechanical components with the air (e.g. spraying equipment) and the ground (e.g. landing gear). Different stages (e.g. refueling, takeoff, landing, etc.) have different noise intensities, because the influence or its factors variations (e.g. power used, wind direction and ground contact). Different aircraft also have different characteristics (e.g. cockpit closing mechanisms) that can decrease noise exposure. In addition, different types of products need different equipment installed in the aircraft that can generate different noise intensities. In this study, we sought to characterize noise exposure in different aircrafts (most used in southern Brazil) and different types of application (e.g. herbicide and fertilizer) according to the equipment used and time between takeoffs.

To reach this goal, the noise levels were collected in different work situations (see details in section 2). The measurements results are showed in section 3, within a discussion related to the research field, followed by the conclusions.

2 MATERIALS AND METHODS

The changing nature of the noise intensity in agricultural aircraft makes necessary an assessment of noise dose, where the equipment performs a number of measurements of noise level and generates a projection for daily exposure. The criteria reference that supports the daily exposure corresponds to a 100% dose for an exposure time of 8 hours at the level of 85 dB(A). Furthermore, the assessment considers doubling of the dose ($q = 3$), in other words 88 dB(A) or 85 dB(A) + q is equal to the 200% of the daily exposure.

The data were recorded in three situations: considering EMB-201 A aircraft and EMB-202 aircraft applying herbicide, and EMB-202 aircraft applying fertilizer. These tree situations allowed understanding the differences of noise exposure in different aircrafts and different activities of crop protection. The difference between aircrafts is that EMB201 A aircraft, predecessor of the EMB-202 aircraft, does not have air-conditioning system, and so, having a worst sealing cockpit, and thus, it is expected that exposure is greater for their pilots. The difference between herbicide and fertilizer is the equipment installed and the unloading time. Furthermore, a system of mechanized loading was used, where downtime aircraft that allows the rest of the pilot are minimized.

The data collection to analyze noise dose, were performed by a dosimeter *Brüel & Kjær*, model 4445, Version 1.05, equipped with a microphone *Brüel & Kjær*, model MM 0111, mounted at 10 centimeters far from the pilot ear. The following parameters were used according to ISO1999:1990 standard: criterion level = 85 dB; measurement frequency = 1000 Hz; projected period specified by the user = 8 hours; Root Mean Square (RMS) weighing = A; weighted peak level = C; time weighting = fast; measuring range = 70–140 dB; and, interval between measurements = 1 minute. All measurements were performed after standard procedure for instrument calibration, using a *Brüel & Kjær* 4231 caliper, frequency 1000 Hz ± 0,1%, distortion < 1%, and sound pressure level = 94 dB or 104 dB ± 0,2 dB. A second calibration was taken after the procedures, with the same gauge and microphone used in the measurement, and the same parameters as calibrated before. The data obtained by the measurements were recorded and analyzed through *Brüel & Kjær Noise Dose Meter Link Software* VP7790, version 2.02.

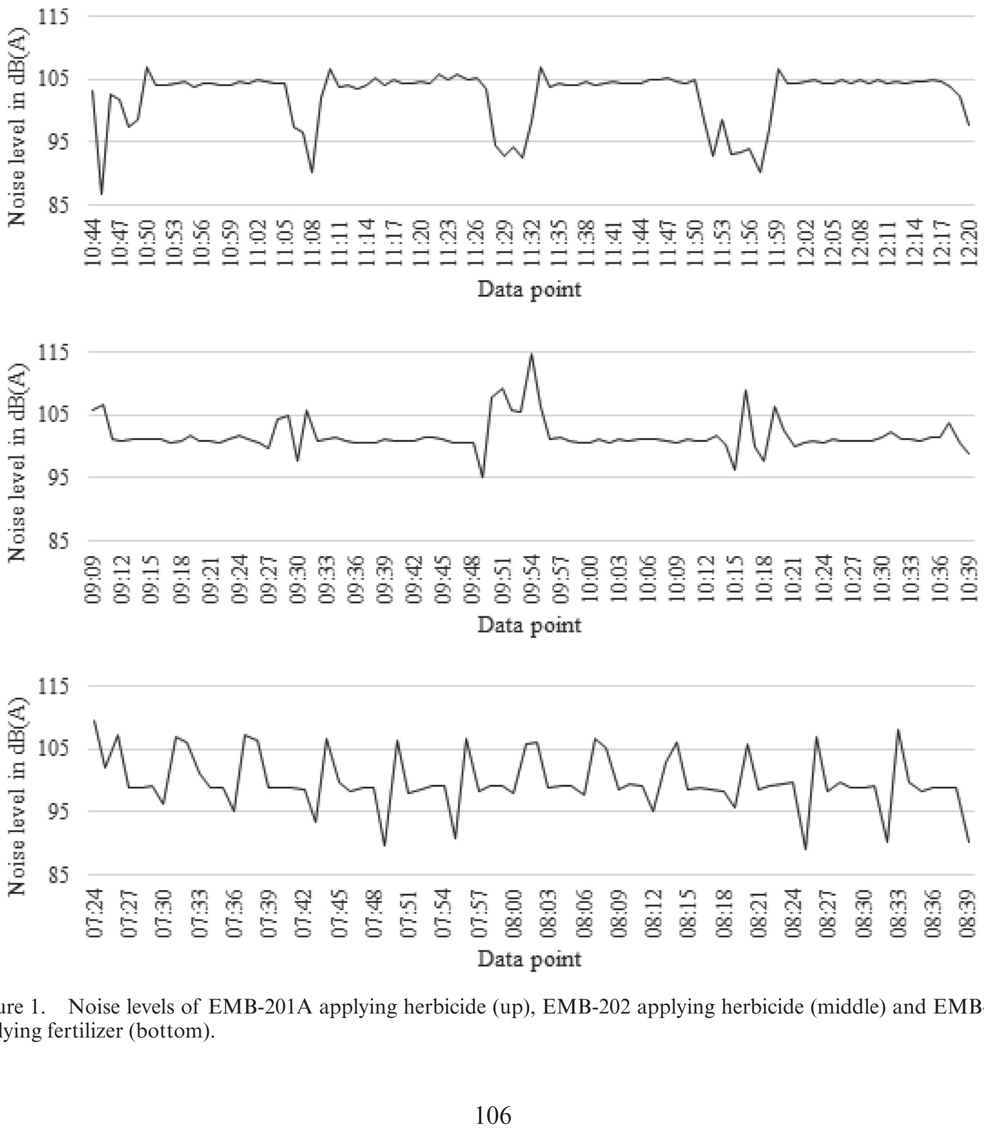

Figure 1. Noise levels of EMB-201A applying herbicide (up), EMB-202 applying herbicide (middle) and EMB-202 applying fertilizer (bottom).

3 RESULTS

The noise intensity in the cockpit of agricultural aircrafts changes rapidly, mainly due to the difference in engine power, which changes according to the activity performed. The lowest recorded readings correspond to the aircraft landing and loading, steps where low engine power is required. The highest readings correspond to takeoff, where maximum engine power is required, with fully loaded aircraft. In addition, during takeoff, noise is increased due the vibrations generated by contact of the aircraft with the ground.

According to the type of product to be applied, the sequence of steps performed showed different duration. For application of fertilizer, each load of the aircraft (approx. 500 kg) yielded approximately 5 hectares, being executed nearby 6 minutes. For application of herbicide, each load of the aircraft (approx. 700 liters) yielded nearby 18 hectares, and being executed in 19 minutes.

During sample collection in herbicide, the EMB-201 A aircraft showed Average Sound Level (LAV) = 101,4 dB(A), ranging from Equivalent Continuous Level (L_{eq}) = 86,8 dB(A) to 107,1 dB(A) (Fig. 1) varying according to the stage which the data were collected. Also in herbicide, the EMB-202 aircraft showed LAV = 98,5 dB(A), ranging from L_{eq} = 95,1 dB(A) to 114,8 dB(A) (Fig. 1). In the application of fertilizer, the EMB-202 aircraft, showed LAV = 97,5 dB(A), ranging from L_{eq} = 89,0 dB(A) to 109,6 dB(A) (Fig. 1).

The wind condition is the worse the herbicide with the EB202 aircraft. In the displacement of the aircraft from the runway to the crop, greater engine power was used than normal cruising speed due to the wind direction. However, it was not possible to determine the effect of wind in this study.

Considering the maximum daily exposure presented by ISO1999:1990, the recorded values exceeded the dose in 888,12% only in the measurement period (1:37 h), or 4391,85% for the projected dose (8 hours), when operating the EMB-201 A aircraft. For the EMB202 aircraft, applying fertilizer, the recorded values exceeded the dose in 282,40% in the measurement period (1:16 h), and 1770,78% for the projected dose (8 hours). Applying herbicide, also with EMB-202 aircraft, the recorded values exceeded the dose in 430,26% only in the measurement period (1:31 h), and 2265,26% for the projected dose (8 hours).

Exceeded levels showed that the exposure conditions were improved for EMB-202 aircraft, compared to the EMB-201 A for noise in the same level or greater than 100 dB(A) (Fig. 2). However, exposure to levels above 85 dB(A) remains a major part of the exhibition, usually registered during takeoff.

4 DISCUSSION

Previous studies cite the agricultural aviation as one of the most dangerous forms of general aviation (Bruggink et al. 1964), due to the dangers, which mainly include obstacles (Reich & Berner 1968; Ryan & Dougherty 1969; de Voogt et al. 2009) and track conditions (de Voogt et al. 2009), but do not present consistent data about the noise influence. Compared to other studies measuring noise conditions, it can be said that agricultural aircraft presents the worst situations exposure than

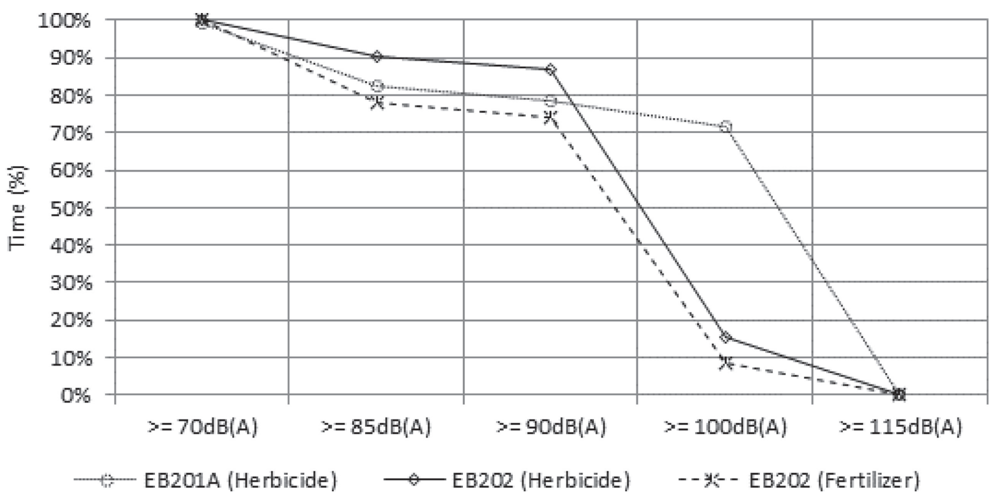

Figure 2. Exceeded levels.

all other forms of general aviation. As an example of exposure time, agricultural pilots flying from the early hours of the day, making up more than 8 hours a day in extreme noise conditions, between 87 dB(A) and 109 dB(A), as found in this study. These magnitudes are similar to those presented in studies concerning military pilots, between 80 dB(A) and 140 dB(A) (Büyükcakir 2005; Kuronen et al. 2004; Li et al. 2003) and air rescue professionals, regularly exposed to noise levels greater than 85 dB(A). It is important to consider that, in rescue situations; the crew is exposed to loud noise only working outside the aircraft. In agricultural aviation, these high levels are always present even with the insulation of the cockpit. This situation makes clear that technology used in agricultural aircraft does not ensure adequate levels of noise, based on the standard ISO1999:1990.

The characteristic of having constant takeoffs and landings makes it necessary to extensive use of maximum engine power, which increases the time when exposure is higher. This feature is also considered for air taxi pilots (Qiang et al. 2008). The lack of protection and misuse of PPE, can also increase the noise exposure (Barach & Baruch 1970; Billings 1963; Gordon & Hirsch 1986; Hall 1991; Reich & Berner 1968; Ryan & Dougherty 1969). In this context, the air conditioning system has an important role in reducing pilot exposure to noise, because the seal cockpit creates a protective barrier against noise. However, in this study it was seen that even in more modern aircraft, using sealed cockpit with air conditioning system, noise still above the recommended levels. Thus, the use of PPE becomes indispensable and their use should be encouraged by training, that enable the proper use and superior attenuation of noise levels (Toivonen 2002), as well as the monitoring by occupational medicine specialists (Küpper et al. 2010). However, it requires solutions to reduce noise with the combination of protective devices (Fitzpatrick 1988), or rather in the development of noise reduction systems at the source. These solutions should consider the professional acceptance, in previous studies it was reported that protective devices are incompatible, uncomfortable, and as causes difficulties even an impediment to communication (Abel 2005). As already suggested in earlier studies, using the knowledge of professionals involved, the product development and technology seems to be a suitable alternative for future projects, as well as strategies for monitoring and control.

5 CONCLUSION

The noise levels presented in this study are too high, even in the most modern aircraft equipped with sealed cabin and air-conditioning system. It was evident the need of PPE use to ensure the hearing integrity of the pilots. Besides the proper use of PPE, it is essential to create a culture of its inspection. However, it should be understood that the use of EPI should not be seen as the main solution to the problem, but as an interim action. It is recommended to create strategies to reduce noise levels at the source, create barriers against the noise transmission to aircraft cockpit and/or managing exposure time.

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Occupational noise exposure and the exposure to ototoxic substances: A case study in the injection sector in the footwear industry

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ABSTRACT: The footwear industry presents several risks to workers, being noise one of the most important. This works aims to evaluate the occupational noise exposure in the injection sector of a footwear industry, in accordance to Decree-Law nº 182/2006 and the guidelines of the NP EN ISO 9612. The possibility of a combined effect with ototoxic substances will also be analysed. The results indicate that workers were exposed to a $L_{EX,\,8h} \geq 85$ dB (A). The hearing protectors available provide different noise attenuations, being observed differences in the acceptability when the Portuguese law and NP EN 458 guidelines were compared. Since the use of at least one solvent containing ototoxic substances was identified, a combined effect with the noise was considered to be synergic. Despite the obtained results from this analysis, it was considered urgent to control the exposure, particularly in implementing collective measures priority to individual ones.

1 INTRODUCTION

Currently the manufacture of footwear is widely recognized as a traditional industrial activity in Portugal and assumes some relevance in the current national economy (ACT, 2013).

The footwear industry along the production process has several risks to workers 'safety and health', and exposure to noise is one of the risks with greater expression, being also transversal to other sectors of activity (Arezes & Miguel, 2001).

The gradual decrease of hearing acuity, resulting from continued exposure to high sound pressure levels, characterizes the Noise-Induced Hearing Loss (NIHL) in industrialized countries and which stands out as a major risk to the health of the worker (Cavalcante et al., 2012). However, there are other agents in the workplace such as the use of ototoxic substances or the use of other agents outside work, that may be considered ototoxic agents or that "have toxic effects on the auditory system" (Santos, 2013). The current information on this topic suggests that workers exposed to ototoxic substances and high noise levels are more likely to suffer hearing problems than workers exposed to these risk factors separately, making imperative attention for the existence of a combined exposure (Santos, 2013). Also according to the publications of the European Agency for Safety and Health at Work, this topic was already regarded as an emerging risk (Santos, 2013).

So the general goal of this case study was the evaluation of the occupational exposure to noise, the analysis of the possibility of a combined effect with ototoxic substances and, if necessary the development of proposals for preventive and/or corrective measures. To achieve this issue several specific objectives were defined: (1) Quantification of the level of occupational noise; (2) Characterization of the exposure in accordance with the Decree-law n.º 182/2006 of 6 September and the NP EN ISO 9612; (3) Identification of the sources of noise in a given sector and study of the possible influence of this noise to other sectors; (4) Comparison of the obtained values with the reference values under the current legislation; and (5) Verification of the adequacy of the available hearing protectors.

2 METHODOLOGY

The strategy to conduct the case study was divided into five main steps: (1) Characterization of the industry and the study sample; (2) Definition of the measurement strategy; (3) Equipment and measurement conditions; (4) Data processing; (5) Identification of the chemical substances and analysis of the possibility of a combined effect of noise and ototoxic substances.

2.1 *Characterization of the industry and the study sample*

In order to help the characterization of the industry a diagnosis sheet was developed and applied on the field. Relevant information was also obtained through direct observations on the field and interviews with the safety technician.

2.2 *Definition of the measurement strategy*

According to the guidelines proposed by the NP EN ISO 9612:2011, a task-based strategy was used. Measurements were performed in accordance with Decree-law nº 182/2006 of 6 September and the guidelines of the NP EN ISO 9612.

To ensure the representativeness, the measurements were carried out under normal operating conditions of sound sources and in the presence of the worker, with the same running tasks, methods and usual cadences.

If the daily exposure of workers was higher than the values of action legally defined (lower value of action $L_{EX,\,8h}$ = 80 dB (A) and L_{Cpeak} = 135 dB (C), higher value of action $L_{EX,\,8h}$ = 85 dB (A) and L_{Cpeak} = 137dB (C)), a new measurement of sound pressure level was undertaken with an octave band filter, to measure on the adequacy of hearing protectors.

The equivalent continuous sound level, A-weighted ($L_{Aeq,\,T}$), maximum and minimum values and the maximum values of instantaneous sound pressure C weighted (L_{Cpeak}) were recorded in each measurement.

2.3 *Equipment and measurement conditions*

A precision sound level meter class 1 was used: Brüel & Kjaer, Model 2238; serial nº 2448496, with a Brüel & Kjær microphone mod. The equipment was certified by the Portuguese Institute of Quality and subject to periodic checks and calibrations.

2.4 *Data processing*

A spreadsheet was developed to collect data from the field. To estimate the daily personal noise exposure defined in accordance with the gathered information, a characterization of the productive process regarding the distribution of the different work stations/task, was made. For that purpose, an interval time of exposure was assigned.

The value of the expanded uncertainty, U, was calculated based on the NP EN ISO 9612. Therefore, the value of $L_{EX,\,8h}$, was calculated with the associated uncertainty (LEX, 8h + U). Later on, the results were compared with the values legally defined. If the obtained value of $L_{EX,\,8h} + U$ exceed the legally values, a calculation of the effective daily personal exposure, $L_{EX,8h,\,efect}$, was made.

In order to verify the adequacy of the available hearing protectors, a comparison of the criteria of acceptability of the Portuguese legislation and those presented on the NP EN 458, was made. According the Portuguese legislation the criteria are: (1) satisfactory, when the $L_{EX,\,8h,\,efect}$ <85 dB (A) and (2) insufficient, when the $L_{EX,\,8h,\,efect} \geq$ 85 dB (A). According to the information of the NP EN 458 and considering a working-period of 8 hours the criteria are (1) excessive protection if the $L_{EX,\,8h,\,efect} \leq$ 65 dB; (2) acceptable if the $L_{EX,\,8h,\,efect}$, 8h is between 65 dB (A) and 70 dB (A) (included) (3) satisfactory regarding the interval of 70 dB (A) < $L_{EX,\,8h,\,efect} \leq$ 75 dB (A); (4) acceptable to 75 dB (A) < $L_{EX,\,8h,\,efect} \leq$ 80 dB (A) and finally, (5) insufficient if $L_{EX,\,8h,\,efect}$ > 80 dB (A).

2.5 *Identification of the chemical substances and analysis of the possibility of a combined effect of noise and ototoxic substances*

Firstly, an identification of the chemicals used in the section under study, was made. For that purpose, the Chemical Safety Sheets available in the company were consulted. This step allowed the selection of the substances that possibly have an ototoxic effect. Then, a literature review was performed in order to show evidence about this subject.

3 ANALYSIS AND DISCUSSION OF RESULTS

3.1 *Characterization of the industry and the study sample*

This study was conducted in the footwear industry, namely in the 4th sector of the injection process, with a total of 16 workers. This sector was selected due to indications of the industrial engineer responsible for the production. Also previous studies conducted in the company indicated a gradual noise-induced hearing loss among workers of this section. Notice that in the production area, the injection section was adjacent to the assembly and finishing sections. No separation/physical barrier between sectors was identified.

Due to the productive process, only the second sift was considered for analysis. The sample was composed by eight male with an average age of 42 years old ± 8 years. The workers presented in average 16 years ± 7 years of work in noisy environments.

Previous evaluations of noise exposure and audiometric tests made by the technical services of the company, resulted in the selection of two models of hearing protection for personal protection: the 3M1271 and the SMARTFIT.

3.2 *Results of measurements—evaluation of occupational exposure to noise*

Measurements were performed considering the totality of the tasks performed on the 8 hours shift.

Results for each worker daily exposure to noise are presented in Table 1.

According to the Decree-Law No. 182/2006, the workers are exposed to levels equal to or above the upper action value (85 dB (A)). The highest value was recorded in the Hammering and Shaping tasks. Regarding the peak values (L_{Cpeak} dB (C)), results indicate lower values than those of action values. Thus, in accordance to the legislation, the employer shall establish and implement a program of technical and organizational measures leading to the reduction of the exposition.

According to the results, the implementation of risk control measures were recommended, namely: (1) reduction of the noise at source and in the transmission namely by, improving the ventilation system attached to the air extraction system related to the demolding station; replacing the steel hammer with a less noisy tool; implementing a periodic maintenance of machines and extraction systems and replacing metal benches by another material less transmitter noise; (2) reducing noise radiation by the optimization of the carding and sanding machine placement which is used occasionally; enclosing the injector with a coating of sound absorbing material to reduce the noise levels including those that can be transmitted to the adjacent posts; (3) intervening in the buildings acoustics by increasing the distance between the workstations that do not depend on direct-injection engine; and analyse the possibility of placement of noise barriers to minimize the influence of noise from other sectors in the industry under study, and vice versa. Finally, a reorganization of the work is proposed through the implementation of a turnover scheme, a definition of suitable working schedules, including rest periods. According to the general principles of prevention, these measures should be prioritized. However, until they become effective, measures of individual nature that ensures the availability and effective use of hearing protection must be considered.

Given that company offers two hearing protectors, a new measurement was made (octave band filter), to verify the suitability of the attenuation. For that purpose, the $L_{EX,\ 8h\ effect}$ was calculated. The obtained values were significantly different from those in the company's reports. This can be explained by the diversity of existing noise sources in the industry and the changings that were occurring in the layout. Thus, the noise in this sector is considered to be floating as it presents a level of noise that varies continuously and to an appreciable extent in the observation period (Arezes & Miguel, 2009).

Regarding the attenuation provided by the hearing protection aforementioned, the results indicate that different designs provide different levels of adequacy. According to the established by national legislation, it was found that the SMARTFIT model presents satisfactory adequacy for all the workers. When compared with the standard criteria, the attenuation does not differ significantly, except for three workers being considered acceptable for these. With regard to the protective 3M 1271 and also according to the standard, the attenuation was satisfactory only for a worker and insufficient for two workers, being acceptable for the remains ones. Regarding the criteria establish in the Portuguese Decree-law, only one hear protect attenuation demonstrated to be insufficient.

A disagreement between the NP EN 458 and the Decree-law criteria on the adequacy of the attenuation conferred by the protector 3M1271 was found in the results obtained in one worker. That is, according to Portuguese Decree-law attenuation is satisfactory and according to the standard criteria is insufficient. However, the legislation provides

Table 1. Characterization of worker daily exposure to noise (8 hours shift).

Workers	Task	$L_{Aeq,\ T}$ dB (A)	$L_{EX,8h}$ dB (A)	U	$L_{EX,8h}$ + U dB (A)	$L_{EX,8h,\ efect}$ dB (A) with protection SMARTFIT	$L_{EX,8h,\ efect}$ dB (A) with protection 3M 1271	L_{Cpeak} dB (C)
1	P1—Hammering and shaping	89,0	89,0	2,2	91	75	81	131
2	P2—Supply machine	83,4	83,4	2,3	86	68	75	118
3	P3—Application of mold release/PSA 1	85,4	85,4	2,2	88	70	76	114
4	P4—Carding/PSA 2	87,5	87,5	2,1	90	71	78	128
5	P5—Unmould	82,7	84,2	1,5	86	72	78	117
	P6—Deburring	85,3						
6	P7—Retouching/finish	82,8	82,8	2,1	85	72	79	126
7	P8—Painting booth	83,4	83,4	2,1	86	78	87	114
8	P9—Supervision	85,1	85,1	2,2	87	71	79	124

that, if technically possible, $L_{EX,\ 8h,\ effect}$, should be lower than the lower action, which agrees with that defined in the standard.

3.3 *Ototoxic substances*

Some constraints have been identified to obtain the Chemical Safety Sheets for the chemical substances used in the production. The company provided the Safety Sheet just for one solvent. The information reported the presence of n-heptane with a concentration of 70% in the composition of this solvent. According to Santos (2013) the n-heptane is considered to be an ototoxic substance. Also, the safety technician reported that some inks were used in the production and were also solvent based. According to Santos (2013), these can be a source of exposition to ototoxic substances (example, p-xylene, toluene, etc.).

Even though the combined effect of noise and ototoxic substances was not proved, this effect should be considered. According to Santos (2013), the effect is synergic. That's way; some prevention measures are recommended namely, the replacement of a solvent by another which does not have ototoxic substances in its composition. The quantification of the occupational exposure to chemical agents and the analysis of the possibility of dispersion agents by the adjacent sections should also be analysed.

4 CONCLUSION

Results indicate that the workers are exposed to a noise level higher than the action level defined by the Portuguese Legislation ($L_{EX,\ 8h} \geq 85$ dB (A)).

The analysis of possible causes for the obtained sound pressure levels identified the injection nozzles, the use of hammer and the paint station as main sources. In this sense, constructive and organizational measures were proposed.

Results also showed differences in the criteria defined by the Decree-Law n.° 182/2006 of 6 September and NP EN 458 for the acceptability of the attenuation conferred by hearing protectors between, once the national legislation does not include possible episodes of overprotection; scenario provided the NP EN 458.

The use of chemical products that contain ototoxic substance in its composition, such as the n-heptane was demonstrated.

5 LIMITATIONS TO STUDY/FUTURE WORK

This case study has raised some limitations that can become opportunities for future work, including: (1) the application of questionnaires to the workers, for the collection of symptoms related to the noise and perception towards risk; (2) the analysis of correlations between measurable hearing loss on audiometric tests and duration of exposure to noise sources, held in noisy places, the combined effect of exposure to ototoxic substances, effective use of hearing protection; (3) the application of the established methodology to other companies and, (4) the determination of the concentration of ototoxic substances in the workplace.

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Exposure of agricultural pilots to Whole-Body Vibration

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ABSTRACT: The Whole Body Vibration (WBV) can cause losses for both health and safety. Between agricultural pilots, the WBV exposure can promote the occurrence of low back pain and other degenerative spine's diseases. Furthermore, WBV can cause visual problems, neuromuscular interferences and other problems related to performance and thereafter to safety. Based on these work-related problems, the aim of this study is to determine the projected dose, in different aircrafts (the most used in Brazil) and different procedures of crop protection. The results showed that WBV levels are above the exposure limit values, compared to the Directive 2002/44/EC.

1 INTRODUCTION

The exposure to WBV occurs when a person are exposed to head-to-toe vibration (Wasserman 2001). Samples of occupational exposure to WBV include truck, bus, heavy equipment, forklift, and farm vehicle drivers, train engineers and conductors, helicopter and fixed-wing aircraft pilots and ship personnel. The WBV exposure represents a loss and a high risk to the professional environment and can influence the health and safety of the persons exposed (Griffin 1990; Seidel & Griffin 2001; Brammer 2010).

Health effects mainly include low back pain (Boshuizen et al. 1990; Bovenzi & Hulshof 1999; Lings & Leboeuf-Yde 2000; Wasserman 2001; Wilder et al. 2002; Litchfield 2003; Guimarães et al. 2004) and degeneration of the lumbar vertebrae (Wasserman 2001; Wilder et al. 2002), may also have effects on the circulatory, gastric and auditory-vestibular systems (Litchfield 2003).

Concerning to safety, WBV can cause difficulties in vehicles control due to the resonance associated with some frequency bands (Griffin 1990; Wasserman 2001; Brammer 2010). The frequencies that affect the visual and vestibular systems may cause difficulties in orientation and reception of visual information (Lewis & Griffin 1978; Ishitake et al. 1998; Guimarães et al. 2004), which are of fundamental importance for the agricultural pilots. In addition, the WBV may be related to other psychological problems that cause mainly the loss of attention and concentration (Griffin 1990; Litchfield 2003; Smith & Bramer 2008).

For the agricultural pilots, WBV exposure occurs due to the vibrations generated by the propulsion system (motor and propeller) as well as by contact of the landing gear with the ground during takeoffs and landings. One of the main characteristics of the agricultural aircraft operations is the use of specially built tracks. However, these tracks generally improvised, have surface irregularities, which cause shocks and high intensity vibrations.

Based on these factors, this study aims to determine the WBV dose supported by agricultural pilots. To do this, is measured WBV dose in two of the aircrafts most used in Brazil (EMB-201A and its successor EMB-202) and in two different crop protection procedures (Fertilizer and Herbicide dusting), better described in the next section.

2 MATERIALS AND METHODS

Some of the characteristics of the aerial application cited in section 1 (Aircraft model and kind of crop protection procedure), can make the WBV exposure variable. Different aircraft may have significant differences, either in structure or in the interface with the pilot. Different crop protection procedures need different equipment installed in the aircraft. In addition, different cycle times is performed (for each takeoff), changing the time that the aircraft meets the ground. Thus, these characteristics can influence the WBV supported by the pilots.

The measurement of WBV was carried out in two different aircrafts and two kinds of crop protection procedures. It was used an EMB-201A aircraft applying herbicide, an EMB-202 aircraft applying herbicide and an EMB-202 aircraft applying fertilizer. Data were collected following ISO2631-1:1997 standard procedures (International Standards Organisation 1997), using a *Brüel & Kjær* human vibration analyzer type 4447, hardware 1.5, firmware 3.0.1, equipped with a Seat Pad *Brüel & Kjær* 4515-B-002 where is mounted an accelerometer *Brüel & Kjær* 4524-B–001. The Seat Pad was mounted on the interface between the aircraft seat and the pilot. This instrument was configured with the following parameters: criterion for value of vibration in terms of acceleration (Root Mean Square—RMS) = 0,5 m/s^2; projected period (user specified) = 8 hours; Unit = m/s^2; frequency range = 0,25 Hz–900 Hz; operation range = 0,1 m/s^2–320 m/s^2 ± 0,01 m/s^2; and, interval between measurements = 1 second. All measurements were performed after standard procedure for instrument calibration, using a *Brüel & Kjær* 4294, frequency of 159,2 Hz. A second calibration was taken after data collection, with the same

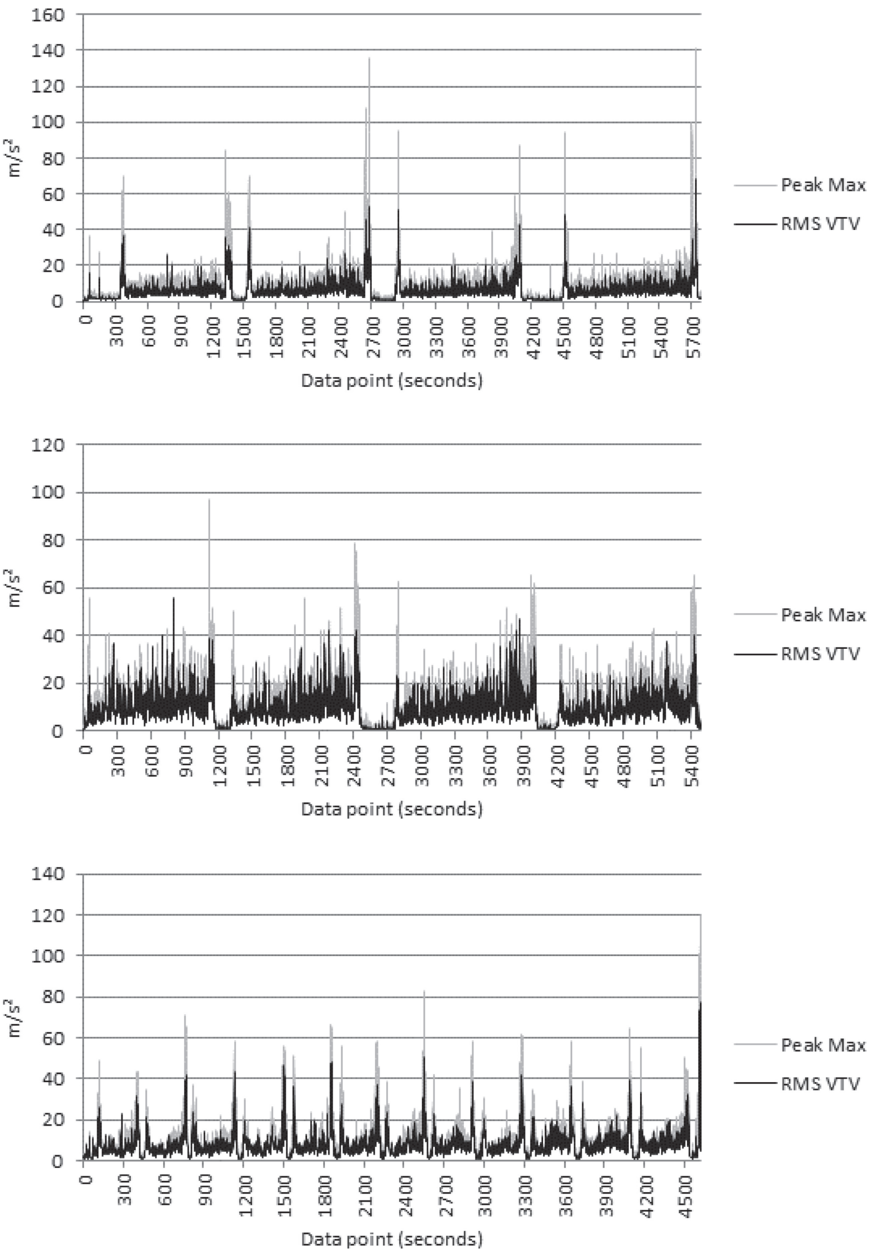

Figure 1. RMS VTV and Peak for EMB-201A applying herbicide (top), EMB-202 applying herbicide (middle, and EMB-202 applying fertilizer (bottom).

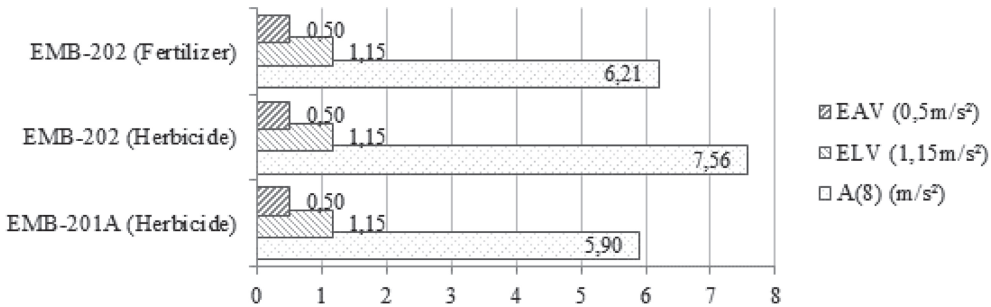

Figure 2. Weighted acceleration (for eight working hours), compared with ELV (1,15 m/s²) and EAV (0,5 m/s²) for the tree samples.

calibration device, same accelerometer used in the measurement, and the same parameters as the first calibration. The collected data were recorded and analyzed using a *Brüel & Kjær* BZ-5623 4447 Vibration Explorer Software, v. 2.0.0.

3 RESULTS

In accordance with the type of crop protection procedure, the stages of the work had different cycle times. For herbicide application, the complete task was done in approximately 18 minutes, while, in the fertilizer application was finished in only 5 minutes. Samples collection allowed us to identify the Vibration Dose Value in RMS (RMS VDV), maximum peak level (Peak), and value of daily exposure (8-hour reference period) to WBV (A(8)). EMB-201A aircraft applying herbicide, (sample = 01:36:41, n = 5792), showed RMS VDV = 8,053 m/s² and Peak = 141,490 m/s². Also applying herbicide, EMB-202 aircraft (sample = 01:31:40, n = 5493), showed RMS VDV = 11,098 m/s² and Peak = 96,774 m/s². Finally, EMB-202 aircraft applying fertilizer (sample = 01:17:11, n = 4624) showed RMS VDV = 9,470 m/s² and Peak = 120,277 m/s². Figure 1 show data points corresponding to the combined axis (X, Y and Z) Vibration Total Value (RMS VTV) for these three situations respectively.

Highest recorded measures for each procedure correspond to takeoff and landing, where aircraft landing gear meets the ground, and the shocks are constant due to irregularities in the track. Note that during the application of fertilizer, with shorter cycles, the agricultural pilot is exposed to high intensities of vibration due to the more frequent takeoffs and landings, periods in which the aircraft is in contact with the ground. Lowest measures recorded correspond to loading and refueling, where the engine power is the lowest used.

For the three samples, RMS VDV was compared to Exposure Action Value (EAV) and Exposure Limit Value (ELV), as recommended by the Directive 2002/44/EC (European Commission 2002) (Fig. 2). The EAV set the level of vibration that need action (for WBV, EAV = 0,5 m/s²), and ELV set the maximum value must not be exceeded in a single day (for WBV, ELV = 1,15 m/s²). EMB-201 A aircraft applying herbicide showed the lowest RMS VDV, however, the exposure is higher than recommended by standard. Only during loading and refueling RMS VDV stay lower than ELV, reaching EAV in 02:05 hours.

4 DISCUSSION

The vibration present in the cockpit of agricultural aircrafts can come from many sources, including the mechanical systems, wind and contact with the ground. These are transmitted to the interfaces with the pilot through the aircraft structure composed typically of tubular profiles, manufactured with carbon steel.

In the context of agricultural aviation some studies as Gribetz et al. (1980) and Richter et al. (1980) presented the vibration as a contributing factor for the occurrence of accidents. However, these studies have their focus to other work-related problems. Thereby, the exposure to vibration of agricultural pilots is not adequately explored.

Other studies have addressed the exposure to WBV for train drivers (Boshuizen et al. 1990; Birlik 2009), forklift drivers (Hulshof et al. 2006; Boshuizen et al. 1990), truck drivers (Nitti & De Santis 2010), drivers of agricultural machinery (Milosavljevic et al. 2011; Boshuizen et al. 1990), etc. In the general aviation, studies have mainly addressed WBV of helicopter pilots (de Oliveira et al. 2001; De Oliveira & Nadal 2005; de Oliveira & Nadal 2004; Kåsin et al. 2011; Balasubramanian et al. 2011; Aydog et al. 2004) and fighter pilots (Smith 2004; Aydog et al. 2004). In all of these studies, the most important factor that contributes to increase the intensity of vibrations was the contact of mechanical systems with the ground. In agricultural aviation particularly, with improvised tracks, and with the aircraft at high speeds, contact with the ground becomes a serious aggravating factor. The shocks contribute too much to the results, which, in the three analyzed situations, are higher than recommended by standard. This factor is most evident when comparing the results between the applications of fertilizer and herbicide by EMB-202 aircraft. In the case of fertilizer, which the takeoffs and landings are more frequent, the exposure was higher.

In conclusion, face to the possible health and safety problems pointed out in the contextualization of this study (Section 1), it is necessary to take preventive measures, including the improvement of the insulation of the interfaces, in the work shift regulation, and the improvement of track conditions.

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Ergonomics cost-benefit indicators on a large auto parts manufacturer

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ABSTRACT: The need to include financial benefits as means to justify investments in interventions is discussed on companies and on scientific literature. On both situations there is a relationship between the need of certain information to quantify these benefits and the barriers represented by the lack of knowledge and the disrepute of Ergonomics among managers. This paper aims to analyze the ergonomics cost-benefit related indicators in a Brazilian auto parts manufacturer. A systematic model created to support the cost-benefit analysis of ergonomics projects was applied. Within the model, a checklist of productive, administrative and occupational health management indicators was investigated concerning its use by the company. Results shows that most of the indicators used by researchers were also available in the company management system but not whit the expected ergonomics financial justification approach.

1 INTRODUCTION

Scientific studies have indicated that occupational problems, which in many cases can be reduced through ergonomics, often generate quantifiable financial losses for companies in many areas (Hendrick, 2003; Beevis, 2003). The criteria to measure the advantages of ergonomics projects are similar to those of other areas within an organization and need to pass through cost-benefit analysis. Given the business perspective on investments to improve working conditions, there have been many discussions about the cost-benefit of Ergonomic projects. Simpson (1990), Andersson (1992), Oxenburgh (1997), Grozdanović (2001), Beevis (2003), Hendrick (2003), Morse and collaborators (2009) and de Looze and collaborators (2010) among others, have presented successful business cases of Ergonomic projects. These authors discussed the need to include economic and financial benefits as means to justify investments in interventions, ranging from prevention programs to substantial modifications on production lines.

The results of such studies and some reviews (Goossens & Evers 1997; Nelson & Hughes 2009; Tompa et al. 2010; Neumann & Dul 2010) should be used as good practice guides to ergonomists and occupational health and safety professionals. Even so, there is a need to use this information in a better way, aiming to analyze real-life situations. As much specific and wider the description of those could be, better will be the way to companies use productivity data to demonstrate the need for improvements in working conditions.

Tompa and collaborators (2010) presented some reasons to understand the lack of studies about Ergonomic projects that performed economic analysis, explaining also, why these are usually of poor quality. One reason is that there are few practical guides about costs and benefits of interventions; other is the shortage of available information in the organizations. These hindrances represent major technical challenges that result in serious difficulties to obtain useful and reliable information.

One of the most critical points of this discussion is the relationship between the need of certain data to quantify benefits and the barriers represented by the lack of knowledge and the disrepute of Ergonomics among managers (Da Silva et al. 2014). Prior to performing cost-benefit analysis, it is necessary to identify which costs will be considered, and how they will be measured (Goossens & Evers 1997). However, managers which often are skeptical about Ergonomics do not have the necessary information to perform any kind of cost analysis (Beevis 2003). Furthermore, there is still no defined way to use and organize such information when it comes to Ergonomics projects. There are no exclusive indicators related to current ergonomics conditions of a company, for they may include data associated to the productive process, occupational health and safety and also costing information.

One of the main barriers is the absence of available management indicators directed for this purpose. Hence, a miscalculation of possible financial benefits of ergonomics intervention caused by the lack of the right set of information is common among companies with different complexity levels. The aim of this paper is to analyze the ergonomics cost-benefit related indicators in a Brazilian auto parts manufacturer. Thereby, is possible to understand how those improvements in the working conditions can be justified trough companies indicators and the support of managers.

2 MATERIALS AND METHODS

To attend the purpose of this paper, a systematic model to support the cost-benefit analysis of ergonomics projects (Da Silva 2012) was applied in a southern Brazilian large auto parts manufacturer. The analyzed company is an auto parts manufacturer that provides to an also large car manufacturer. There are more than 1500 workers at their site and several ergonomics difficulties mainly on the production. The company was visited on 2013 and the model was applied with the acceptance of the board directors.

The systematic model consists on a framework based on literature review about ergonomics interventions considering cost-benefit analysis in their evaluation. The model structure involves four steps:

a. Introduction of the concepts: considering that those hypotheses are not well known among managers; on the first meeting with a group of twelve managers the main theoretical concepts was presented. The topics discussed were: ergonomics definitions, intervention approach, possible benefits, cost-benefit analysis and published success cases. Questioning and discussion about the topics was encouraged in order to balance the ergonomics understanding.
b. Definition of the sponsors: each sponsor is a manager with experience in their department that could be responsible for answer to this research interview; the definition of the sponsors for each department took place; a group of eight managers representing the human resources, occupational safety, occupational medicine, production, process engineering and juridical department was defined; the model's checklist information was the basis to that choice; this checklist presents a group of financial and non-financial cost-benefit information used on ergonomics studies (*e.g.* health treatment costs, rework costs, absenteeism index, hiring costs, etc.).
c. Investigation around the indicators through interviews; individual interviews with the sponsors to feature the indicators form of use by the company; three categories separate the specific indicators into productive, administrative and occupational health aspects (Table 1). This was necessary to avoid misunderstandings with the sponsors, but the categories were not exclusionary regarding the interviews. Rework costs indicators, for example, was questioned even for administrative sponsor. Every type of information on the checklist was inquired to the respondent in order to understand how the institution manages them and how ergonomics projects can be related to each indicator.
d. Limitations and possibilities for improvement and suggestions: for indicate new indicators and form of use that could facilitate the cost-benefit analysis on the company ergonomics projects; the checklist's information that is not used or it is not known by the company management can indicate the improvements possibilities and suggestions; this was a delicate step because the relation of absence of information and suggestion is not direct; it was important to discuss two questions with the sponsors: (1) it is possible to implement the suggested indicator into the company management system? and (2) the indicators already known were considered on the ergonomics cost-benefit analysis context?

Table 1. Checklist of financial and non-financial data (Da Silva 2012).

Category	Non-financial data	Financial data
Productive aspects	Productivity Work days missed Products with errors, defects or returns Task cycle time	Cost of substandard performance Rework costs
Administrative aspects	Turnover Overtime	Compensation cost due to work leave Administrative procedural costs for new hires Judicial proceedings, fines, and compensation costs due to injuries or illnesses Cost of training new workers
Occupational health aspects	Absenteeism due to injury or illness Loss of time due to injury or disease Prevalence and severity of injuries and disease Prevalence of physical pain	Costs of treatment of illnesses or injuries (physicians, tests, prescription drugs, physical therapy, transport)

3 RESULTS

Considering the information about occupational health, one of the most important indicators considered by company managers is the absenteeism caused by injuries or occupational diseases. This information is sourced on medical and human resources company's sectors. The doctor's office is located in the company and the employees can access it anytime they please. During care routine, the doctors register plenty of information about the worker and the most serious or the ones that will result in work absence are reported to the human resources department. The Human Resources department deals with all cases of work absence related to occupational health. Other factors as social and economics are source of further absenteeism causes. The occupational health's most important information is based on number of lost working days, allowance and medical certificates. Depending on how many days will the employee be away from work, the managing of the information varies because it can be accounted at different cost centers and at more or less specific sectors. Longer absences generate the need of an investigation about sector and job's work conditions of the employee away. Also is done an indirect study of the injury's severity by analyzing how many days the worker missed work.

In this context, another kind of information the company manages is the incidence of employees' physical pain. This indicator is measured at least once a year at periodic medical examinations by applying questionnaires as Body Part Discomfort scale (Corlett & Bishop 1976).

Besides pain registry, the severity/intensity is also investigated by analog visual scales realized by the physiotherapy department.

Cost indicators may consider only employees' injuries' treatments and not all of them have occupational source. Among treatment costs are: data of first aid post, physiotherapy, gym, corporative gymnastic programs, pharmaceutical drugs and medical exams.

Is important to emphasize the way the company manages occupational health is known as self-managing, at it every workers' health control is internal. Besides, each unity's managing indicators compound a global indicator, which results influence the employees' health plan and benefits' format and quality.

The administrative indicators more related to ergonomics that the company owns are: turnover, overtime, training staff costs and new employee's hiring costs. Among these, only overtimes is known to every job and used on improvement projects. The turnover indicator is known but is not specific neither used on projects. Training staff and hiring costs are not used as well. These last ones are collected by an outsourced company which makes new employees' selection and hiring and they are considered fixed costs and there is no way of cut it on a short or medium time.

The company uses as mainly production indicator one that relates the quantity of hours applied on operations and effectively worked hours. The operations named encompass all departments and company activities and the number of worked hours is controlled by point card system. The fact of there is not a production indicator which may be associated to a job or specific production line makes hard the benefits' quantification generated by an ergonomic improvement.

Further than that, the performance's variations are continuously followed and when there is a lower performance there is also a financial quantification of this lost.

In this case, the performance cost is calculated considering lead time (cycle time) variations, efficiency fall and their associated costs.

Besides the production indicator be the mainly, other indicators related are also part of company's management, as loss of time and missed days, for instance. The lost of time is known by some departments inside the company and is controlled by engineering department. In case of work missed days the company also controls the impact on the general production indicator, beyond the quantity of lost work days. The cost related to job mistakes and rework is partially known. The more direct indicators refer to scrap costs and the mistakes' number and severity which are controlled by quality department.

One of the main results regarding all the interviews was the lack of ergonomics financial justification approach. None of the sponsors mentioned ergonomics interventions established under financial indicators on the company. Nevertheless all of them endorsed this kind of approach.

4 DISCUSSION AND CONCLUSION

This paper presented a study seeking to help a better quantification of Ergonomics projects' benefits in a large auto parts manufacturer. Results show that most of the indicators used by researchers were also available in the company's management system, however not with the expected ergonomics financial justification approach.

It is important to discuss how the characteristics of the company can impact on the improvement possibilities. The absence of a complete financial loss information, or even its insufficient use, associated with the unfamiliarity with the pre and post-intervention comparison logic are negative results. The company's perception of occupational problems, which can cause considerable financial losses and therefore should guide ergonomic interventions is blocked, so any action in this sense is not promoted. As a result, potentially avoidable financial losses (for example, compensation costs) are added to losses inherent in the productive process (such as training and rework costs), even though they could be easily reduced. The improvement possibilities aim to revert this present scenery. In this regard, one aspect is the lack of the existent information for Ergonomics projects' use and also the possibilities of different sources for this information. At last, the difficulty to use this information as it is presented, which can be solved through source suggestions (use of external tables, questionnaires). It is believed to be possible, considering that is common to have the knowledge and tools to reduce losses under more evident perspectives (such as changing machinery, for example).

Unlike Tompa and collaborators (2010) that presented the shortage of available information in the organizations as reasons to understand the lack of studies about Ergonomic projects that perform economic analysis, this case study reveled the possibility that a company could have enough indicators but don't know or don't want to use them for this purpose.

Furthermore, this research has considered characteristics and barriers of business practices and local culture, such as the difficulty to insert new management procedures and the need for a proper cost-benefit analysis on any kind of intervention (Da Silva 2012).

Other relevant point is that the use of indicators in researches seeks to present and quantify the financial benefits of ergonomic interventions, focused solely in specific problems (for instance, prevalence of low back pain in Nelson & Hughes (2009). This way, theses interventions' performance worth and cost are achieved gradually, by scientific publications such as Seeley & Marklin (2003) and Chhokar and collaborators (2005). Besides that, with regard to the Ergonomics' management, the use of such research indicators is still a gap, both in the literature and in practical terms. Such gap can be filled using an information support that makes possible to analyze projects in a more complete way, easing the inclusion of such information and analysis in managerial proceedings.

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An exploratory pilot study on occupational accidents in farming

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ABSTRACT: The statistics of occupational accidents are essential sources of information to the development of both prevention and economic policies. This work aimed to present an exploratory study on accidents at work related to farming activity. To achieve the defined objectives, data collection was done from a questionnaire prepared in accordance with the European Statistics on Accidents at Work (ESAW) and performed by interview to farmers from four villages of northwestern Portugal. Descriptive statistics, crossing of variables and statistical tests were done. Most of the accidents at work identified were not reported (75,9%). The incidence rate of non-fatal accidents identified, according to the ESAW (2001) methodology, presents a value of 7,91% per year. Regarding the incidence rate, according to the ICLS (1998) methodology, the value obtained was 10,6% per year. In the pilot region, farming activity presents an incidence rate of non-fatal accidents above the National and European average.

1 INTRODUCTION

In 2013, the European Union (EU) underlines a problem that many voices were already stressing that effective management of safety and health at work is triply advantageous: it is good for workers, business and society as a whole (EU-OSHA, 2013).

Farming is an activity that has multiple risk factors, thus many researchers have reported that the rate of occupational accidents occurring in farming sector is one of the highest of those obtained for the different sectors of activity (Kumar and Dewangan, 2009; HSE, 2013; Chae et al., 2014 and Svendsen et al., 2014).

According to the European Agency for Safety and Health at Work, workers in the agricultural sector suffer 1.7 times the average rate of non-fatal occupational accidents and 3 times the rate of fatal accidents (OSHA, 2011).

In this context, it is crucial to understand what actually happens in this sector in terms of accidents with the purpose of identifying what measures can be implemented to reduce the negative values of the variables present in the statistics.

Various study methodologies, including statistical and epidemiological analyses, studies of safety attitudes and safety behavior, case studies, near-accident studies, motion and work experiments, interviews and others, have been conducted over time (Lundqvist & Guastafsson, 1992). In the EU there is a methodology for the collection of comparable data—European Statistics on Accidents at Work (ESAW)—that began in 1990.

Based on the existence of many variables that must be evaluated in detail in the analysis of accidents at work, this study aims to test an approach in order to understand what is behind the statistics in relation to work related accidents in farms. Once validated this approach can be generalised to other populations and situations.

2 MATERIALS AND METHODS

2.1 *Data collection*

This pilot study was based on a convenience sample of 107 workers from 44 companies. In addition to the workers, data from 42 companies of four villages of northwest of Portugal have also been documented.

In the characterization of the sample, the questionnaire developed by Nunes et al., (2007), was used. This questionnaire was developed to retrieve data in a condensed way, according requirements of the ESAW. The questionnaire was designed to be adapted to any sector. In this case it was adjusted to the farming sector (in terms of specific vocabulary and nomenclature associated to the type of sector companies).

The questionnaire performed included the following surveys:

1. General characteristics of the companies;
2. Overview of the workers;
3. Characterization of occupational accidents.

The data collection model above-mentioned allowed the collection of 53 variables. Fifty eight accidents were recorded. The surveys were answered voluntarily and data processing act in accordance with the Portuguese legislation on the protection of personal data, ensuring its confidentiality. The data collection period was between March and May of 2014, corresponding to a period of accidents at work from January 2013 to March 2014 (15 months—reference period).

2.2 *Analysis and data processing*

After the data collection was carried out a detailed analysis, from which the information was compiled in descriptive statistics, crossing of variables and statistical tests.

In this study stage was used Microsoft Office Excel® and IBM Statistical Package for the Social Sciences software® (SPSS) version 20 for Windows®.

The incidence rate of non-fatal accidents at work according to ESAW (2001) (Eq.1) and ICLS (1998) (Eq. 2) methodologies were also calculated. Calculations performed consider accidents reported to insurance and/or social security, because the methods used require the establishment of days' absence from work.

$$\textit{Incidente rate } (ESAW) = \frac{\textit{Number of non-fatal accidents*}}{\textit{Number of employed persons in the studied population}} \times 100000 \quad (1)$$

*Accidents leading to more than 3 days' absence.

$$\textit{Incidente rate } (ICLS) = \frac{\textit{Number of new cases of occupational injury during the reference period}}{\textit{Total number of workers in the reference group during the reference period}} \times 1000 \quad (2)$$

3 RESULTS AND DISCUSSION

Based on data collected, approximately 95.2% of the surveyed companies had more than 15 years of activity in farming sector. The main activity of 86.9% of the evaluated workers was milk production (Fig. 1).

This study reveals that 23.1% of companies had occupational hygiene and safety services and 17.9% had health services, all by external enterprises. Nevertheless regarding the health surveillance, about 91.6% of workers had a medical checkup in the last year. This could be an indicator of their concern with their own health. In a survey developed in Norway about half of the farmers have access to occupational health services (Svendsen et al., 2014).

Regarding professional knowledge, 60.7% of the sample had some kind of training on Occupational Safety and Health (OSH). In the above-mentioned study in Norway was reported that more than half of the workers evaluated (not specifying the exact value) had some kind of formal education on OSH (Svendsen et al., 2014).

It is also important to note that 94.4% of workers had also family members working in the farming sector and 60.7% were self-employed. Based in the scenery of the EU-27, OSHA highlights the predominance of family and

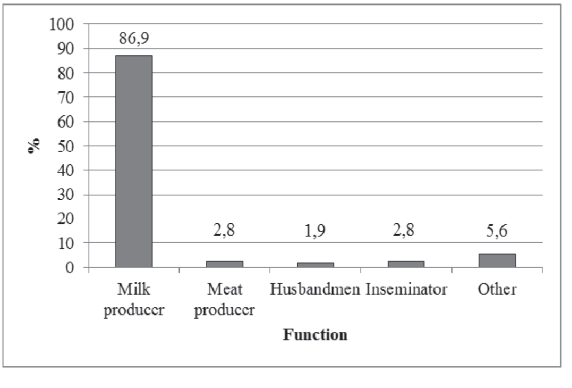

Figure 1. Percentage of workers interviewed by function.

independent work in farms, presenting a value of 89% for family work in this sector (OSHA, 2011).

Regarding to the accidents registered, it is important to note that of the fifty-eight accidents identified, fourteen (24.1%) were reported to insurance companies and/or social security, and from these, eleven (19.0%) had more than three days' absence. Considering the reported accidents (24,1%), 4 (28.6%) were reported to social security. These results indicate that, in this sample, the larger percentage of accidents identified were not recorded (75,9%). Chae et al., (2014) reported in their study that injuries of independent workers, whose reporting is made to certain subsidiaries entities, are not included in the calculation of the statistical process, which can lead to an underestimation of the values of accidents in the farming sector.

Based on Figure 2, which shows the total workers interviewed and victims (42% of workers interviewed) by age group, it appears that there was a predominance of victims in the age groups 18–24, 25–34 and 55–64 years compared with the fraction of total workers interviewed. This is in accordance with other studies (Svendsen et al., 2014). Thus, it appears that younger farmers have a higher percentage of occupational accidents.

The application of the chi-square test (X^2) to explore the hypothesis of independence between the variables age group and victims indicated an $X^2(5) = 9.1$ ($p < 0,05$). This result indicates that the accident rate is independent of age group.

By comparing the percentage of surveyed and injured workers, it appears that there are no differences between sexes. The result obtained from the application of the chi-square test to explore the hypothesis of independence between sex and victims indicated an $X^2(1) = 0.001$ ($p < 0,05$). The result indicates that the accident rate is independent of sex.

With the application of Odds Ratio (OR) with a Confidence Interval (CI) of 95% for sex and victims (OR = 1.01, 95% CI = 0.46 to 2.22) it appears that the association is not statistically significant and the results may be due to causality.

Through the comparison of qualifications among interviewed workers and victims it appears that there is no association between the number of accidents at work and education.

Application of the chi-square test to the number of victims by education level, is indicated an $X^2(4) = 6.2$ ($p < 0,05$). The results allow to conclude that the accident rate is independent from the education level.

On Table 1 is presented the percentage of victims by class of variables.

The presented outcomes indicate that it is in the age group 18–24 there was the greater number of victims, in other words, within this age group was 75% of victims. With regard to sex it appears that the accident rate is very similar for both sexes.

The incidence rate of non-fatal accidents at work leading to more than 3 days' absence, according to the ESAW methodology, presents a value of 7 908.0 accidents per 100 000 workers per year (7.91% per year). According to the HSE (2013), based on the Labour Force Survey from UK, the incidence rate for agriculture can vary between 3% and 6% for injuries with more than 3 days' absence from work, even for different years. However, this entity refers that the proportion of reported injuries in agriculture is actually low, making it difficult to obtain meaningful conclusions about trends in this sector.

Regarding the incidence rate of non-fatal accidents at work, according to the ICLS (1998) methodology, the value obtained was 100.6 accidents

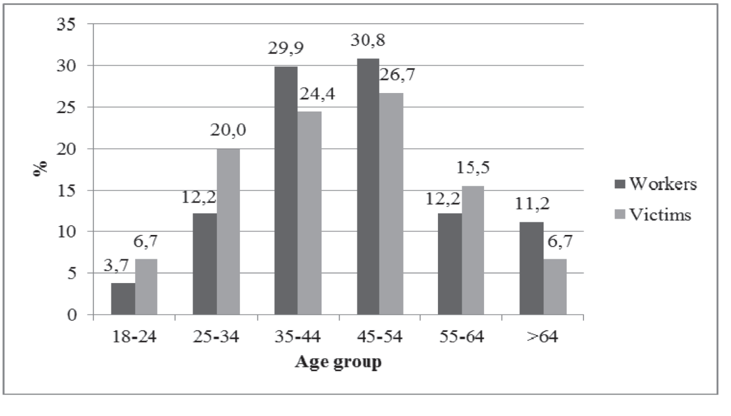

Figure 2. Percentage distribution of workers and victims by age group.

Table 1. Percentage of victims by classes of age, sex and educational qualifications.

									Educational qualifications				
Variables	Age group (years)						Sex		Elementary school			High school	Higher education
Classes	18–24	25–34	35–44	45–54	55–64	>64	M	F	4 Y	6 Y	9 Y		
Victims (%)	75,0	69,2	34,4	36,4	53,8	25,0	42,2	41,9	37,5	58,3	35,0	44,4	0,0

per 1000 workers per year. Based on the study of Pickett et al., (1995) on non-fatal accidents at work in Ontario, Canada, the incidence rate was 58 per 1000 workers per year. Karttunen & Rautiainen (2013) reported an incidence rate of 62 per 1000 workers per year in Finland.

4 FINAL REMARKS

Farming is an activity with a high level of risk triggering many occupational accidents and some of them are not officially recorded.

It was the age group of young workers and workers before the retirement which detained higher injury rate, however was confirmed the independence of these variables.

The rate of accidents reported to insurance companies and/or social security has a low value (24.1%), of which only 28.6% were reported to social security.

The incidence rates of non-fatal accidents at work in the farming sector of a region of northwestern of Portugal are greater than those shown in other studies of other countries.

The promotion of health and safety at work and of more and better workplaces are important goals to be achieved and are the key requirements for a sustainable farming sector. These should be considered as an essential part of managing this type of activity. To achieve these objectives monitoring and evaluation actions are increasingly necessary. Thereafter, appropriate safety measures must be designed to the needs of sector companies.

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Characterization of indoor air pollution in a Portuguese pre-school

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ABSTRACT: The objective of this work was to investigate the levels of some relevant indoor pollutants (total volatile organic compounds—TVOCs, ozone—O_3, carbon dioxide—CO_2, carbon monoxide—CO, formaldehyde—HCHO, total suspended particulate matter—TSP) with emphasis on Polycyclic Aromatic Hydrocarbons (PAHs) in a pre-school environment and to assess the risks associated with the exposure to carcinogenic PAHs for 3–5 years old children. The levels of indoor pollutants were sampled during 15 days at one pre–school located in urban zone of Porto, Portugal. Obtained CO and TSP levels were in compliance with the existent Portuguese legislation on indoor air of public building whereas mean concentrations of TVOCs, CO_2, and formaldehyde exceeded (up to 4.5 times) the limit values. Total concentration of 18 TSP–bound PAHs ranged from 0.40 to 16.0 ng m^{-3} (mean of 4.75 ng m^{-3}). Estimated values of lifetime lung cancer risks exceeded 40 times the health–based guideline levels thus demonstrating that long–term exposure to PAHs at the respective levels might cause some adverse health outcomes.

1 INTRODUCTION

As people spend 75–90% of time indoors (offices, schools, homes, etc.) indoor air quality has been recognized as an important factor for human health. The available evidence is rather alarming. According to World Health Organization (WHO) in 2012 4.3 million people died worldwide due to the effects of indoor air pollution (WHO, 2014). The potential health consequences of exposure to indoor pollution indicate the need for further studies in order to fully comprehend the respective health consequences. This is especially relevant for sensitive groups, such as young children who are particularly susceptible to air pollution. Children spend at schools up to 8–9 h per day, which raises an interest in better understanding of air pollution in these environments. Thus this work aims to investigate the levels of indoor pollution at one pre-school located in an urban area. Specifically, the concentrations of indoor health-relevant gases, namely Carbon Monoxide (CO), Carbon Dioxide (CO_2), Total Volatile Organic Compounds (TVOCs), formaldehyde (HCHO), ozone (O_3), Total Suspended Particulate matter (TSP) and particulate-bound Polycyclic Aromatic Hydrocarbons (PAHs) were evaluated. The risks associated with the exposure to PAHs for 3–5 years old children were also assessed.

2 MATERIALS ND METHODS

2.1 *Sampling*

Indoor gases (CO, CO_2, O_3, TVOCs, formaldehyde), TSP, and 18 particulate PAHs (16 considered by USEPA as priority pollutants, dibenzo[a,l]pyrene, and benzo[j]fluoranthene) were sampled during 15 consecutive days of March—April 2011 at one pre-school situated in urban zone of Oporto Metropolitan Area, (north of Portugal); previously it was demonstrated that emissions from vehicular traffic are the main source of pollution in the respective area (Slezakova et al., 2013a, b). The sampling was conducted in a common room that was used throughout the day for educational and entertaining activities as well as for physical exercising. In order to minimize direct influence of any source all the samplers were located as far as possible from windows and doors.

The concentrations of CO, CO_2, O_3, and TVOCs were measured 2–3 times per every school day. The measurements were performed both in morning and in the afternoon for 15–20 min long periods by multi-gas sensor probe (model TG 502; GrayWolf Sensing Solutions, Shelton, USA) that was daily calibrated. The levels of formaldehyde were registered with Formaldemeter™ (model htV-M; PPM Technology, Caernarfon, UK) following the same methodology as for other indoor pollutants. In addition, indoor temperature (mean of 18.2 ± 1.1 °C) and relative humidity (mean of 58.7 ± 9.0%) were monitored by Testo mini data-logger (model 174H; Testo AG, Lenzkirch, Germany) which operated continuously during 24 h with a logging interval of every 10 min. TSP was collected each day for a period of 24 h on Polytetrafluoroethylene (PTFE) membrane filters with polymethylpentene support ring (2 µm porosity, Ø47 mm, SKC Ltd., United Kingdom) by constant flow sampler (model Bravo H2; TCR TECORA, Italy) combined with sampling head and using an air flow rate of 38 L min^{-1}. TSP masses were then determined gravimetrically according to Slezakova et al. (2013). After the sampling the filters were stored in a freezer (–20 °C) before consequent chemical analysis.

2.2 *PAH extraction and quantification*

The extraction and quantification of PAHs from TSP were performed by previously validated analytical procedure (Castro et al. 2009, 2011). External calibrations with PAHs mixed standards, using at least 6 calibration points, were performed. Each analysis was performed at least in triplicate.

2.3 *Health risk analysis*

The risks associated with inhalation exposure to all 18 PAHs were assessed by Toxicity Equivalency Factors (TEF) using the values estimated by Muller (Boström et al., 2002). Consequently, the lifetime lung cancer risks were calculated according to the methodology provided by WHO (2000). Over the sampling period children spent approximately 8 hours at pre-school during each day. Residence time of children spent indoors and outdoors were daily registered in order to correctly assess the total carcinogenic target risks.

3 RESULTS AND DISCUSSION

3.1 *Gaseous pollutants*

Over the sampling period, the levels of gaseous pollutants in indoor air of the pre–school ranged up to 2.84 mg m^{-3} (mean of 1.01 mg m^{-3}) for CO, 1360–3400 mg m^{-3} (mean of 2340 mg m^{-3}) for CO_2, and between 0.60 and 4.51 mg m^{-3} (mean of 2.67 mg m^{-3}) for TVOCs. The estimated mean of formaldehyde was 184 µg m^{-3} (range up to 479 µg m^{-3}) whereas it was 0.130 µg m^{-3} for O_3 (range between 8.97×10^{-2} and 0.180 µg m^{-3}). CO fulfilled the limit of 10 mg m^{-3} set by Portuguese legislation for indoor air of public buildings (Decreto Lei 118/2013) whereas CO_2 exceeded (slightly) the limit value of 2250 mg m^{-3}. The levels of formaldehyde and TVOCs highly surpassed (1.8 and approximately 4.5 times) the limit values of 100 and 600 µg m^{-3}, respectively. It is though necessary to point out that the legislation concerning the gaseous pollution in indoor air of public buildings was recently (in 2013) revised. While the limit values of gaseous pollutants remained mostly the same, the recommended sampling duration was set to 8 h instead the previously suggested 5 min interval. In view of these revisions, the obtained exceedances need to be implied carefully, though the highly surpassed values (especially for TVOCs) indicate the need for air quality improvements the studied pre–school in order to protect the health of the exposed populations of children and school staff.

3.2 *TSP and TSP-bound PAHs*

The daily levels of TSP in the studied pre–school ranged from 2.2 to 70 µg m^{-3} (median of 14.9 µg m^{-3}) resulting in a mean indoor concentration of 20.8 µg m^{-3}. This obtained TSP mean was approximately twice lower than the limit value of 50 µg m^{-3} set for PM_{10} by Portuguese indoor legislation.

The levels of 18 PAHs in TSP are presented in Table 1.

The results clearly show that lower molecular weight PAHs (i.e. with 2 rings), namely naphthalene corresponded to approximately 1% of the total PAH content (i.e. ΣPAHs), probably due to the predominant presence in gas phase. On the contrary, compounds with 5 and 6 aromatic rings were the most abundant groups of TSP-bound PAHs, accounting for 52 and 25% ΣPAHs, respectively. These results were in general agreement with the previous indoor studies conducted in Oporto Metropolitan Area (Castro et al., 2011; Slezakova et al., 2013b). Specifically, dibenz[a,h]anthracene (5 rings) was the most abundant PAH in indoor air of the studied pre-school (mean of 1.35 ng m^{-3}, i.e. 28% of ΣPAHs); the dominance of this compound indicates emissions from motor light-duty gasoline vehicles (Ravindra et al., 2008). The other

Table 1. Levels of TSP–bound PAHs (ng m^{-3}). Concentrations are presented as sums of individual compounds according to the number of aromatic rings, i.e. groups with 2, 3, 4, 5 and 6 rings, respectively.

PAHs	Mean	Range
2–rings	5.16×10^{-2}	n.d – 6.47×10^{-2}
3–rings	0.22	3.58×10^{-2} – 0.46
4–rings	0.85	0.117–2.48
5–rings	2.46	0.30–9.24
6–rings	1.17	3.90×10^{-2} –3.94
ΣPAHs	4.75	0.40–16.0

n.d—not detected.

most abundant compounds were, by descending order, benzo[b+j]fluoranthene (5 rings; 14% of ΣPAHs), indeno[1,2,3–cd]pyrene (6 rings; 13%), and benzo[ghi]perylene (6 rings; 9%). According to other studies (Ravindra et al., 2008; Slezakova et al., 2013a, b), these PAHs are considered as indicators of vehicle emissions, suggesting that outdoor emissions from road traffic were relevant contributor to indoor PAH pollution of the studied pre–school.

The total concentration of 18 TSP–bound PAHs ranged from 0.40 to 16.0 ng m^{-3} which resulted in a mean of 4.75 ng m^{-3}. There are very few information concerning PAH levels in indoor air of educational environments (i.e. pre-school and schools). Furthermore, there are significant differences among the existent studies. Whereas Ruchirawat et al. (2007) reported concentration of 0.28 ng m^{-3} (Bankok, Thailand) for indoor particulate-bound PAHs, Wilson et al. (2003) observed levels of 1044 ng m^{-3} (North Carolina, USA). Certainly, geographical and seasonal influences, meteorological conditions, level of urbanization and development of the surrounding area might account for some of the differences. However, it is necessary to point out that the designs of the available studies vary greatly, namely in terms considered particulate fractions (differing between $PM_{2.5}$, PM_{10}, or TSP) and number of individual PAH compounds considered, which can hamper the potential comparisons.

Out of 18 analysed PAHs, naphthalene, benz[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[j]fluoranthene, benzo[k]luoranthene, benzo[a]pyrene, dibenzo[a,l]pyrene, dibenz[a,h]anthracene and indeno[1,2,3–cd]pyrene were reported as carcinogenic ones (possible, probable) (IARC, 2002, 2010). The mean concentrations of these ten carcinogenic PAHs (i.e. $\Sigma PAHs_{carc}$) was 3.27 ng m^{-3} (range between 0.30 and 12.3 ng m^{-3}). Dibenz[a,h]anthracene, a strong carcinogen with TEF 5 times higher than benzo[a]pyrene (Okona-Mensah et al., 2005), was the most abundant carcinogen and accounted for 38% of $\Sigma PAHs_{carc}$. Considering the protection of public health, it is important to enhance that dibenz[a,h]anthracene exhibited the highest concentrations of all 18 PAHs in indoor air of the studied pre-school, being followed by other carcinogens: benzo[b+j]fluoranthene (19% of $\Sigma PAHs_{carc}$) and indeno[1,2,3–cd]pyrene (17% of $\Sigma PAHs_{carc}$). Finally, benzo[a]pyrene, the most studied and characterized carcinogen (IARC, 2010), was the fifth most abundant particulate (and the fourth most abundant carcinogenic) PAH, contributing 8% of TSP–bound $\Sigma PAHs_{carc}$.

3.3 *Health risks assessment of TSP-bound PAHs*

As scientific community has recognized that there is no identifiable threshold below which PAHs do not pose risk to humans, genotoxic and carcinogenic PAHs require the fullest possible risk assessment. Several approaches have been developed to evaluate the potencies of the components of a complex mixture of PAHs. In this work values of TEF reported by Muller which includes a assessment for dibenzo[a,l]pyrene (Boström et al., 2002) were used in order to calculate the TEF–adjusted concentrations (based on benzo[a]pyrene). The results of TEF–adjusted concentrations for 18 PAHs at the studied pre-school are presented in Table 2.

Dibenzo[a,l]pyrene appeared previously in TSP in the lowest levels (mean of 134 pg m^{-3}, i.e. less than 3% of ΣPAHs), nevertheless due to its high TEF (100) it was the largest contributor to ΣTEF_{-PAHs} contributing 89%. Dibenz[a,h]anthracene with TEF of 0.89 was the second largest contributor (8%) to ΣTEF_{-PAHs} in indoor air. These results emphasize the importance of the analysis and evaluation of these two potent carcinogens that are being currently discussed as possible surrogate compounds for PAH mixtures from various environments (Okona-Mensah et al., 2005). Muller (Boström et al., 2002) did not report TEF for naphthalene, hence this compound could

Table 2. TEF–adjusted concentrations (C) of PAHs in indoor air of the studied pre-school (pg m^{-3}).

Compound	TEF[a]	C	Compound	TEF	C
Naphthalene	n.a.	–	Acenaphthylene	n.a.	–
Acenaphthene	n.a.	–	Fluorene	n.a.	–
Phenanthrene	0.00064	7.54×10^{-2}	Anthracene	n.a.	–
Fluoranthene	n.a.	–	Pyrene	0	–
Benz[a]anthracene	0.014	1.29	Chrysene	0.026	5.62
Benzo[b+j]fluoranthene	0.11	74.6	Benzo[k]fluoranthene	0.037	5.52
Benzo[a]pyrene	1	284	Dibenzo[a,l]pyrene	100	13 400
Dibenz[a,h]anthracene	0.89	1 200	Benzo[ghi]perylene	0.012	5.13
Indeno[1,2,3-cd]pyrene	0.067	40.4			
ΣTEF_{-PAHs}	–	15 040			

n.a.—not available.

not be further evaluated. Furthermore, the associated health risks of PAHs in TSP are expected to be higher than those predicted by an additive model of these two pollutants.

The values of ΣTEF-PAHs were used to estimate the corresponding lifetime lung cancer risks for the exposed groups. Regarding the lung cancer risk for PAH mixtures, WHO suggests the unit risk of 8.7×10^{-5} (ng m^{-3})$^{-1}$ of benzo[a]pyrene for lifetime (70 years) exposure (WHO, 2010). Considering that children and teaching staff spent indoors approximately 7 h of their school time, the corresponding lung cancer risk was 3.91×10^{-4} in indoor air. This estimated values slightly exceeded the WHO health–based guideline level of 10^{-5} (approximately 40 times; Boström et al., 2002).

4 CONCLUSIONS

Despite the current concerns about regulations of indoor pollutants, there is a lack of studies in educational settings especially concerning carcinogenic compounds such as PAHs. A better understanding of indoor pollution may lead to further recommendations for air quality improvements and potentially to review existent air quality guidelines. Children represent one of the most vulnerable groups in society. The detailed characterization of pollution (both indoors and outdoors) of schools is of great importance, since it may allow preventing potential health risks of children and occupationally exposed adults.

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Non-fatal accidents at work in the farming sector—a short review

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ABSTRACT: This study aims to present a short systematic review of studies on occupational injuries in the farming sector. To achieve this goal was used the PRISMA Statement™ methodological guide. After selection from the qualitative synthesis 13 articles were found. Depending on the country and culture, risk factors vary and the accidents have different consequences. There are also many conclusions reached by the different researchers. These include the causes of accidents, suggestions for specific preventive measures and limitations associated with the design of the research. There is also a high potential for improvement of working conditions in farming sector and improvements can be attained through more studies that include more variables.

1 INTRODUCTION

Farming is an activity that has multiple risk factors. In EU-27, there is a predominance of family work which presents a value of 89% (OSHA, 2011).

Despite the existence of two review papers on farming in the XXI century, one in 2002 (Solomon, 2002) and another in 2007 (Angoules et al., 2007), no recent work was found synthesizing the knowledge acquired since then. It is in this context that this work arises, whose aim is to make a first summary of existing knowledge worldwide, its trends and limitations.

2 MATERIALS AND METHOD

This research was conducted between March and May 2014 and follows the principles of methodological guide Prisma Statement™. After screening and quality assessment of studies, from the 710 articles found, 13 were selected for detailed analysis. The search by subject included 6 Scientific Journal editors (BioMed Central Journals, MetaPress, Oxford Journals, SAGE Journals Online, ScienceDirect and Wiley Online Library) and 5 Databases (AGRICOLA Articles, AGRICOLA Books, PubMed, SCOPUS and Web of Science) available in the Documentation and Information Services of Faculty of Engineering of University of Porto. The keyword combinations used were: agricultural & accident, agriculture & accident, farming & accident, livestock & accident, agricultural & ESAW, agriculture & ESAW, livestock & accident, farming & accident, agriculture & accident statistics, farming & accident statistics, livestock & accident statistics.

Exclusion criteria were: articles outside the theme, without statistics and not related to agriculture or livestock.

Inclusion criteria were: publication period (1st phase 2005–2014 and 2nd phase1995–2014), title and summary in accordance with the scope of study (statistics of accidents in agriculture).

3 RESULTS AND DISCUSSION

From the 13 selected articles, 2 (Angoules et al., 2007; Solomon, 2002) correspond to review papers. The results of 11 other studies are summarized in Table 1, Table 2 and Table 3. Of these, eight are working with data collected by the researchers themselves [1, 2, 5–9, 11] and 3 with data collected by other entities [3, 4, 10]. None of the studies explicitly states follow the ESAW. Also only one study [2] refers explicitly working with data collected through an assisted questionnaire.

The articles reflect different realities, since they are from different continents and cultures. Four of them were developed in Europe [1, 3, 4, 9], 3 in Asia [2, 5, 6] and 4 in the North American continent [7, 8, 10, 11].

Nine papers deal with non-fatal accidents [1, 2, 4–9, 11]. Fatal accidents are only managed by official bodies such as HSE [3] or are presented as a

Table 1. Systematic review on occupational accidents in the agricultural sector—scope.

N.º	Author	Country	Objective	Sector	Type of accident
1	Svendsen et al. (2014)	Norway	Describe the nature and occurrence of non-fatal injuries in farmers in two counties in Norway	Farming	Non-fatal
2	Chae et al. (2014)	Korea	Estimate the agricultural injury rate among Korean farmers using data from the first KFODIS to identify the relationship between agricultural injury and general characteristics	Farming	Non-fatal > 4 days' absence
3	HSE (2013)	Great Britain	Study injuries and work related injuries	Farming, (forestry & fishing)	Fatal and non-fatal
4	Karttunen & Rautiainen (2013)	Finland	Identify types of injuries and diseases that tend to reoccur among those with high personal injury or disease claim rate	Farming	Non-fatal
5	Kumar & Dewangnan (2009)	India	Investigate the various types of agricultural accidents, their magnitude, causes, severity and economic consequences in Arunachal Pradesh	Agriculture	Non-fatal
6	Kumar et al. (2008)	India	To understand the mechanism of hand tools injuries in traditional farming activities and to conduct ergonomic study of hand tools to minimize injuries	Agriculture (just hand injuries)	Non-fatal
7	Sprince et al. (2003)	USA—Iowa	Assess risk factors for animal related injury among a large group of Iowa farmers who raise livestock	Livestock	Non-fatal
8	Hwang et al. (2001)	USA—New York	Describe the nature of the farm injuries and injured participants, present estimates of the incidence of injury, and present risk factors that place this group of farmers at unusually high risk for injury	Farming	Non-fatal (>severity)
9	Rasmussen et al. (2000)	Denmark	Report accident and injury rates in relation to work-specific factors in a representative cohort of farmers followed in a 1-year prospective registration period	Farming	Non-fatal
10	Coury et al. (1999)	Alberta—Canada	Describe farm injury accidents and fatalities reported in Alberta (1976–1989) and also compare the data on injury accidents (1995)	Farming	Fatal and non-fatal
11	Pickett et al. (1995)	Ontario—Canada	Estimate rates of non-fatal farm injury in Ontario and to describe patterns of injury among the provincial agricultural community	Farming	Non-fatal

Table 2. Systematic review of articles on occupational accidents in the agricultural sector—method/results.

	Method			Results		
N.º	Data source	Period	Sample	IR*	IR**	Sex
1	Survey (questionnaire by e-mail and postal addresses)	2010	2699	–	–	No sex differences in the injury rate
2	Survey (assisted questionnaire with 29 items)	2008	8064	3,2%	–	Men have a higher OR (Odds Ratio) of injury compared with women
3	The Health and Occupation Reporting Network—THOR, Labour Force Survey-LFS	2010/11 2012/13	–	3,8%	–	–
4	Social security data	1982–2008	93564	–	–	Men had more injuries than women
5	Survey	2000–2005	4040	–	–	Men had more injuries than women
6	Survey	–	2 phases: 1ª-19273 2ª-78890	–	–	–
7	Survey	1997	116	–	–	–
8	Survey	1994–1997	1706	–	9%***	Men have a higher OR of injury than women
9	Survey	1 year 1993/94	1597	–	–	–
10	Data from various entities	1976–1989	–	–	–	–
11	Survey	1991	4110	–	5,80%	Men have a higher OR of injury than women

*IR—Incidence rate (ESAW 2001); **IR—Incidence rate (ICLS 1998); ***(only great severity).

result of the treatment of data collected by official entities [10] (Table 1).

The concept of "farming" is also not always clearly defined, since it represents various realities. As an example, in a significant number of countries, the official data join in the same group, agriculture, livestock, forestry and fishing. Even when the general reference is "farming" it is not always clear what the activity or activities that are specifically reported. In the analysed articles, one of them explicitly states that the study covers forestry & fishing [3], two studies originated in India are just working with agricultural data, not including handling of animals [5, 6] and a study from the US only deals with working accidents occurred during the manipulation of animals [7] (Table 1).

Five papers worked with data collected after 2000 [1–5], but one of them [4] uses data collected between 1982 and 2008, meaning that represent different realities. Agriculture in 2008 was completely different from 26 years before. One article do not mention the period of data collection [6] (Table 2).

In terms of incidence rate, there are four articles that present values, but these are not comparable. In two of them [2, 3] the calculation is done using ESAW (2001) methodology and the other two [8, 11] follow ICLS (1998) procedures. These last two papers are also not comparable, because one of them [8] only presents results from accidents of great severity.

The way how the data are collected and the sample size are always important factors to evaluate the quality and the importance of the study. Despite the collecting data procedures, be described in all the presented researches, 2 of them [3, 10] do not makes any mention to the size of the sample.

Concerning to the differences in accident rates between men and women, 6 of the 11 articles mention this factor [1, 2, 4, 5, 8, 11]. From these, only one [1] had not detected any differences. All others refer that men have an higher rate.

Another important factor to design preventive measures is the age at which the highest number of accidents occurs. This detail is addressed in 8 [1, 2, 4, 5, 7, 8, 9, 11] of the 11 articles. However opinions are not converging, although there is a tendency to point the workers below 50 years as the worst affected (Table 3).

There are three aspects that call the attention, only of a few number of authors: education level [5, 7, 8], professional experience [2, 7, 8] and the time at which the accident took place [2, 5, 8]. The presented results are not consensual, what means the need for more research in these fields.

Animals and livestock facilities are considered one of the main sources of accidents in

Table 3. Systematic review of articles on occupational accidents in the agricultural sector—results.

	Results						
N.º	Age	Education	Experience	Time of the accident	Accident site	Causes	Injuries
1	Higher number of injuries—workers 20–29	–	–	–	1st 45,4% in livestock facilities	1st 75, 3%—due to animals in livestock facilities	–
2	≥ 50 years have lesions greater than OR 50	–	≥ 20 years had more injuries	Higher percentage of accidents after 10 hours of work/day	Highest percentage in orchards	Environmental factors (falls due to tree height)	–
3	–	–	–	–	–	1st.21%: slips, trips, falls on level; 2nd.17%: falls & 3rd 16%: injured by animal (ref. of 5 years)—major injuries	–
4	Older workers had more injuries	–	–	–	1st 41,3%—livestock	1st 20,1%: outside working environment; 2nd 18,0%: due to animal handling	1st 85,9%—injury, poisoning and consequences of external causes
5	40–49 had the greater number of victims	"Only" 30.38% of the victims were literate	–	66,5% of the accidents in the 1st 4 hours	1st 30% —Cut air-busts (agriculture)>	1st > 39%—due to hand tools	1st. 33,14%: cuts
6	–	–	–	–	–	58% due to hand tools	Foot and legs were the most frequently injured
7	Major risk factor in young workers (22–39)	Greatest risk factor for workers with greater education than high school	No statistical difference between cases and controls	–	–	1st 47,6%—due to animal aggression	1st 26,6%—due to strains and sprains
8	35–44 years—higher incidence of victims	Higher IR: workers with high school	Highest incidence between 15 and 30 years of experience	Higher incidence as of 8 h of work per day	1st 25%: barn; 2nd 18%: field, 3rd 13% milking parlor	1st 24%—due to animals	1st Upper and lower limb
9	16–49 more injuries than > 50	–	–	–	–	Working with animals with the second highest incidence rate, preceded by repair/maintenance	1st 76,6%—wounds, 2nd 12, 6%—contusions; 3rd 7, 5%—strains, sprains
10	–	–	–	–		2nd 30%—livestock	–
11	21–50—the highest number of victims	–	–	–	1st 35%—barn	1st 70%—machinery, 3rd 39% —livestock	1st 35%—strains and sprains

8 works [1, 3, 4, 7–11]. However, the most recent works [1–5] do not mention the injuries or do not establish a clear relationship between the work with animals and injuries. Among the older researches are referred foot and legs injuries [6], strains and sprains [7, 9, 11], musculoskeletal disorders [8], wounds and contusions [9] as main injuries/disorders.

Finally it should be noted that only one study [7] reported the use a control group for verifying the results. However, no differences were detected between this group and the sample.

4 FINAL REMARKS AND LIMITATIONS

It is usual the official statistics mix the farming sector with others, like fishing, forestry and/or hunting. As example, in this article, this can be seen in the work done by HSE (2013). However, farming itself has different realities concerning the kind of work. Livestock and agriculture are usually held by many farmers at the same time as complementary activities. Nevertheless, most often, only one of them is the main activity.

It is also an evidence that there are not homogeneity between the set of variables dealt (or considered as important) by the different authors. This means that there is a lot of work to do in this important field to the sustainability of the humanity.

Despite working with a relatively large samples, most studies works with data from official collection or with self-administered surveys. This approach entails from the outset a bias resulting in the first case of mixing different realities and, in the second, there is no guarantee of re-presentativeness of the collected answers.

Regarding the development of this study, it can be improved, not only by adding new keywords, as well as refining the inclusion criteria.

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Slope instability risks—approach methodology proposal based on a comparative analysis of several Unitary Development Plans

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ABSTRACT: Landslides have always been a concern to public safety. These are characterized as widespread and sometimes difficult to predict. One potential tool for landslide risk mitigation is territory planning legislation. In Portugal, a specific instrument of this kind is the Unitary Development Plan (UDP). The aim of this work was to select a few UDP and assess how landslide risk is approached. Eight city councils were selected based on location, history of landslides, population and soil use, and the respective UDP were analyzed. This yielded that UDP generally have different approaches and frequently are not fully adequate to deal with landslide risk. This work converged in the proposal of improvement measures for UDP regarding landslide risk management, including risk mapping methodology. The development and international dissemination of this work was provided by Master in Occupational Safety and Hygiene Engineering (MESHO) from Faculty of Engineering of the University of Porto (FEUP).

1 INTRODUCTION

1.1 *Natural hazards—landslides*

Landslides are generically defined as mass movements on slopes, and are considered both of relatively common and frequent occurrence, as well as a type of phenomenon that is influenced by a complex and vast range of factors (Cruden & Varnes, 1996, Burton et al., 1993, Varnes, 1984, Robinson & Spieker, 1978). These traits make landslides a problem—the complexity and numerous influential variables, associated with the wide type of possible mass movements, become a major obstacle in preventing its occurrence and mitigating its consequences (Larsen, 2008, Dikau et al., 1996). The following factors are the considered by most authors as the most influential in the occurrence of landslides (Keller, 2012, Bateira et al., 2008, Teixeira, 2005, Bateira, 2001, Press and Siever, 2001, Cruden & Varnes, 1996): lithology and geological formations (mineralogy, structure); morphology (slope inclination, shape, dimensions); climate; water and vegetation. Adding to these is the fact that Human intervention may cause natural hazards where none existed before. (Press & Siever, 2001, Burton et al., 1993). Landslides are a force to be reckoned with, causing as much as thousands of deaths and injuries and resulting in high economic expenses (Thiebes, 2012, Tsou et al., 2011, Dikau et al., 2007). Therefore, these should be considered as a risk to existing populations, implicating the necessity of implementing adequate precautionary measurements to ensure Civil Defense (Keller, 2012, Press and Siever, 2001, Varnes, 1984). Considering Portugal, sources suggest that while these are associated with low casualties (around <10 casualties per landslide), a considerable amount of landslides do occur (Pereira et al., 2014, Zêzere et al., 2008).

In order to prevent and mitigate the consequences of this risk, several tools and measures of prevention and protection exist, such as legislation, physical barriers and monitoring systems (Pereira et al., 2007, Abramson, 2002, Bateira, 2001, Selby, 1986,). One particularly effective type of tool is territory planning legislation, as it reduces the exposure component of the risk. The following work focused on the analysis of a specific type of Portuguese territory planning legislation known as "*Plano Director Municipal*"—Unitary Development Plan (UDP). The UDP exist to establish, at a municipal level, the existing national directives for territory occupation planning and soil use, according to the Portuguese Act of Law (*Decreto—Lei nº 316/2007, 19 Setembro*). An UDP has three components: Regulation—the actual legislative document that has the directives regarding territory occupation and use; Constraints Plant—a map of the municipality that indicates restrictions and limitations for soil occupation; Planning Plant—a map of the municipality that shows the territory occupation model and identifies the permitted types of soil use. Each city council has the obligation and responsibility to develop its own UDP, which may pose as a difficulty, as it allows divergent approaches to the same problem or may lead to the complete disregard of specific questions.

1.2 *Objectives*

Considering this fact, and given the importance of UDP in terms of prevention and Civil Defense regarding the risk of landslides, the aim of this work was to select a group of 8 UDP from different city councils and analyze how these documents approach and manage landslide risk individually and comparatively, in order to identify possible flaws and problems, possible influential factors for their development regarding this risk, and to propose improvements.

2 MATERIALS AND METHODS

For this work, 8 Portuguese city councils were selected, based on the following factors: demography; type of anthropic occupation and soil use; geological properties; history of recorded occurrences of slope instability and landslides; and geographical localization and general importance of the area. The following eight Portuguese city councils were selected: Arcos de Valdevez; Gondomar; Lisbon; Maia; Matosinhos; Porto; Póvoa de Lanhoso and Valongo.

These UDP were then analyzed individually and comparatively regarding the three components, based on the identification of influential factors for landslide risk and how they were considered. The considered factors were: mass movements; steep slopes; floods; geological susceptibility; earthquakes; soil excavation and topography alterations; drainage; vegetation removal and deforestation; waterproofing; soil erosion and degradation. The resulting data was cross-referenced with demographic and soil use statistics, topography and landslide occurrence history of each municipality, in order to identify potential flaws in each UDP, as well as possible reasons for their development in such a way. The identification of flaws and differences between UDP regarding landslide risk mitigation led to the proposal of some improvement measures.

3 RESULTS

3.1 *UDP comparison*

The results of the comparative analysis of the UDP's Regulations according to the "variables" considered as having clear importance on landslide risk and territory planning are exposed in Table 1. These show that there isn't an adequate degree of similarity between the city council's Regulations. While some, such as Porto and Lisbon, are adequate in most aspects, others, like Matosinhos and Gondomar, are quite lacking. Furthermore, it was also observed that even if these variables are present in the UDP, the approaches differ. Such is the case of vegetation removal and deforestation, which sometimes refer to embellishment or specific soil uses.

Regarding the UDP's Constraints Plant and Planning Plant analysis, one fundamental point was observed—out of the eight considered city councils, only Lisbon possessed actual identification and classification of its territory in terms of landslide risk in its Constraints Plant. Although some city councils considered other important risks, such as flooding, none other explicitly presented landslide

Table 1. Comparison of the presence of the considered variables in the UDP's regulations.

Variables	Arcos de Valdevez	Gondomar	Lisboa	Maia	Matosinhos	Porto	Póvoa de Lanhoso	Valongo
Landslides	Yes	–	Yes	–	–	–	–	–
Floods	Yes	–	Yes	Yes	–	Yes	Yes	–
Earthquakes	–	–	Yes	–	–	–	–	–
Geological susceptibility	Yes	–	Yes	Yes	–	Yes	Yes	Yes
Steep slopes	Yes	Yes	Yes	–	–	Yes	Yes	Yes
Soil excavation	Yes	Yes	–	Yes	Yes	Yes	Yes	Yes
Topography alterations	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Waterproofing	Yes	Yes	Yes	Yes	Yes	Yes	–	Yes
Deforestation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	–
Vegetation removal	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Draining	Yes	–	Yes	Yes	–	Yes	–	–
Soil erosion and degradation	Yes	Yes	Yes	Yes	Yes	–	Yes	Yes

risk cartography in its UDP. This poses as a problem not only regarding territory planning directly, but also the organization of precautionary and response measures. Adequate risk mapping would better the organization of specific response units; communication and transport infra-structures and even monitoring stations for known landslide triggering variables, such as rain and earthquakes. From these observations it is possible to understand that UDP differ considerably from each other, and that most of them are lacking in regard to public safety facing the risk of landslide occurrences.

3.2 *Discussion*

Based on the previous analysis, some hypotheses which may explain the verified flaws are presented. First of all, each UDP is at the sole responsibility of its city council. Therefore, time is an influential factor, as objectives and concerns may change over time. It should be also noted that the older UDP—Matosinhos and Gondomar, which date from 1992 and 1995, respectively, are also the most lacking. The reverse is also verified. Another possibly influential factor is the location's history of landslides. It would be logical for city councils with a high record of this kind of phenomena, especially those with severe consequences, to adapt and develop their UDP in order to prevent future problems. This was confirmed to some degree, since the three city councils that demonstrated higher focus and attention to landslide risks—Lisbon, Porto and Arcos de Valdevez, were identified as having a considerable history of such occurrences (Pereira et al., 2014, Zêzere et al., 2008, Teixeira, 2005, Bateira, 2001). This factor may also be an indicator of the level of susceptibility of an area regarding landslide risk. Tied to larger histories of occurrences are locations with higher altitudes and topography, higher population densities and anthropic pressures over the territory, climates associated with intense rain periods, etc. (Pereira et al., 2014, Soares, 2013, Zêzere et al., 2008). It should be noted, however, that this is a very complex situation and that there may be more influential factors that are not so evident.

3.3 *Improvement proposals*

In order to improve existing UDP by expanding and developing the attention given to landslide risk, here are some proposals and a brief explanation of their objective.

3.3.1 *Methodology for constraint plants*

Cartography and risk mapping is one most useful tool for proper territory planning and the prevention of exposure. Figure 1 represents a suggested

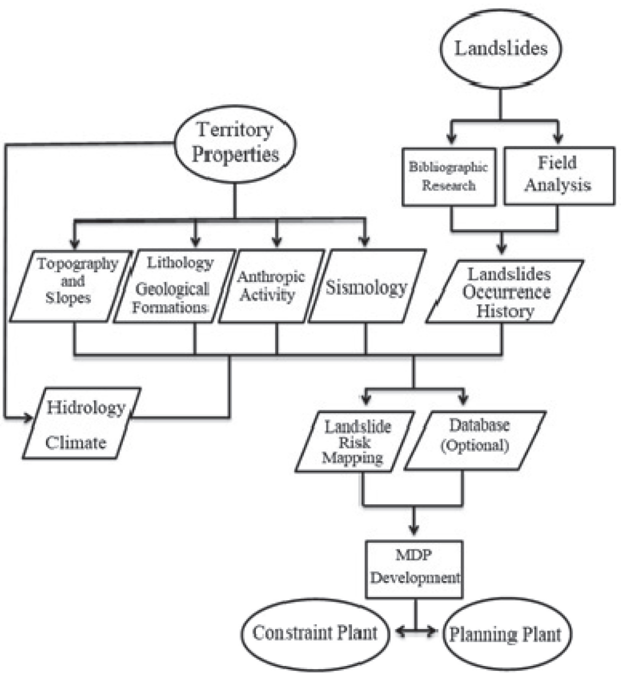

Figure 1. Proposed methodology for constraint and planning plant improvements.

methodology for the creation of landslide risk maps.

This methodology is divided in two stages. One stage refers to the creation of an inventory for past occurrences, following a methodology similar to (Teixeira, 2005). This would be based on: field observations; and bibliographical research from local and national newspapers, academic works, Civil Defense reports, etc. The result would be a data file for each occurrence, containing information such as: type, range, inclination and behavior of movement; slope morphology (profile, inclination, altitude and extension); hydrological properties (existing water pathways, climate); geological properties (mineralogy, specific formations, degree of alteration and erosion); anthropic factors (activities and occupation); GPS coordinates and local address; resulting consequences, and date of occurrence. The other stage would consist in an extensive study of the municipality's properties which are considered as most influential to the occurrence of landslides. These are presented in Figure 1. The completion of these two stages would allow the production of proper landslide risk mapping from the cross-reference of the obtained data. The inclusion of these results in the Constraint Plant of a given UDP would promote a more proper planning of territory occupation considering the risk of landslides, limiting anthropic occupation and activities in dangerous areas, therefore reducing the risk of exposure.

3.3.2 *Landslide occurrence database*

As stated in Figure 1, although optional, the creation of a national database capable of storing all the information regarding landslide occurrences according to the proposed methodology would be of value. This Database would be beneficial for further development of UDP, landslide risk cartography in general, and also the academic study of landslides. This measure could be adopted by other organizations, whether academic or governmental, besides city councils. Some efforts already exist regarding this subject, with projects of regional and national landslide databases being developed (Pereira et al., 2014, Soares, 2013, Pereira et al., 2007).

3.3.3 *Inclusion of variables in the regulation*

It was observed that there are some variables, previously described in Chapter 2. which are considered essential for inclusion the Regulation of every UDP. The application of specific legal measures regarding these variables under a landslide risk management perspective would be an important first step in municipal safety.

3.3.4 *Stricter government directives and support*

Another suggestion, based on standardization, would be the creation of a government "guide" for the development of UDP, which would include obligatory key-points, including those regarding landslide risk management. Specific governmental organizations could be assigned as a means of support to the city councils, also preventing existing flaws and irregularities.

4 CONCLUSIONS

Civil Defense and safety is a prime and most fundamental concern, and all measures and instruments should be developed in order to minimize every possible risk. In Portugal, on the subject of landslide risk, the importance of Unitary Directing Plans as a preventive organizational tool is evident. It was confirmed, however, that not all UDP share the same concerns or approach to this problem. In order to promote the development of UDP to better Civil Defense and Occupational Safety, some improvement proposals were presented, which include a methodology for landslide risk mapping and analysis, and other useful measures surrounding this topic.

This work aims to convey a notion on the actual state of UDP in Portugal and the importance of its adequate development for public safety, providing a possible first step in this direction.

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The applications of muscle fatigue/muscle activity assessment using multi-channel surface EMG during repetitive movement—a short review

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ABSTRACT: Repetitive movement is commonly observed in daily-life activities. Exposure to it for a long period of time can cause muscle fatigue. The aim of this study was to examine and present the applications of muscle fatigue/muscle activity assessment during the repetitive movement by using multi-channel surface EMG. The systematic searches were conducted over 35 electronic databases, through the search methods type of integrated and metasearch. Four studies were included in the review. Two of them were associated with one-dimensional array surface EMG, and another two studies were involved with two-dimensional array surface EMG. Both types and their utilization of advanced mathematic algorithm were capable to evaluate EMG signal during dynamic tasks. In order to have the higher accuracy and reliable results, the two-dimensional array surface EMG is required, due to its multiple detection sites can provide greater information detected over larger muscle fiber area.

1 INTRODUCTION

Repetitive movement is commonly seen in daily-life activities, for instance in sport particularly widely seen in the occupational task, such as existence in the production line of industrial sector, where workers have to perform their work tasks repetitively roughly 8 hrs a day, 5–6 days a week and for many years during their employment. Repetitive movement over such a long period of time can result in muscle fatigue, that is a consequence from a chain of metabolic, structural and energetic change in muscle, due to the insufficient oxygen and nutritive substance supplied through blood circulation, as well as a result of change in the nervous system efficiency (Cifrek et al., 2009). Most of the studies investigating muscle fatigue/muscle activity have been limited to either isometric contractions of increasing force or sustained isometric contractions (A and K, 2006, Bu et al., 2000). That is not functional in most of the applied fields, such as occupational health and safety, sport etc. The main obstacles of this limitation consist of, firstly due to the artifacts generated from the movement and vibration on the fixed dry inter-electrode closely located over the skin of subject during the dynamic contraction. Secondly due to the non-uniformity of motor unit distribution that changes rapidly over time of repetitive movement, depending on the different location within the muscle (Falla et al., 2006). So far there have been a number of studies conducting to investigate muscle fatigue/muscle activity by using a classic bipolar Electromyography (EMG) applied over a tiny area of muscle region. And due to the complexity of surface EMG signal extraction then leading to only simple tasks are frequently considered (D et al., 2004). Preferably isometric or constant force contraction has been used to assess muscle property through EMG signal for over three decade (B et al., 1981, L et al., 1989). This poor functional property can provide such limited information, of frequency content necessary for myoelectric fatigue manifestations assessment, and for its EMG signal amplitude, that can be used to evaluate muscle activation through motor unit distribution. Moreover as a result from its very small detected area over the small portion of muscle, this also leads to a high variance of the EMG variables, and may even be contradictory (Falla et al., 2014). This review was conducted to examine and present the applications of muscle fatigue/muscle activity assessment during the repetitive movement by using the multi-channel surface EMG considered as a more suitable tool than using just a pair of bipolar EMG, in order to obtain a comprehensive insight over its current situation of muscle fatigue/muscle activity during the repetitive movement.

2 METHODS

2.1 *Search strategy*

The literature searches were conducted on August 28, 2014, August 31, 2014, September 1, 2014 and September 5, 2014. The searches were performed over 35 electronic databases through the search method of integrated and metasearch. The database type was E-journals. The key search terms were focused on words including "Multi-channel surface EMG", "High-density surface EMG", "Muscle fatigue", "Repetitive movement", "Ergonomics", "Prolonged work", "Dynamic tasks" and were used in all the database with the appropriate Boolean operators (such as And and Or). In addition other literature searches were also performed through google search engine and reference list of those relevant articles. Only full papers were considered and insufficient information formats, such as abstracts published in term of conference or workshop proceedings were not included.

2.2 *Screening and eligibility criteria*

After duplication removal, all the articles found were considered as excluded ones after being screened following these criteria:

- No related subject
- Publication before 01–01–2005
- Language not accessible
- Text not available.

Articles were considered eligible if they meet the following criteria:

- Studies which whose objectives are involved with Multi-channel surface EMG applying during the repetitive movement
- Studies which provide information about multi-channel surface EMG based muscle fatigue/muscle activity evaluation during the repetitive movement
- Studies that testify the practical application of multi-channel surface EMG in repetitive task
- All the above considered studies were performed in humans not in animals.

3 RESULTS

3.1 *Study selection*

The details of the selection of all relevant articles both, excluded articles and included articles were performed through several criteria, based on the PRISMA statement established for reporting systematic reviews and meta-analyses of studies (PLoS_Medicine, 2009). All those details can be shown in Figure 1.

3.2 *Multi-channel surface EMG applications in muscle fatigue/muscle activity assessment over repetitive movements*

Four studies were found associated with the examination of muscle fatigue/muscle activity by

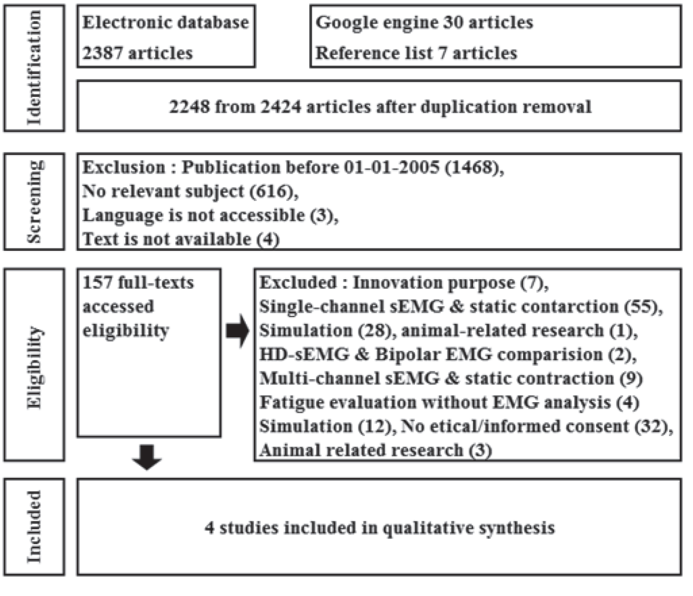

Figure 1. Selection criteria of relevant articles.

using Multi-channel surface EMG in repetitive movement activities (Table 1), that is considered as useful for the practical investigations of muscle fatigue/muscle activity in occupational tasks, which mostly employ the repetitive movement. In this review, the first two studies shown in Table 1. used one-dimensional of multi-channel surface EMG, and other two remaining studies applied two-dimensional of multi-channel surface EMG investigating muscle fatigue/muscle activity during the repetitive tasks. All of these studies evaluated muscle fatigue/muscle activities on upper limb of subjects' body. In summary, the evaluated muscles consisted of upper trapezius, upper, middle and lower trapezius, biceps brachii and lumbar elector spinae muscle respectively. Remarkably all of surface EMG electrode arrays were used with a semi-disposable adhesive grid separating electrode arrays from the skin of subjects.

The first study from Table 1, Falla and Farina (2005) conducted the experiment to investigate muscle fiber Conduction Velocity (CV) compared among a group of nineteen upper trapezius muscle patients and nine healthy controls. The EMG signals were measured bilaterally by linear adhesive arrays of four electrodes (bar electrodes, 5 × 1 mm size, 10 mm apart) packed with a semi-disposable adhesive, separating surface EMG electrodes from subjects' skin with small cavity filled with 20–30 μL of conductive gel.

The test was conducted as the subjects were performing repetitive task of tapping their hands in a cyclic manner between targets placed at mid-thigh and 120° of shoulder flexion, according to the beat of 88 beats/min generated from metronome up to 5 min. Muscle fiber Conduction Velocity (CV) was computed at each cycle at the time instant corresponding to 90° of flexion (Farina et al., 2004a). Instantaneous Mean Power Spectral Frequency (iMNF) was computed at the same time instants as CV value. Average Rectified Value (AVR) was also computed as the same time instants as CV and iMNF simultaneously achieved. The results appeared that CV decreased over time as fatigue progressed during dynamic contraction, but CV of the upper trapezius muscle was higher in people with chronic neck pain than in the control group. The iMNF also decreased over time of fatigue during dynamic contraction, but iMNF slope was greater in the patient group compared to the control group. Meanwhile the Average Rectified Value (AVR) increased over time of fatigue during dynamic contraction, and AVR slope was higher in the patient group compared to the control group. The second study from Table 1, Falla and her team (2007) conducted the experiment to investigate spatial muscle activation during a dynamic cyclic task of the upper limb, consisting of upper, middle and lower division of trapezius muscle on the right hand side of thirteen healthy subjects. At the upper division of trapezius, it was applied with three consecutive electrodes, at middle division of trapezius, it was applied with two consecutive electrodes, and at the lower division of trapezius, it was applied with three consecutive electrodes. The selected surface EMG in use was linear adhesive arrays of eight electrodes (bar electrodes, 5 mm × 1 mm size, 5 mm apart; LISiN-SPES Medica, Italy), it was used with semi-disposable adhesive, separating surface EMG electrodes from the skin with small cavity filled with 20–30 μL of conductive gel. The test was conducted as the subjects were performing repetitive task of tapping their hands in a cyclic manner between targets placed at mid-thigh and 120° of shoulder flexion, according to the beat of 88 beats/min generated from metronome up to 5 min. Instantaneous Mean Power Spectral Frequency (iMNF) was computed at time instants corresponding to 45°, 90° and 120° during the concentric phase of shoulder flexion and was estimated over 30-ms time interval (P et al., 2001) in order to reduce the variance. Average Rectified Value (AVR) was computed as the same time instants as iMNF estimation. The results appeared that iMNF was affected by different positions of trapezius division in the upper and lower division, namely it decreased over time as fatigue progressed during dynamic contraction, but it was different for the various locations of electrodes. For the ARV value, it was affected by position for the upper and middle division, namely

Table 1. Multi-channel surface EMG applications in repetitive movement.

Authors	Year	Type of array electrodes	Number of electrodes	Number of subjects	Type of muscle
(Falla and Farina, 2005)	2005	One-dimensional	4 (1 × 5)	19 Patients 9 Healthy	Upper trapezius
(Falla et al., 2007)	2007	One-dimensional	8 (1 × 9)	19 Healthy	Upper, middle, lower trapezius
(Farina and Falla, 2008)	2008	Two-dimensional	64 (13 × 5)	4 Healthy	Biceps brachii
(Falla et al., 2014)	2014	Two-dimensional	64 (13 × 5)	19 Patients 17 Healthy	Elector spinae

it increased over time as fatigue progressed during dynamic contraction, but it was also different for the various locations of electrodes. The third study from Table 1, Farina and Falla (2008) conducted the experiment to demonstrate the capability of multi-channel surface Electromyographic (EMG) signal detection with negligible artifacts during the fast dynamic movement and to estimate muscle fiber conduction velocity, that is one of the reliable indicators, identifying muscle fatigue and indicates motor unit recruitment (Houtman et al., 2003), by using a new method of short epochs estimation. They used two-dimensional surface EMG of 64 electrodes (13 × 5 electrodes) packed with a semi-disposable adhesive grid of electrodes (OT Bioelettronica, Torino, Italy). Surface EMG signals were collected from four subjects' right biceps brachii muscle during horizontal elbow flexion/extension movements (rang 120–170°). Subjects were asked to perform the movement as fast and as accurately as possible for 2 min. In this study it was demonstrated for the first time that multichannel (>50 channels) EMG can be recorded with negligible artifacts (Farina and Falla, 2008) and able to compute topographical maps from the EMG root mean square values, which can be used to investigate regional muscle activity changes. The conduction velocity estimation proposed algorithm was demonstrated by applying distal portion of 4 × 5 electrodes grid, using a Gaussian window with standard deviation 30 ms. This technique was beneficial to avoid the innervation zone in conduction velocity estimation and the use of the average of muscle fiber conduction velocity from the distal part of electrode grid (4 × 5) provided less variability (Farina et al., 2001, Farina et al., 2004a) and higher value in reliability (Farina et al., 2004b) and accuracy of conduction velocity estimation, rather than using only a few channels (Farina and Falla, 2008). The fourth study from Table 1, Falla and her team (2014) conducted the experiment to investigate lumbar erector spinae muscle activity distribution change and pressure pain sensitivity across the low back portion, as they were performing the repetitive lifting task. The selected electrode in use was two-dimensional 13 × 5 grid of electrodes, packed with a semi-disposable adhesive grid of electrodes (OT Bioelettronica, Torino, Italy), that was placed over lumbar erector spinae muscle. The subjects consisted of 19 people with chronic nonspecific Low Back Pain (LBP) and 17 healthy control individuals. The task was performed by repetitive moving a box (40 × 20 × 30 cm) with the weight of 5 kg through upward and downward direction from knee level to shoulder level as a cyclic movement, 1 s of time interval for box moving and 3 s for interrupted waiting interval, in total the approximate time of experiment was ~200 s or about 25 cycles. Electromyography signals of Mean power spectral frequency (MF) and Root Mean Square (RMS) were computed through each bipolar recording from adjacent, non-overlapping signal epochs of 1-second duration as described previously (R et al., 1990). And for spatial distribution of muscle activities, that were computed through RMS and MF averaged over 59 signals interpolated by a factor of 8. In addition 2 coordinates x- and y-axis for the medial-lateral and cranial-caudal directions were also separately demonstrated (D et al., 2008). The results associated to EMG estimation presented as averaged RMS values across the electrodes grid of LBP group during both lifting and lowering were significantly higher than values obtained from control group, and for the averaged MF value across the electrode grid of LBP group significantly appeared to decrease lower toward the end of the task duration. For the topographical map from EMG RMS value appeared to observe the shift of muscle activity toward caudal direction across the duration of the task particularly for the control group, but minimal change observed in the LBP group despite the appearance of its increasing of amplitude over time. Accordingly on y-coordinate of the centroid, the control group demonstrated higher value toward the end of the task.

4 DISCUSSION

From these four included studies, two were found associated with one-dimensional surface electrodes arrays with 1 × 5 and 1 × 9 electrodes respectively, and other two applying two-dimensional surface electrodes array with 13 × 5 electrodes. All of them were utilized to investigate muscle fatigue/muscle activities over repetitive movement. As we all known that during the dynamic tasks, it will generate lots of movement and vibration, resulting in large artifacts over the interface between electrodes and subject's skin. However this problem itself and the progressive evolution of related researches had driven the solution to the development of adhesive linear arrays using with those either dry one-dimensional or two-dimensional metal electrode arrays, separating them from subject's skin but still maintain the electrical conductivity through the small cavities filled with 20–30 μL of conductive gel. This allows the action potential travelling along the muscle fiber, during dynamic contraction to be directly detected (Farina et al., 2004a). With this unique design, it is clearly that, the evolution of EMG signal analysis during the continuous movement, by multi-channel surface EMG is capable with negligible artifacts and enable the researches found in this review to be achieved over such repetitive movement. According to the study of one-dimensional surface EMG in this review, apparently there was correlation among two studies of the first and the second shown in the Table 1. It demonstrated that CV and iMNF decreased but ARV increased toward the end of the task, meanwhile patient group had a greater slope than healthy group, however the different location of the electrodes affected iMNF and ARV value, as shown in the second study. This implies that during the dynamic, cyclic task of the upper limb, muscle activity and its change over time depended on the position within the three divisions of the trapezius muscle (Falla et al., 2007). And it suggested that the multiple recorded sites are needed for the trapezius muscle investigation, due to the non-uniformity in muscle fiber distribution and/or recruitment/de-recruitment of motor units (Falla et al., 2007). Accordingly from the finding of the second study, it had then been re-assured its own finding, through the applications of the third and fourth study respectively. With the feature of larger coverage of the electrode grids, as the results of first time demonstration of multi-channel surface EMG (>50 channels) detection with negligible artifacts during the fast dynamic task (Farina and Falla, 2008), that was used in either third and fourth study, this allows regional muscle activity change investigation through the topographic map. Furthermore the new proposed CV estimation algorithm using a Gaussian window (short epochs) helps provide less variability (Farina et al., 2001, Farina et al., 2004a) and higher value in reliability (Farina et al., 2004b) and accuracy of conduction velocity estimation, rather than using only a few channels (Farina and Falla, 2008) such as one-dimensional array electrode, which was clearly demonstrated in the fourth study, that applied EMG RMS spatial distribution of muscle activity to differentiate muscle activity change among patients and healthy group, which couldn't be capable by using such a few-channel surface EMG.

5 CONCLUSION

As the results of this review, it is shown that there had been a progress in development of research on muscle assessment during the repetitive movement over time, and it had demonstrated that, the applications of muscle fatigue/muscle activity investigation is increasingly applicable by using multi-channel surface EMG, particularly with more effectiveness for the use of two-dimensional array electrodes type, along with its advanced mathematic algorithm, that had loomed up the muscle assessment in our daily-life applied field activities more applicable.

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An overview of the current three-dimensional body scanners for anthropometric data collection

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ABSTRACT: Three-dimensional body scanners have revolutionized the anthropometric data collection. These data can be used for numerous applications, in different fields of expertise. However, there are different types of technologies and products to be used, influencing the results obtained. This paper presents a non-exhaustive synopsis of the existing technologies and products available in the market.

1 INTRODUCTION

With the diffusion of digital devices for body scanning, the science of anthropometry gained a new powerful tool that allows deeper investigations on the human body shape. The new digital shape analysis tools allow rethinking the anthropometry science since, in the digital environment, the measurements are not limited to the traditional one dimensional ones, and instead it is possible to have complex geometrical features (i.e. curvatures and partial volumes). 3D body scanners have revolutionized anthropometric data acquisition, being more practical, accurate, fast and, when compared to traditional anthropometry, less expensive.

The purpose of this paper is to present an overview of the currently existing body scanners, the available types of technology and the standard process of scanning test subjects.

2 OVERVIEW

The study of the human body as a 3D object has only started in 1973 with a light sectioning technique proposed by Lovesey (Lovesey, 1966). This was labor intensive as the interpretation of data was extremely time consuming. That technology evolved to what is now known as a three-dimensional body scanner.

A whole body scanner is an optical 3D measuring system that produces a digital copy of the surface geometry of the human body (Daanen and Water, 1998). In most cases, three-dimensional body scanners capture the outside surface of the human body by using optical techniques, in combination with light sensitive devices, without physical contact with the body. The subject being scanned usually wears form-fitting clothes during the process. This means that there is no longer the need for physical contact with the subject's body. However, the image based data collection introduces the question of privacy. There are different opinions regarding the privacy of the body scanner. If in the one hand it provides more privacy, since it avoids the need to actually touch the body, on the other hand the highly accurate, more personal, images produced by the scanners are potentially more invasive since they can be stored insecurely and transferred directly from the scanner over local networks or the internet. Nevertheless, with these advances in the anthropometric science and computer-based human-form modeling it is now possible to give a different perspective to the collection of anthropometric measurements.

One of the earliest 3D body scanning systems was a shadow scanning method developed by the Loughborough University in the UK, the Loughborough Anthropometric Shadow Scanner—LASS—(Jones et al., 1989). This system was developed and used to digitize the human body, but it was necessary to manipulate the data in order to take body measurements from the scan. The original shadow scanning methods are different from other conventional structured lighting approaches since they require very little hardware besides a camera, a desk-lamp, a pencil and a checkerboard. LASS was an automated, computerized 3D measurement system based on triangulation, where the subjects stood on a rotating platform that was turned 360º in measured angular increments. Brooke-Wavell et al. (1994) compared anthropometric measurements taken with LASS with measurements taken using traditional anthropometry and concluded that they were similar. For women, statistical differences were found between various measurements (neck and chest circumferences, waist width, depth and height), whilst for men a significant difference was only found between the measurements of waist depth. These differences were explained as being due to landmarking and to difficulties in making horizontal measurements with the tape measure.

2.1 *Types of imaging techniques*

Currently, there are several types of imaging techniques to create full body images. These imaging technologies, include (i) 2D video silhouette images converted to 3D models, (ii) white light phase based image capture, (iii) laser-based image capture, and (iv) radio-wave linear array image capture (Treleaven and Wells, 2007; Istook and Hwang, 2001). Body scanning systems normally consist of one or more light sources, one or more vision or capturing devices, software, computer systems and monitor screens to visualize the data capture process (Daanen and Water, 1998). There are several types of body scanning technologies but the major ones are those using laser and light. Table 1 briefly describes the various types of technology available for three-dimensional body scanners (Daanen and Haar, 2013).

It is possible to find many studies that compared the various types of existing body scanners. Jones and Rioux (1997), Daanen and Water (1998), Olds and Honey (2005) and Daanen and Haar (2013) discuss the use of 3D whole body scanners in anthropometry as a whole, giving a good overview of the evolution of body scanning technology and the different scanners in use at the time. Olds and Honey (2005) affirm that scanners using white light are generally faster and cheaper than laser scanners, but can produce lower quality scans, with areas of data missing. Despite concluding that body scanners are expensive, require technical expertise, cannot measure skin-folds or compressed bone lengths, they agree that body scanners offer the ability to collect greater amounts of data, extract data when the subjects are no longer present and use the data directly in computer-aided design software applications. McKinnon and Istook (2001) compared two scanners available at that time from TC2, finding that the newer scanner was an improvement on the older scanner, producing data that replicated more closely the one obtained using traditional measurement methods. Then they anticipated that the extraction of fast and accurate anthropometric data would be possible in the future, as in fact it is nowadays.

2.2 *The different body scanners*

Based in a publication from 2013 from Daanen and Haar, there are currently available on the market various 3D whole body scanning systems, as the ones presented in Table 2.

Table 1. Types of technology used by 3D body scanners.

Type of technology	Description
Laser line systems	A laser line is projected on the body from different sides and viewed by cameras under a fixed angle. The advantage of a single line is that the sensor can easily detect it and very accurately compute how the projected 2D line is deformed on the 3D surface. The sequential 3D lines then form the complete 3D image.
Structured light systems	A structured light system projects a full structured light pattern into the scene and, from the sensed deformed pattern, a full 3D image is calculated. This pattern can consist of dots, bars, or any other light patterns. The advantage of a structured light scanner is its speed. Structured light scanning is so fast, that it can be used for 4D scanning; i.e. real time 3D scanning at 200 Hz. This offers nice opportunities to couple movement registration to 3D shape analysis.
Multi-view camera system	A 3D image is acquired from two or more cameras. A stereo-camera records two images at the same time from a different viewpoint. From the content in the two images the depth to the body can be calculated and converted into a dense 3D image in real-time. The advantage of a stereo-camera system is that no laser line or light pattern is transmitted, which means that sunlight cannot interfere with the pattern. However, using the line or patterns enables a 3D image with higher resolution and accuracy.
Millimeter waves	There are active and passive millimeter wave scanners. Active scanners use the reflection patterns of millimeter waves projected on the body. Passive scanners process the millimeter waves that are emitted by the human skin. Millimeter waves offer the advantage that they pass through most clothing ensembles but not the skin. Thus, the shape of the body can be captured without undressing. This offers an advantage in time and effort, but may introduce an ethical problem because the private parts of the subjects can be seen. Millimeter wave scanners are currently employed at airports for the detection of metal parts under garments and offer an alternative for low radiation x-ray scanners.

Table 2. Currently available 3D whole body scanning systems (Daanen and Haar, 2013).

Company	Product	City, Country	Technique
Cyberware	WBX	Monterey, CA, USA	Laser line
4ddynamics	Mephisto EX-pro or CX-pro	Antwerp, Belgium	Structured light projection
4ddynamics	Gotcha	Antwerp, Belgium	Structured light projection
Vitronics	Vitrus Smart LC	Wiesbaden, Germany	Laser line
Vitronics	Vitrus Smart XXL	Wiesbaden, Germany	Laser line
TC2	KX-16	Cary, NC, USA	Infrared
SizeStream	3D body scanner	Cary, NC, USA	Infrared
SpaceVision	Cartesia	Tokyo, Japan	Laser structured light
3dMDbody	Flex8	Atalanta, GA, USA	Stereo photogrammetry

There are some new ways of creating three-dimensional images using systems that were not initially designed to do so. This is the case of Microsoft Kinect that can be used for numerous other applications besides games. The Microsoft Kinect sensor has its place in the class of devices known as depth cameras and fall under the structured light systems categorization regarding the type of technology used (Shotton et al., 2011). Kinect can be seen as a 3D marker-less motion capture system because it provides a simplified skeleton in real time without the need for especial clothes or other equipment. Despite the fact that it cannot be used for extremely accurate studies (Ye et al., 2011; Clark et al., 2012; Bragança et al., 2014), it can be used when there is no need for high accuracy, like in clothes or shoes sizing, indirect fat measurement or clinical rehabilitation (Baena et al., 2012; Weiss et al., 2011).

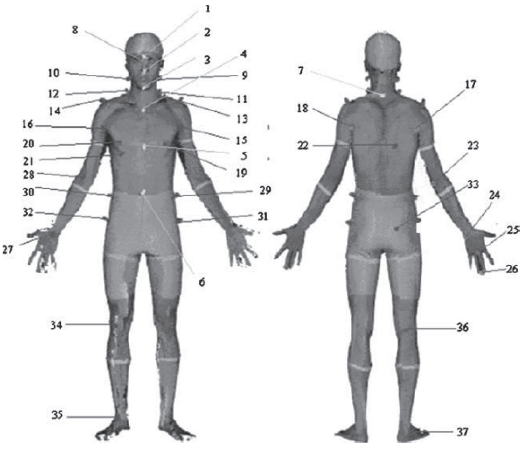

Figure 1. Landmarks used for collecting the anthropometric dimensions (Wang et al., 2007).

2.3 *Landmarking*

Before starting the scanning process it is necessary to identify some body parts to simplify the measuring process—this process is often called landmarking. Landmarking is, indeed, a subject very much discussed throughout the research.

For the purpose of landmarking and body dimensions' collection, the 3D human model is usually segmented at armpits and crotch (process known as segmentation). Five body parts including head and torso, both arms, and both legs can be identified. There are many ways to perform this segmentation, for example, Nurre et al. (2000) proposed a cusp algorithm for segmenting the 3D scanning data of a human body and Wang et al. (2007) applied fuzzy logic concept to locate the armholes and crotch, and then to separate the arms and legs from the trunk.

After segmentation, the scanning data will be ready for landmarking. Landmarking's objective is to find out the anatomical landmarks that are used to define body size and shape (Fig. 1). Since landmarks are mostly bony protrusions, palpation works are needed for identification. In general, anthropometric data technicians place markers or stickers on the surface of human body to highlight the positions.

As this is a process that requires some training, some attention has been given to developing the methods to facilitate correct landmark identification. According to Wang et al. (2007), the landmark identification methods can be generally classified as: (i) premarking, (ii) human body mapping, (iii) geometry analysis and (iv) approximate height location determination. Thus the positions of the landmarks can be easily identified on the scanning image with human eyes. Further, by using the color information obtained from the cameras in the scanning heads, the landmarks can also be identified by analyzing the RGB information in the scanning image (Daanen and Water, 1998; Burnsides et al., 2001; Wang et al., 2007).

2.4 *Applications*

Body scanners are used for a wide variety of applications. Jones and Rioux (1997) divided their applications in:

- Medical: body deformity; glaucoma; orthodontics; orthopedics; surgery; lung function studies; custom prostheses; breast topography; pediatrics; medical management;
- Human systems engineering: work environment; population anthropology; helmets and face masks; gloves; clothing; human morphology; human motion analysis; forensic imaging; hearing studies;
- Virtual reality and communications: three-dimensional portraits; computer animation of human models.

According to Ashdown et al. (2004), more recently, 3D scans have been used to create virtual models of customers of the apparel industry, which consumers can manipulate to mirror their own bodies. Consumers can then try clothing on their model online.

3 CONCLUSIONS

Creating anthropometric databases typically requires considerable resources (time, know-how, funds, equipment and workforce). To overcome these limitations the technological development in recent years, using three-dimensional forms, allowed the study of human size and shape to be done in a more expeditious and efficient way that requires fewer resources. 3D body scanners make the anthropometric data acquisition more practical, accurate, fast and less expensive. With these advances it is now possible to explore and give a different perspective to the use of anthropometric measurements.

3D scanning systems have evolved over the last few years. From LASS to Kinect the technology is always in progress. The type of technology used is different from scanner to scanner, existing four main types of technology—laser line systems, structured light systems, multi-view camera system and millimeter waves. Currently, there is a relatively high variety of three-dimensional body scanners available in the market (nine major products developed all over the world).

According to the technology and product used, the results and applications are different. Different products may have different accuracy values so the applicability of the data may be compromised. Depending on the desired application, i.e., highly precise anthropometric data or less accurate data for apparel applications, there is a variety of body scanners that can be used. For example the Microsoft Kinect, that is less accurate, can be used for apparel applications, while the Vitrus Smart LC, that is more precise, can be used for compiling an anthropometric database.

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A review of the regulatory norms of work in Brazil within the context of biosafety in dentistry

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ABSTRACT: Biosecurity in dentistry is a subject on which there is little discussion in the literature, and in general, the articles found are addressed to dental surgeons and undergraduates. Therefore, it was necessary to conduct a study concerning the work of the dental school faculty member, by inserting it into the context of biosafety, as a professional class subject to all types of occupational risks, thus deserving all the labor and social security rights that Brazilian legislation offers. Occupational infectious diseases such as hepatitis B and C and AIDS are cause for concern among health professionals. In this research, it was determined that dentistry professionals, in general, are exposed to a number of environmental risks defined in Ordinance 3.214/78, in accordance with the regulatory standards of the Ministry of Labor and Employment. Therefore they deserve to receive the additional protection that the law provides, in these specific cases.

1 INTRODUCTION

Concern about the diagnosis of biological risks to which health professionals are subject is a matter of the utmost importance at present. However, this importance dates back to the year 1700, when Bernardino Ramazzini, father of occupational medicine, made references to the biological risks existent for certain professions (Mastroeni, 2006).

This concern refers not only to health professionals, but includes those working in dentistry, since dental practice is linked to close contact with the patients. If the existent biological risks are not considered, they may lead to the dental professional acquiring diseases, in addition to becoming a disseminator of diseases.

In the oral cavity there are over 350 bacterial species, perceived as normal components of the microbiota; with saliva containing 43 million to 5.5 billion bacteria per milliliter. Therefore, the proximity of the dental surgeon to patient's mouth exposes him/her to an extremely high level of biological hazards, and causes him/her to be a possible spreader of certain diseases (Jorge, 1997).

Infectious illnesses such as hepatitis C and B, AIDS/HPV are cause for concern among health professionals, and consequently, among dental professionals as well.

The main diseases that can be transmitted from patient to dentist and vice versa are known to be the common cold, tuberculosis, acute or chronic laryngitis, pharyngitis, acute parotitis, rubella, measles, chickenpox, hepatitis and AIDS (CDC, 1993; Brasil, 2000).

The ease, with which these professionals are subject to contracting certain pathologies and promoting their spread, either through their working conditions, by not using protective equipment, or being unaware of the seriousness of the subject, may result in a simple dental care treatment becoming a public health hazard, or even culminating in the death of the professional.

This literature review was based principally on information provided by the Ministry of Labour and Employment of the Federative Republic of Brazil, through their Regulatory Standards contained in the ordinance 3214/78. Also guides the recommendations of the Center for Disease Control and Prevention (CDC), which are globally recognized for providing information related to biosafety in dentistry, combined with a context enshrined in literature.

2 OBJECTIVES

The objective of this study was to conduct a literature review, based on Brazilian labor legislation, to show the main biological risks to which dental professionals are exposed. Additionally, demonstrate that there is a need to insert dental school faculty members as a professional class, which is exposed to these risks and has the same rights as all other workers.

A further aim was to question the Brazilian legislation within the context of biosafety, pointing out revisions needed in some labor standards.

3 REVIEW OF THE LITERATURE

Nowadays, biosafety has taken on greater significance, since it became a synonym for the protection of life, either within our outside of the occupational sphere.

Biosecurity can be defined as the set of standards and procedures designed to protect health and prevent the acquisition of disease and disorder during professional activities of risk (Hoefel & Schneider, 1997). In dentistry, biosecurity is defined as a set of measures implemented in order to protect the staff and patients in the clinical environment. The goal of these preventive measures is to reduce occupational hazards and to control cross-infection (Ramacciato et al., 2007).

In Brazil, the biosecurity law is legally formalized only where genetically modified organisms concerned, through the Biosecurity Law, Paragraph 8.974 of January 5, 1995.

In the year 2005 the Biosecurity Law underwent changes, at present Law 11.105 of March 24 is in force. This Law assigns responsibilities, guidelines and standards only with regard to the use of stem cells, genetically modified organisms and the audits pertaining to these two subjects.

The regulatory standards govern and provide guidance on required procedures related to safety and occupational medicine. These standards are cited in chapter V, Title II, of the consolidation of labor laws, which were approved by ordinance n° 3.214, of June 8, 1978.

The purpose of Regulatory Standard N°. 32 is to define safety and health at work in health services. It "aims to establish basic guidelines for the implementation of protective measures to ensure the safety and health of workers in the health services, as well as those engaged in promoting activities and health care in general." This Law establishes biological risk as "the likelihood of occupational exposure to biological agents".

The following are considered biological agents: microorganisms either genetically modified or not; cell cultures; parasites; toxins and prions.

The classification of biological risk is defined by Ordinance 3.214/78 of the Ministry of Labor and Employment, in its regulatory standards and job security (Brasil, 2002). Biohazards are represented by bacteria, fungi, parasites, viruses, among others. It is known that occupational exposure to potentially contaminated biological materials constitute a serious risk to health professionals in their workplaces.

The literature describe the lack of biosafety studies in dentistry and most of them it is directed to the dentists (Kennedy & Hasler, 1999; Kerr & Blank, 1999; Younai et al., 2001; Smith et al., 2001). However the dental professional is exposed to biological hazards and the severity of the situation is no more evident in Brazil, probably because this fact is related to the lack of notification of such accidents, preventing the development of further studies that depict this situation, being thus, it is difficult to obtain reliable estimates of the frequency of accidents with these professionals (Belei, 2003).

It has been observed that from the time of graduation, the dental professional is exposed to all these types of risks, and the level of these increases or decreases, according to the specialization each professional will adopt throughout his/her career.

The issue of occupational biosafety in the most diverse environments should be approached with caution. This is due to the fact that dentistry professionals come into direct contact with their patients, and later, with their families, making it even more serious when it concerns the professors that teach subjects involving clinical procedures.

In this case, professor comes into contact with students during the workshop, and obviously, with the patients themselves. Taking into consideration the number of patients and students with whom the professor comes into contact during the academic period, multiplied by the time of his academic career, specifically gives one and idea of the extent of professional exposure.

Developing countries have an increasing number of health professionals infected with the Human Immunodeficiency Virus (HIV), Hepatitis B and Hepatitis C in about 5.84% per year (Singru & Banerjee, 2008; MacCannell et al., 2010). This increase of great importance to dentists due to instrumental work and constant contact with hazardous microorganisms (Kanjirath et al., 2009). Addition to the close contact with the oral cavity and the large number of patients (Nejatidanesh et al., 2013).

Hepatitis B is an infectious and contagious disease whose main routes of transmission are sexual relations, exposure to blood and its derivatives, perinatal exposure, use of contaminated needles and syringes and contact with skin lesions of people who are in an acute or chronic stage of the disease (Baldy, 1997; CDC, 1998).

The risk of contracting the virus of hepatitis B as a result of an accident with perforating sharp instruments, impregnated with tainted blood, ranges from 6 to 30 percent, and a very small amount of blood (0.0001 ml) has a sufficient amount of virus capable of transmitting the disease (Brasil, 2000). According to Center for Disease Control and Prevention (CDC, 2001) the risk of contracting hepatitis B is 10 times bigger that of contracting the virus hepaite C. Comparing the risk of infection by the Human Immunodeficiency Virus (HIV) that is 100 times smaller than the chance of acquiring hepatitis B.

Hepatitis C can be considered the most serious viral infection among types of hepatitis due to its high capacity of chronicity. Only 15 of those with acute infection recover, while 85 of affected individuals feature a chronic infection with the possibility of developing cirrhosis, hepatocellular carcinoma in a third of cases, and even liver failure (Gillcrist, 1999). So far there is no complete study as regards an effective vaccine being developed for the treatment of this disease (Cardo, 2003).

HIV has been isolated: in the blood, lymph nodes, brain, breast milk, semen, vaginal secretions, cerebrospinal fluid, saliva, tears, pericardial fluid, pleural fluid, synovial fluid and amniotic fluid of patients. However, its transmission has only been proven in the case of blood, semen, vaginal secretions and breast milk (Brasil, 1994). Thus the risk of contracting the Human Immunodeficiency Virus (HIV) among practitioners of dentistry is extremely low (CDC, 2003).

4 RESULTS AND DISCUSSION

In the present research, it was determined that dentistry professionals are exposed to a number of environmental hazards. It is noteworthy that they are exposed to not only the biological risks mentioned in the present article, but to all the other environmental hazards that Ordinance 3.214/78 of the Ministry of Labor and Employment set out in its regulatory standard.

As regards environmental risks, the Regulatory Standard N°. 9—environmental hazards, defines environmental hazards as being: biological, physical, chemical, ergonomic and accident risks. It is worth mentioning that in this standard, the definition is as follows: "consider biological agents bacteria, fungi, protozoa, bacteria, parasites, viruses, among others".

Notice that both the dental school faculty member, dental clinic, and dentist are exposed to this environmental risk, in addition to others previously mentioned, therefore they deserve to receive the additional protection that the law provides, in these specific cases.

Annex Paragraph 14 of Regulatory Standard N°. 15—Regulatory Activities and Unhealthy Operations added by ordinance N°. 12 of 1979 provides a list of activities involving biological agents, whose degree of unhealthiness is characterized by qualitative assessment. This standard establishes the following environments and conditions as being of a medium degree of unhealthiness; the work and operations in constant contact with patients, animals or infectious/contagious material, in hospitals, emergency services, hospital wards, clinics, vaccination posts and other establishments intended for human healthcare. This applies only to personnel who come into contact with patients, as well as the handling of objects not previously sterilized, used for or by these patients.

According to this set of standards, all dental professionals, without exception, should be ensured the right to receive compensation for medium-grade insalubrious working conditions, characterized by an additional 20% on the region's minimum wage (Brasil, 1978).

In order to conduct this research, few studies and consistent results were found, which did not allow a definition to be obtained on this specific subject, with regard to additional insalubrity compensation for the dental professional.

It was observed that the existent labor relationship is the situation that defines whether or not the additional payment will be made. When a dental surgeon is registered under the employment conditions that is hiring ruled by the CLL (Consolidation of Labor Laws) he/she receives the additional payment. One is reminded that he/she may apply for the concession of a special retirement.

Whereas, when the professional works as an employee, it does not refer to additional pay, but rather to a special allowance, granted by the INSS (National Social Security Institute).

Grants of this type of retirement became more difficult as from April 29, 1995. Considering that from this date onward, the law began to demand proof of risk to health; that is to say, surgeons had to prove, by means of a technical report, that during the performance of their activities, they were exposed to biologic agents.

Until April 28, 1995, the law assumed the risk to health professionals in this area. It was sufficient to prove that company started as a dentist, irrespective of the specialty, location of the service provided and exposure time. The INSS only recognizes the special service time of dental surgeons up until April 28, 1995. This is due to the changes in the text of the law that caused the INSS to stop considering the special activity by category, and begin to demand proof of exposure to harmful agents, by means of a technical report (Brasil Previdência, 2009).

One perceives that there are provisions for dental professional's rights in the law, due to the working conditions in which he/she works, but these rights are not always granted.

5 CONCLUSION

In accordance with the results of the literature review conducted in order to do this work, and based on Brazilian legislation, a careful review must be made of the regulatory standards that address the healthcare professionals, and consequently, dental practitioners. This applies to both the biological risks with which they come into contact through their work activities, and the rights to which dental practitioners are entitled, be they teachers, dental surgeons, independent practitioners or employees, by virtue of the Brazilian Labor and Social Security Legislation.

It was also possible to conclude that both the dental surgeon and dental school faculty member have the risk to be expose to biological hazards, such as hepatitis C, hepatitis B and HIV.

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Evaluation of a triaxial operating vibration monitor applied to farm tractor

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ABSTRACT: High levels of vibration coming from agricultural machinery can be transmitted to the operator's body, requiring the need to create or enhance devices that allow the measurement of vibration levels. Design cost-effective equipment capable of monitoring the occupational vibration on machines and workstations allows one to extend the application of this equipment to monitor occupational conditions by detecting any inadequate conditions, thereby preserving the health of the worker. The present study was to evaluate the performance of a device for monitoring the operating vibration of an agricultural tractor, running during field operations. By means of tests, it was concluded that the device presented satisfactory performance, allowing the vibrational conditions of all three axes to be monitored from a distance, by means of spectral analysis, present at the point of installation on the agricultural tractor tested. The results shown were similar to those obtained in measurements taken with equivalent laboratory equipment.

1 INTRODUCTION

Operations with farm equipment are activities that basically comprise two factors: the operator and the equipment. According to Grandjean (1998), these two factors interact with each other, forming the man-machine system, and it is necessary for this system to be in equilibrium, i.e. there is a need to establish conditions in a job that will not endanger the health of the operator.

One of the factors responsible for this imbalance is vibration. According to Saliba et al. (2002), vibration is defined as an oscillatory motion of a body due to unbalanced forces of moving parts and alternating movements of a machine or equipment.

Vibration is a harmful physical agent present in various day-to-day industrial activities, because workers are submitted to vibrations located at the extremities (also called hand and arm- or end vibration) and whole-body vibration. This agent is an intrinsic feature of heavy vehicles and agricultural machinery, such as tractors, and its transmission to the body and the operator's members, occurs if the operator is in contact with the seats of vehicles, and also through the steering wheel, pedals and control levers.

When vibrations are transmitted to the human body (occupational vibration) they can trigger muscle, vascular and neurological disorders, osteoarticular lesions, in cases of hand and arm vibrations; or pathologies in the lumbar region and spinal injuries when whole-body vibration occurs (Soeiro, 2011).

For the measurement of vibration levels, accelerometers are used. An accelerometer is the instrument that captures the vibratory movement, and transforms it into an electrical signal proportional to acceleration (Soeiro, 2011). Accelerometers are sensors capable of dynamically measuring the intensity and direction of the acceleration of a body, in one or in three axes (Ilha et al., 2005).

The vibration monitor presented in this paper is based on an integrated triaxial accelerometer, and incorporates a radio frequency communication system implemented on ZigBee® architecture (Saleiro & Ey, 2009). The aim of the present study was to evaluate the performance of this device, which is under development by the Department of Electrical Engineering of the Bauru College of Engineering FEB/UNESP.

The device was tested in field situations (operations using agricultural an tractor), which assessed its response to the excitement produced by agricultural tractor and the ability to transfer the data collected to a base station located in a remote position from the tractor operation.

2 OBJECTIVE

The aim of the present study was to evaluate the performance of a vibration monitoring device fitted to a farm tractor, operating under the working conditions of plowing 30 cm deep soil at 1700 RPM. This equipment is being developed at the Bauru College of Engineering of São Paulo State University—FEB/UNESP.

3 MATERIALS AND METHODS

This work was conducted on the Campus of UNESP, in the experimental area of the Department of Mechanical Engineering in the College of Engineering of Bauru.

The area was predominantly vegetated with grazing brachiaria (*Brachiaria brizantha*) with an apparent slope 3 gradient.

3.1 *Materials*

Materials used in this study are listed in Table 1.

3.2 *Methods*

The field trial was conducted in ten steps, as shown in Table 2. All trials were conducted with the tractor engaged in first gear, ranging in the gear reduced and simple. The tractor was subjected to three situations: static operation (tractor stopped only in operation) and dynamic operation (tractor only moving) and performing plowing (30 cm depth).

Table 1. Materials and equipment used in this study.

Materials	Description
01 Vibration monitor	Microcontroller-based vibration monitor with triaxial accelerometer
01 Base transceiver	ZigBee® transceiver model UBEEMax-FRACTUM
01 Microcomputer	HP-1000 Series-1400 (Intel Core Duo; HD 500 GB)
01 Tractor	Massey Ferguson brand 4 × 2 TDA-Model 290 (1975) 85 cv
01 Plow	Massey Ferguson 26″ discs tubular chassis model 204–effective with 0.90 m
01 Vibration meter	Mark Larson Davis model HVM100 (piezoelectric)

Table 2. Specifications of the operations performed in trial.

nº	Operation	Gear	RPM	nº	Operation	Gear	RPM
1	Static	–	800	6	Plowing	Simple	1700
2	Static	–	1700	7	Dynamic	Reduced	800
3	Dynamic	Simple	800	8	Dynamic	Reduced	1700
4	Dynamic	Simple	1700	9	Plowing	Reduced	800
5	Plowing	Simple	800	10	Plowing	Reduced	1700

(a) (b)

Figure 1. (a) Vibration monitor tested; (b) location of the anchorage point on the tractor.

The vibration monitor was fixed at the back of the tractor seat, by means of the magnets (Fig. 1). It should be noted that the objective of this work was to analyze the readout performance and record the unit in relation to different field situations, thereby eliminating the testing in accordance with the technical standards laid down, since the appliance is at the development stage.

4 RESULTS AND DISCUSSION

The results obtained by means of the tests allowed evaluation of the vibration levels present in every operation performed. Figures 2, 3 and 4 show examples of the response provided by the tested device, through the graphs resulting from the 10 Tests, which display the spectral content of the three orthogonal axes of vibration.

Due to the spectral analysis of vibration in each axis, the device tested increased the details of the variable evaluated when compared with instruments that provide only the RMS (root mean square value) values of vibration for each axis. This allows the analysis not only of the magnitude of vibration, but also of the frequencies present in the phenomenon.

Data acquisition is performed remotely through wireless communication via radio frequency,

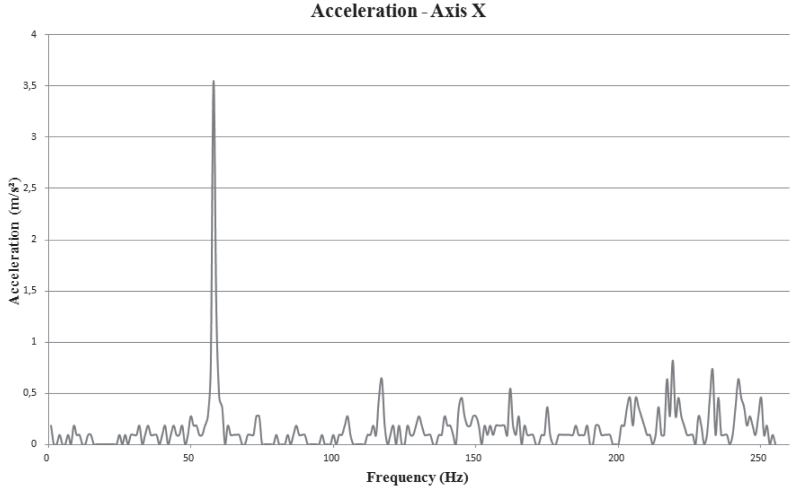

Figure 2. Vibration spectrum graph of the x-axis.

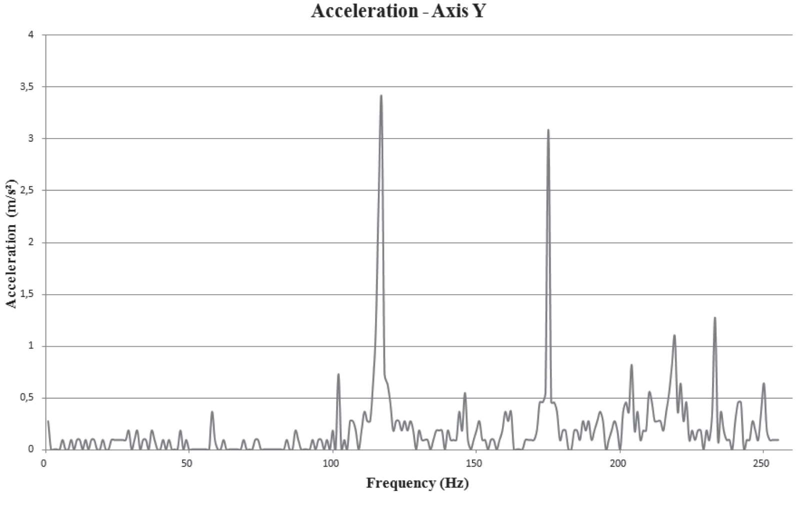

Figure 3. Vibration spectrum graph of the y-axis.

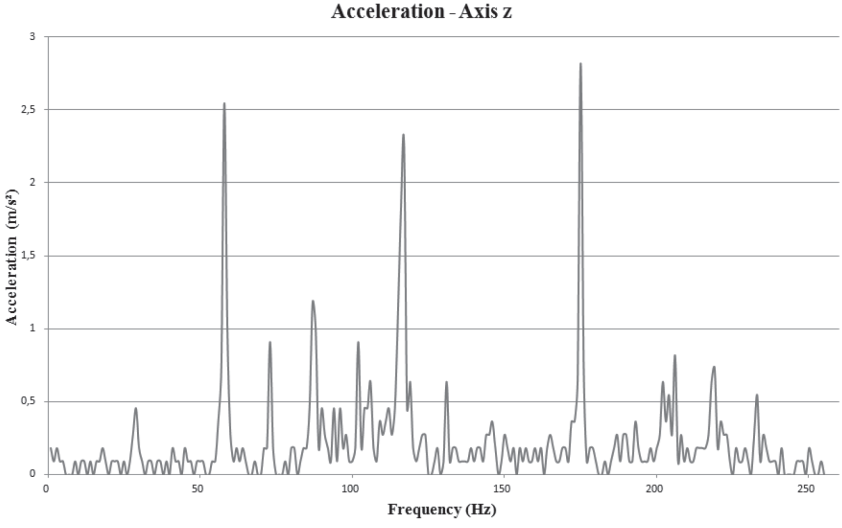

Figure 4. Vibration spectrum graph of the z-axis.

Table 3. Comparing values of vibration.

Operation nº	Vibration monitor under test (RMS)—axis [m/s²]: x	y	z	Calibrated vibration meter (RMS)—axis [m/s²]: x	y	z	Error (%)—axis: x	y	z
1	2.5	0.1	0.5	2.4	0.1	0.5	4.2	0.0	0.0
2	4.0	0.3	1.2	4.1	0.3	1.1	–2.4	0.0	9.1
3	1.5	3.0	0.7	1.4	3.1	0.7	7.1	–3.2	0.0
4	3.6	2.2	1.3	3.4	2.4	1.4	5.9	–8.3	–7.1
5	4.1	1.5	0.4	4.0	1.6	0.4	2.5	–6.3	0.0
6	0.7	3.6	0.3	0.7	3.8	0.3	0.0	–5.3	0.0
7	0.2	0.9	3.2	0.2	0.9	3.0	0.0	0.0	6.7
8	0.1	1.1	4.1	0.1	1.2	4.3	0.0	–8.3	–4.7

which allows monitoring of the real-time operation, and thus makes it possible to implement tools for assessing operator exposure to the workstation, and provide the basis for interventions that eliminate health risks resulting from prolonged operation of the equipment.

To evaluate the accuracy of the equipment under test, 8 bench trials applying accelerations with different amplitudes and directions were performed. Acceleration values obtained by the tested equipment were converted in RMS values to allow the comparison with readings performed by the calibrated accelerometer. Obtained data from devices and comparison are presented in the Table 3.

Data presented in Table 3 demonstrate that the device under test values indicates with reasonable accuracy when compared to calibrated equipment. Eventual equipment adjustments in future can improve the accuracy of measurements made with the developed device.

The applicability of the unit includes assessments of agricultural activities carried out with the use of the tractor, identifying those that are most harmful to the operator, and therefore, those that will be carried out with caution in accordance with the evaluation of vibration dose.

In future studies, the creation of a network of machine monitoring units, for tractors of different models and characteristics, performing the same activity in the same area, will check which models feature greater vibrational emission, enabling the causes and the possible consequences to be investigated. The analyses obtained in this way will also identify whether the readouts obtained are correlated to the operations themselves or whether they are intrinsic to the machines in question.

5 CONCLUSIONS

Evaluation of the device allowed the vibration spectrum analysis to be made for each of the operations performed, enabling identification of the possible undesirable conditions to the operator, or any anomalies of signaling function.

The remote data collection system allowed the tractor operations performed to be monitored in real time and in a remote position from the field work, demonstrating that the communication system adopted meets the requirements inherent to agricultural tractor operations.

The rated vibration monitor is in the development stage, allowing for future expansion of its functions in order to meet the various objectives to those already shown in this study. Thus the device becomes a valuable tool for analyzing and processing signals, which involve physical quantities related to the operation of agricultural equipment, with a high potential applicability in various rural areas.

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Construction project failure due to uncertainties—a case study

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ABSTRACT: During recent years, there has been a major interest in managing uncertainties to increase the level of project's success. Among the engineering activities, construction is one of the projects which is associated with a high degree of uncertainty and risk due to the nature of its business character. Therefore managing of uncertainties, as the main causes of failure in construction has been recognized as a very important task in order to achieve the project objectives. The scope of this study is an attempt to make a more clear understanding of uncertainties in construction projects which may result in undesirable failures. This task has been supported by a decision model to define and understand more clearly the different concepts of risk including uncertainties in a decision process. Furthermore, the defined concepts have been validated in a historical case.

Keywords: Uncertainty, Decision making, Risk management, building uncertainties, project risk management

1 INTRODUCTION

In fact, construction is one of the most risky projects which is associated with a high degree of uncertainty and risk due to the nature of its business activities, processes, and the external environment. Late completion of projects, surpassing their estimated budgets and in some worse instances not even achieving the desired quality and operational requirements, due to uncertainties, has given a bad reputation to this sector. Thus, effective management of construction associated uncertainties and risks remain a big challenge to the industry stakeholders. The literature shows that the main problems in construction projects are: Lack of safety culture, Existing of different actors with different goals and lack of communication between them, Lack of knowledge, Climate changes, Lack of reliable data, Technology changes, Complexity, Self-confidence about the experiences, Project similarity, Lack of competence of the staff in the project manager's team, Lack of competence about future needs. Finding a solution to these problems, which may face the project with risk of failure and applying risk management, is one of the greatest challenges faced by the researchers. The main objective of the study is to see how uncertainty is related to variables, hazard and risk in a process of decision making in construction?

The study is based on a literature review and interviews with some experienced project managers. In this study a conceptual approach developed by Shahriari (2011) was used in a construction project case to identify the risk relevant concepts including uncertainties and their roles in decision making and avoidance of failure.

2 UNCERTAINTY AND RELATED CONCEPTS IN DECISION MAKING PROCESS

Decision model description: In this part of the study an attempt is made to show the relationship of the aforementioned concepts in the frame of a decision model. In fact, decision makers face variables along the project life cycle from the beginning up to the end. However, the type of variables might be changed, or new variables added to the decision making process through the project life cycle. These variables in general could provide a potential for project failure or deviation from the project objectives causing loss of capital investment, reputation, productivity, assets, human life, environmental problems, etc. The hazard situation could in turn result in a feeling of threat and an urgency to act against an uncontrollable and uncertain situation by finding some alternatives

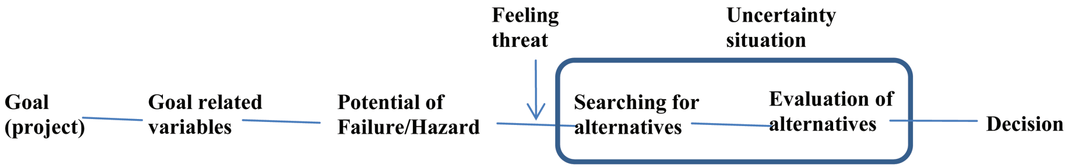

Figure 1. The simplified decision model.

and to try to make proper decisions. Once decision makers feel a threat they have to make a decision and choose the best options to prevent the hazardous situation. Decision makers analyze the received information and variables in order to identify, analyze and evaluate the alternatives. The lack of enough knowledge about the alternatives causes the decision makers to face an uncertain situation. To move from this uncertain situation, there is a need to improve the level of knowledge about the alternatives by quantification of uncertainties. In order to quantify the uncertainties, each alternative should be evaluated by estimating the relevant risk probabilities and consequences, calculating risk and comparing weaknesses and strengths of different alternatives. This process is referred to as risk assessment. The result of risk assessment is feedback to the decision maker as a decision support to choose the best option among the alternatives. In the following section a case study is given to define the decision making based concepts in a construction project. The model can be simplified follows in Figure 1.

3 A CASE STUDY

3.1 *Project definition*

A case can be dedicated to analyze a building for research activity in France. This building should be designed and built as the figurehead of a complex of advanced technology. The initial Investment Cost was estimated 8M€, for 5000 m². In addition to the common objectives (quality in terms of adequacy of the usage, budget and time limits), the given context and the desire of the client was the most important issue to make an exemplary building regarding the energy aspect in terms of minimizing the needs of energy, increasing efficiency of the system as a whole and using renewable energy. But unfortunately, the project failed and the client couldn't gain the expected goal.

As a case the project is analyzed on the basis of the decision model presented in the previous chapter of this paper (Shahriari, 2011). The main objective of the study is to identify the influencing uncertainty factors causing failure of the project. The goal is to learn a lesson from this case.

Table 1. Groups of variables associated with the project.

Group of variables	Explanations
Group 1	Different activities involved in the building
Group 2	Number of occupants
Group 3	Operational organization: In this project three different companies are involved as the clients and future operators of the building.
Group 4	Facility manager of the building: Establishing strategy for operation and maintenance at the beginning of construction and operation are essential for such technical buildings. Several design choices could depend on the level of maintenance. For instance a low strategy implies redundancy of devices.

3.2 *Variables*

Obviously, there are a lot of variables associated with this project. But, here in this paper we will focus on four groups of variables as examples (Table 1).

3.3 *Hazard*

Ignoring variables at the beginning or during the inception phase of the project could provide a potential condition (Hazard) for project failure e.g. delay, extra expenses, deviation from the planning. This condition faced the managers with many uncertainties but no one took it seriously.

3.4 *Uncertainties*

In this project the uncertainties according to the above mentioned variables could be developed at three levels:

Level 1: Basically, the two first variable groups were precisely defined, but uncertainties were not considered seriously at the beginning of the project. In fact, three main activities were defined in the project as: Research in the fields of building and energy consisting 130 persons, training including 10 teachers, and 15 administrative staff.

According to the project, 155 persons should have a work place in this building. As far as the third and fourth variable groups are concerned the situation will be quite uncertain due to the behavior and interaction of the different operators.

Level 2: The definition of the third variable was postponed to the later stage by the client who said: "we will define the operational organization later". This could cause an important uncertainty followed by a serious risk.

Level 3: The fourth variable was totally ignored by the client, although the best practices identified this point as a very important issue which should be taken into account at the inception phase.

Relationship between variables and uncertainties are shown as follows (Table 2).

3.5 *Risks*

There is risk in terms of probability of inadequacy of usage of the building, delay of the project, and failure to gain the goal regarding corporate image. Project risk due to uncertainties might be assessed as follows (Table 3).

3.6 *What happened?*

First unwanted event: During the project the organization of the client changed and a new directorship was in position in May 2007. The decision making process was affected by a new strategy and the client decided a rise of the budget for 5 M€ in December 2007. However the time limit of the project remained according to the same constraint for commissioning. This decision introduced a revision of the requirements. Accordingly, a new functional brief was delivered in February 2008, whereas the project was already defined. Consequently, values of variables 1 and 2 changed i.e, the usage of some of the rooms had to be modified. As no uncertainties were considered on these points before, designers now needed time taking into account these new requirements.

The first direct consequence: It was no more possible to respect the previous time limit, it became "as soon as possible". As a result, due to the delay, economic context evolved in a bad direction, this mean that costs increased a lot. In spite of a new budget, the financial constraint remained too strong regarding the functional brief.

The second consequence: The client had to choose between his two objectives, usage of building or corporate image. The second one was finally downgraded.

Second unwanted event: Whereas the building was built at 50%, the client defined the operational processes for the functioning of this building, in October 2011. This variable which was undefined until this date, led to new requirements concerning the spatial organization. Its strong impact on the project induced important consequences on the usage of the building. This variable was neglected by all the actors (client and designer), and consequently no alternative had been studied. Thus, risks due to inadequacy of usage of the building and the delay became very high.

3.7 *And finally*

In this project a better understanding of the uncertainties of the selected variables could allow to manage the evolution of the project. Furthermore, the probability of the first unwanted event was very high, and then a risk analysis, based on the identification of consequences, could show the client to specify alternative solutions. Although, in such a way the cost of design study would increase but at the end the objectives would be respected. Project goals with regards to level of satisfaction are shown as follows (Table 4).

Table 2. Relationship between variables and uncertainties in different levels of the project.

Variables	Kind of uncertainties according to the designer	Real uncertainties
Group 1	Level 1 (no uncertainties)	High
Group 2	Level 1 (no uncertainties)	Medium
Group 3	Level 2 (knowledge of variable postpone)	Medium
Group 4	Level 3 (ignored variables)	Very high

Table 3. Project risk due to uncertainties.

Project goals	Risk assessment (qualitative values)
Inadequate usage of building	Very high
Project delay	Medium
Corporate image	High
Extra expenses	Medium

Table 4. Project goals with regards to level of satisfaction of the realized building.

Project goals	Level of satisfaction of the realised building
Inadequate usage of building	Low (not enough places)
Project delay	Poor (delay: 3 years)
Corporate image	Medium (efficiency to be proved)
Extra expenses	Very poor (final cost: 2 times initial investment)

4 UNCERTAINTIES AND LIFE CYCLE ANALYSIS CONSTRUCTION SECTOR—A GENERAL DISCUSSION BASED ON CONCEPTUAL APPROACH

As for any product, the life cycle of a building goes through various stages from inception up to final deconstruction. Without going into details, some specific characters of such a life cycle are: every building is unique, attached to a site; its life may be very long, for decades with possibly heavy steps of rehabilitation; many actors are involved in the life cycle organized in complex processes of decision. Every decision during the life of the building is associated with some uncertainties as the results of technical, economic, environmental or social variables. These uncertainties do not disappear during the life of the building, but evolve for instance from qualitative (e.g. good soil) to quantitative judgement (soil bearing pressure = 0.2 MPa ± 20%). There are different types of uncertainties in building projects. Some of them depend directly on the environment and the site characters of the project and cannot be controlled due to lack of knowledge. This could lead many changes to the building e.g., renovating and renewing (Arja 2009) which might create negative economic and environmental impacts. For this category of uncertainty no risk is assessed except for those which are related to major natural hazards. Some of these uncertainties are taken voluntarily by designers (especially for technological solution) in order to hold on the flexibility of the project. However, the designers do not carry out a detailed analysis to express the risks associated with these uncertainties which are voluntary (Arja 2010). It doesn't mean that they accept or tolerate the risks, but because there is no culture to assess these kinds of risk. During the design phase, usually the first reaction of the different actors, especially engineers, is to try to identify and reduce uncertainties, which leads to freeze some solution choices at the expense of other concerns. The designers want to ensure performance in accordance with the customer requirements, without clarifying the various uncertainties related to the use, environment, etc (Carvalho 2008). As a result, lots of performances are evaluated according to references, often regulations, which do not reflect the present operation of the future building in an operational context. It should be noted that the design procedures are mostly based on conventional data and standards e.g., simplified scenarios of use, climatic environment type, etc. During the design phase, the uncertainties associated with architectural and technical choices (voluntary uncertainties) could be reduced and then disappeared. In this case the control of the evolution of these uncertainties is necessary to have an efficient design. A project manager has an important role to manage consistency and coordination between different specialists who should control uncertainties, But, usually they do not asses and communicate the risks with these specialist and even client or investor whose the risks are mainly on their shoulders. To avoid of such a problem, the project manager should have enough competence in building technology and risk assessment as well. The effectiveness of the implementation phase depends on the uncertainties related to final choices of devices and materials (Bazzana 2010). Furthermore, the quality of the implementation leads to the achievement of real value to be compared with what has been designed to build. Thus, once the building is delivered, the information concerning with the real finished building is available and much more accurate. But it is still associated with new uncertainties, generally coming from the measures of the characters of the finished building. During the operating phase, some of the uncertainties concerning with design and implementation phases will remain and also new uncertainties will appear. Therefore, during this phase, the facility manager should make an attempt to control the uncertainties (Taillandier 2011). At this stage, the facility manager should be flexible enough in order to adapt the operation of the building in accordance to the requirements of the users in a real context. Thus, he will keep control on some uncertainty during the operational phase i.e., the uncertainties arising due to occupants requirements and behaviours in terms of the culture of the users (Taillandier 2009a). It is therefore important that the facility manager can cope with changes in regulations, in use, and in technologies (unexpectedly) related to the previous phases. The facility manager must be able to steer the building and identify the occurrence of events that deviate from the planning and impact on the interests. As soon as he/she can identify any failure will have to be taken into account to minimize the effects. At this moment, the most important uncertainty is the lack of knowledge of the facility manager about the previous phases during the design and construction. Due to that and in order to minimise the risk due to these uncertainties it would be more effective if the facility manager could have an observation role on the project from the beginning. Although uncertainty is a source of risk, but it is also essential in order to guarantee the flexibility of actions and evolution of the building, in terms of providing alternatives, during its life cycle. A risk analysis can always let us know if there are needs to reduce the risks at tolerable level. The goal is to maintain a maximum of action strategy in the context of controlled risks, by identifying and managing uncertainties. The actors of the buildings are somehow aware of the uncertainties and the risk, but they do not have the culture to apply a methodology to assess these risks. In addition there is no any emergency planning and responses in case of occurrence of an unwanted event. This problem will cause unexpected economic losses and productivity problem. The reason is very simple; it would increase significantly the costs of the study. However, looking to the progress of current projects, it is questionable whether these investments would not be preferable in considerable financial excesses of the vast majority of projects due to uncontrolled changes.

5 CONCLUSION

The conceptual approach was used to identify the different concepts of risk and their relationships. Life cycle investigation shows that a lot of variables produce uncertainties that affect decision making process. These could be divided in two main packages: Lack of knowledge about risks and the complexity of the project (Taillandier 2009b).

Some of the most important findings in this study could be summarized as: 1). Lack of communication between the managers involved in different phases of the life-cycle, and lots of information and hypothesis are lost during the life-cycle, introducing discontinuity of risks analysis if is conducting. 2). There is no culture in risk assessment and identification of uncertainties in this sector. Moreover client is not informed of the existing risks. 3). Facility manager should be involved in the project from the beginning in some way, for instance as an observer from the beginning (Taillandier 2009c). 4). Though uncertainty has a bad face which brings losses but it has a good face as well. Because it could be used as a tool in construction projects for holding on flexibility.

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Safety and security in a higher education establishment laboratories using a checklist from the University of Illinois at Chicago

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ABSTRACT: In laboratories, teaching and research can be performed. To avoid accidents in laboratories and to ensure safety, there is a need and responsibility for periodic inspection as well as an assessment of user's risk perception, which can be achieved by the use of checklists. In this work, the Chemical Hygiene Officer Laboratory Self-Audit Checklist from University of Illinois at Chicago was the elected template to apply in higher education establishment laboratories. This checklist was distributed to a sample of 128 users (59% women and 41% men). The objective of this work was to analyze the answers given by these users to investigate to assess risk perception coupled with risk assessment. Based on these results, women seem to be more aware of the risks than men. The themes with more positive risk awareness are Access and Personal Protective Equipment and the themes that require more attention are chemical hygiene officer and chemical hygiene plan.

1 INTRODUCTION

Laboratories are facilities in which scientific training and research activities are developed. Laboratories can have various aspects and risk according to scientific disciplines: chemistry, biology, physics and others. Classifying these laboratories is therefore, a difficult task, particularly in terms of risk assessment. Different risk groups with different knowledge and risk perception can be found in these spaces: students, teachers, researchers, maintenance and cleaning teams. New laboratory workers and students are particularly relevant groups as they are not fully aware of the risks related to the use of dangerous products. But also, experienced users are not free from dangers (Watch, 2008; Fruchtnicht et al., 2013; Van Noorden, 2013). As a result, accidents do happen. The evaluation of risks is made through the following steps: Identifying hazards and corresponding risks; evaluating and prioritizing risks; deciding on preventive action; taking action; monitoring and reviewing (OSHA 2011; Wargniez et al., 2012; Phifer, 2014; Theis, 2014). Safety is a priority in chemical and biological laboratories. To ensure that all users are familiar with rules and regulations and understand how to operate laboratory equipments various laboratory safety manuals are available. Usually, these manuals are elaborated by someone with proper safety training, namely a chemical hygiene officer (Ashbrook, 2014). The different laboratory manuals include instructions to safety, identification of hazards (physical, biological, toxic, radiation,…), good laboratory practices, laboratory safety checklists (Agilent Technologies, 2000; British Colombia, 2003; WHO, 2008; CDC, 2009; WHO, 2009; ACS 2013). Some publications related to laboratories are specifically published for students including safety guides and short laboratory courses where they should have satisfactory scores. With these tools, an increase in safety awareness is expected (ACS, 2003a; ACS, 2003b, Crockett, 2011). With the advance of technologies, it is increasingly common to manage the laboratory risks with appropriate software. New laboratories are designed according to the specific research themes and respective risks. The disposal of materials, reagents and equipments should comply with local and regional safety and environmental regulations that may vary with country (Cagiltay et al., 2010; Maiti, 2010; Marendaz, 2013). For this work, the checklist from University of Illinois at Chicago was distributed to survey the risk perception from laboratories of a higher education establishment. The findings will support the design of a short safety course for laboratories in order to provide risk awareness to the users.

2 METHODS

In this work, out of 36 checklists found from different laboratories, the Chemical Hygiene Officer's Laboratory Self-Audit Checklist from University of Illinois at Chicago[1] was selected as the most appropriate and used as a template to apply in the

[1]http://www.uic.edu/depts/envh/HSS/Documents/CHOChecklist.pdf

laboratories in a higher education establishment. The checklist was composed of 12 general categories, ranging from chemical storage and compressed gases to fume hoods and PPE. This checklist was distributed in paper format to 128 respondents (59% women and 41% men) of which: 66% were students, 9% researchers and 25% were part of cleaning and maintenance teams. The completed checklists were analyzed for age, gender, profession and qualifications. In addition, the laboratories of the higher education establishment were also evaluated for aspects such as principal investigator, number of scientists, and the type of laboratory (teaching or research). The results obtained from 128 answered checklists were organized in a matrix and two new possible answers were included in data management: "not valid" and "not answered". Results were divided according to gender to survey if this variable might play a role in risk perception. After this analysis, all the original answers "yes", "no", "not applicable/not available" were converted into logical values of "zero" or "one", depending if the risk perception is negative (0), or positive (1), respectively. The average values for each topic was calculated. Bar graphs and histograms were constructed for each set of questions. Line charts were constructed to evaluate the percentage of positive risk perception.

3 RESULTS

Figure 1 shows the variation of score with cumulative percentage of respondents representing the total of positive perception that each respondent expressed. The maximum score (87%) of positive perception was obtained by two women. Another reading that can be made is that 60% of respondents show score below 50%.

Seventy-eight questions were arranged in descending order, according to the score relative to positive perception. Figure 2 shows the top 8 questions with more positive perception, i.e., with value "one". It can be seen that the major theme questions are "access" and "general work environment". The average value of these top 8 questions with positive perception is 81%.

Figure 3 shows the top 6 questions with the least positive perception. The themes "chemical hygiene plan" and "emergency training" are the most representative and therefore the most serious. The average value of these top 6 questions is 10%.

The average values were calculated for each theme and represented in Table 1. The results showed that the most critical themes were "chemical hygiene plan", "chemical hygiene officer" and "emergency training". The theme where users demonstrate more positive perception were: "access", "personal protective equipment" and "general work environment".

4 DISCUSSION

The results showed that some respondents left some answers blank (i.e. without a response). This behaviour is possibly due to the lack of

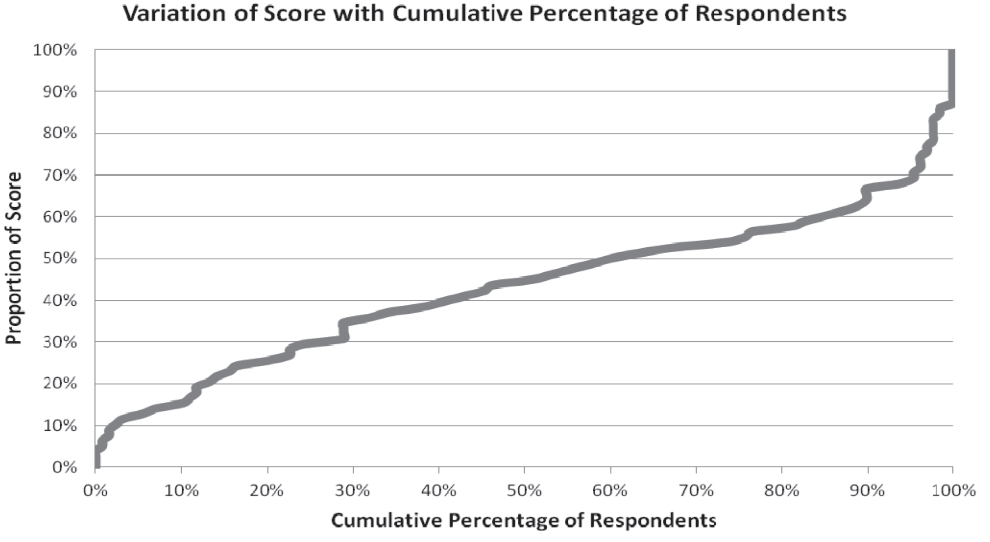

Figure 1. Representation of variation of score with cumulative percentage of respondents.

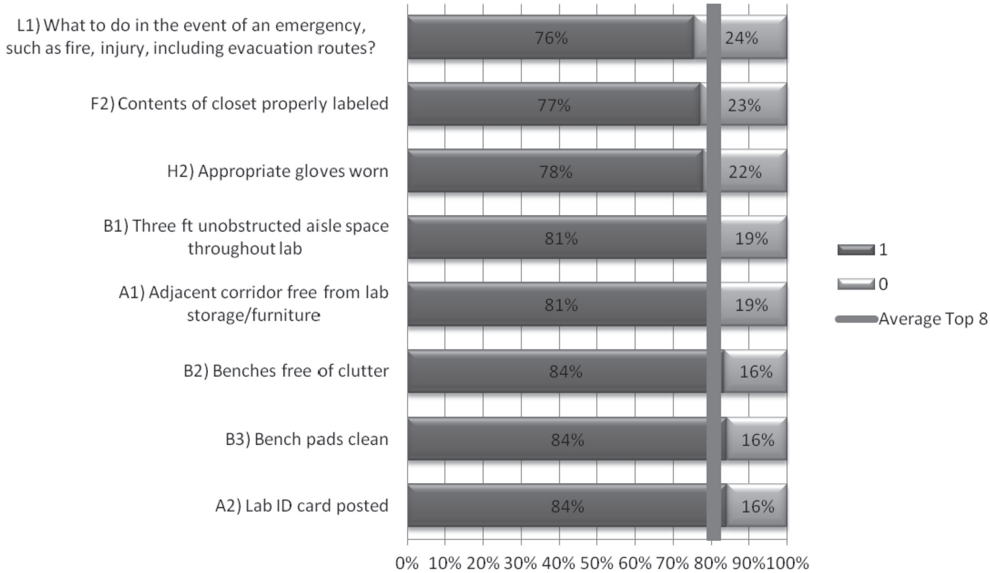

Figure 2. Top 8 questions for the most positive perception.

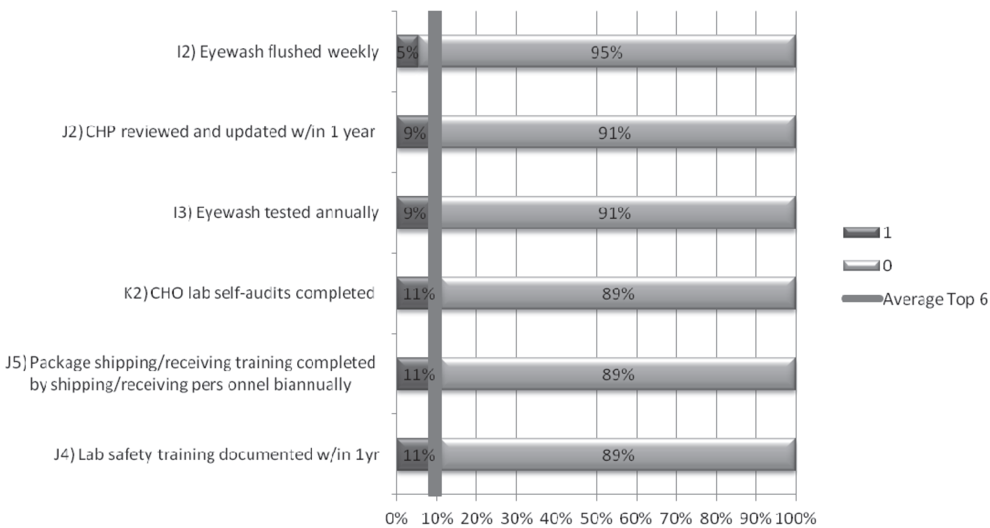

Figure 3. Top 6 questions for the less positive perception.

information or the user did not want to collaborate in the questionnaire. Therefore, it is an urgent aspect to address from a prevention standpoint. If checklists were to be available on-line, more users could be reached for answers. It addition, completing the questionaire could be made a requirement (not unlike other mandatory online questionnaires adopted by Universities) in order for students to better assess their knowledge.

The transformation of the original results, i.e., the answers "yes", "no", "not applicable/not available", "not valid" and "not answered" into scores allowed for added information about prevention in laboratories. All the original results are relevant, but concerning risk prevention, the absence of information should be penalized. The 78 questions of checklist were constructed in such a way that a "yes" to all the questions translates

Table 1. Summary of positive perception averages obtained for the different themes.

Theme		Average
A	Access	71%
B	General work environment	64%
C	Chemical storage	39%
D	Chemical hazardous waste	48%
E	Compressed gases	29%
F	Closets	58%
G	Fume hoods	48%
H	Personal protective equipment	68%
I	Emergency training	27%
J	Chemical hygiene plan	14%
K	Chemical hygiene officer	19%
L	Awareness—do laboratory workers know	51%

into a "perfect laboratory" while conversely, all "no" answers score the lowest.

Concerning the laboratories that checklist were applied, some showers and eye wash stations contained obstacles that prevents their use. Eye wash stations should have appropriate access and should be flushed weekly to prevent bacterial build up and to check for water quality. Some storage cabinets had heavy bottles on the upper selves and not all laboratories contained extinguishers. It is important to maintain heavy glass bottles (which may contain hazardous liquids) below eye level to avoid spills.

5 CONCLUSIONS

In this work, many conclusions can be resumed. Safety in laboratories is a very important area that should be taken seriously and comply with its rules. Still, many users are unaware or ignore the importance of safety in laboratories, and as a result, the accidents occur. There are laboratory safety manuals and chemical hygiene plans that several universities and foreign institutions use. In laboratories, the location or placement of equipment, materials and reagents should be done taking into account the size of these items and safety of the user and worker. The checklist distributed via paper served to study attitudes, values and beliefs from the 128 participants. One limitation of the questionnaire was the need to input the responses from checklist to checklist on a digital platform (excel), which took time to organize of the information. It was observed that laboratories of a higher education establishment still have safety opportunities and there are improvements to be made, for example, in training and communication of safety in laboratories. The checklist used within this study did not have questions related to ergonomic safety or seismic safety, issues that should be taken into account in the future.

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Genotoxic assessment in different exposure groups working with antineoplastic agents

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ABSTRACT: Antineoplastic drugs are widely used in treatment of cancer, and several studies suggest acute and long-term effects associated to antineoplastic drug exposures, namely associating workplace exposure with health effects. Cytokinesis Blocked Micronucleus (CBMN) assay is one promising short-term genotoxicity assays for human risk assessment and their combination is recommended to monitor populations chronically exposed to genotoxic agents. The aim of this investigation is the genotoxicity assessment in different professionals that handle cytostatics drugs. This research is case-control blinded study constituted by 46 non-exposed subjects and 44 workers that handle antineoplastic drugs, such as pharmacists, pharmacy technicians, and nurses. It was found statistically significant increases in the genotoxicity biomarkers in exposed comparising with controls ($p < 0.05$). The findings address the need for regular biomonitoring of personnel occupationally exposed to these drugs, confirming to an enhanced health risk assessment.

1 INTRODUCTION

Antineoplastic or cytostatics drugs are a heterogeneous group of chemicals widely used in the treatment of cancer and in some non-neoplasic diseases, having in common an ability to inhibit tumour growth by disrupting cell division and killing actively growing cells. These drugs have nevertheless been proved to be also mutagens, carcinogens and teratogens (Gulten, 2011).

In general, chemicals that interact directly with DNA by binding covalently or by intercalating, or indirectly by interfering with DNA synthesis, were among the first chemotherapeutics developed. Compounds that inhibit mitotic spindle formation and those that affect endocrine function are also used in cancer chemotherapy. Also, these drugs can induce reactive oxygen species that can lead to DNA damage and, consequently, mutations.

Accordingly, several antineoplastic drugs have been classified by the International Agency for Research on Cancer (IARC), on the basis of epidemiological reports, animal carcinogenicity data, and the outcomes of *in vitro* genotoxicity studies, as belonging to the group of human carcinogens (Group 1), probable human carcinogens (Group 2 A), or possible human carcinogens (Group 2B). In addition, investigational agents have also to be considered as potentially hazardous until their safety can be established. According to European Guidelines (Corrigendum to Directive 2004/37/EG), any use of carcinogenic, mutagenic or teratogenic substances, including the application in health care settings, are assigned to the highest risk level (Gulten et al., 2011).

There are several studies that suggest both acute and long-term health effects associated to antineoplastic drug exposures, and various studies have associated workplace exposure with health effects such as skin rashes, hair loss, irritation, hypersensitivity, and headaches after reported skin contact. Negative reproductive health outcomes are also associated with antineoplastic exposure. Spontaneous abortions have been reported approximately twice more often among exposed pregnancies than unexposed ones; the same goes for congenital malformations, infertility, and possibly leukemia, as well as other cancers (Kopjar et al., 2009).

Health care workers who prepare or administer hazardous drugs or who work in areas where these drugs are used may be exposed to these agents in the air, on work surfaces, contaminated clothing, medical equipment, patient excreta, and other surfaces (Kopjar et al., 2009). Exposures may occur through inhalation resulting from aerosolization of powder or liquid during reconstitution and spillage taking place while preparing or administering to patients, through skin contact, skin absorption, ingestion, or injection. Inhalation and skin contact/absorption are the most likely routes of exposure, but unintentional ingestion from hand to mouth contact and unintentional injection through a needle stick or sharps injury are also possible (Kopjar et al., 2009; El-Ebiary et al., 2011). Hand contact with contaminated equipment used in preparing and administering these drugs, or contaminated food or cigarettes, all lead to oral ingestion. Furthermore, patients may excrete these drugs and their metabolic by-products in body wastes, exposing personnel who handle such items (Kopjar et al., 2009; El-Ebiary et al., 2011).

Contamination of the work surfaces and also permeation of gloves to some antineoplastic drugs were reported already in several studies (Kopjar et al., 2009; Gulen, 2011). Moreover, vaporization of spilled antineoplastic drugs may represent an additional route of exposure to healthcare workers through inhalation. However, contact with contaminated surfaces seems to have the most important role in exposure due to dermal absorption. Therefore, the monitoring of surfaces contamination is a common way to assess occupational exposure, being the wipe sampling the most common method used (Hedmer, 2004) allowing for the demonstration of widespread workplace contamination, even when strict protocols and standard operating procedures have been applied.

The monitoring of genotoxic risks should be done combining environmental and biological monitoring with procedures of biological effect monitoring (primary DNA damage and chromosome damage). In this integrated chemical/biotoxicological approach, the use of genotoxicity biomarkers measuring changes in cellular or molecular endpoints (e.g., DNA and/or chromosome damage) will allow us to combine environmental and biological monitoring with biological effect monitoring. Cytokinesis-Blocked Micronucleus (CBMN) assay is recognized technique that can be a predictor of cancer risks in humans, and because of its ability to detect both clastogenic (e.g., chromosome breakage) and aneugenic (e.g., spindle disruption) effects, it could have a role in occupational health surveillance programs for workers exposed to antineoplastic drugs to monitor long-term exposure effects (a so-called biomarker of early/preclinical biological effects). Basically, it can be measured by CBMN assay Micronuclei (MN), biomarker of chromosome loss and breakage; Nucleoplasmic Bridges (NPB), biomarker of chromosome rearrangement, and Nuclear Buds (NBUD), biomarker of gene amplification.

The aim of this study was to assess genotoxic effects and compare it by professional exposed group.

2 METHODS

2.1 *Samples*

As for exposure to cytostatics, the sample of cases comprised 44 workers which have been exposed in two pharmacy laboratories and three nursing hospitals. The control group was formed by 46 subjects from academia who have not been exposed to cytostatics. To all individuals (controls and workers) were asked if they take any prescribed or not prescribed drug or health treatment that can influence the health effects measured. Ethical approval was obtained from the Institutional Ethical Board and Service Director of the hospitals, and all subjects gave informed consent to participate.

2.2 *Cytostatics exposure assessment*

Surfaces contamination was investigated in the two hospitals by wipe sampling in areas where antineoplastic drugs and were prepared administered as recommended by Hedmer et al. (2004). The studied cytostatics—cyclophosphamide, 5-fluorouacil and paclitaxel, were considered suitable indicators for occupational exposure to antineoplastic drugs because are frequently used in preparations and in high amounts in both hospitals considered (Castiglia et al., 2008). Sensitive analytical methods are already established for these drugs. In both hospitals, sampling was developed in two different days. Regarding antineoplastic drug administration, the days were indicated by workers and services as normal working days.

2.3 *Genotoxicity assessment*

Heparinized blood samples were obtained by venipuncture from all subjects and freshly collected peripheral blood was used for the CBMN assay. All samples were coded and analyzed under blind conditions. The criteria for scoring the nuclear abnormalities in lymphocytes were the ones described by Fenech et al. (1999). All samples were coded and analyzed under blind conditions.

3 RESULTS

Two samples were formed—the group of those occupationally exposed to cytostatics and the non-exposed group (controls). Population characteristics such as gender distribution, age, years of exposure, tobacco and alcohol consumption for the control and exposed groups are shown in Table 1.

The two studied hospitals presented cytostatics contamination with one of the three studied drugs or with more than one drug. The data of cytostatics exposure assessment regarding these units were previously published in Viegas et al., 2014 and Ladeira et al. 2014.

Table 1. Characteristics of the samples.

	Controls	Exposed
Number of subjects	46	44
Gender		
Females	34 (73.91%)	37 (84.09%)
Males	12 (26.09%)	7 (15.91%)
Age (mean ± standard deviation, in years)	38.93 ± 9.70	33.60 ± 8.31
Range	20–61	24–58
Years of exposure (mean ± standard error of mean, in years)	n.a.	6.01
Range	n.a.	0.17–30
Tobacco consumption		
Non-smokers	12 (73.91%)	40 (90.91%)
Smokers	34 (26.09%)	4 (9.09%)
Alcohol consumption		
Non-drinkers	33 (71.74%)	32 (73.73%)
Drinkers	13 (28.26%)	12 (27.27%)

Comparing the control group with the three occupations studied it was found statistical significant differences for some of the genotoxicity biomarkers. In what concern to pharmacists there were statistical significant differences in MN in binucleated lymphocytes, NPB, and NBUD and the control group. Pharmacy technicians presented statistical significant results for MN in bi and mononucleated lymphocytes, and NPB. The nurses group present statistical significant differences in MN in binucleated cells and NPB. No association was found between years of exposure and presence of any of the biomarkers measured by CBMN assay. Regarding demographic and lifestyle habits, MN tended to increase with age whereas gender, alcohol and tobacco consumption did not shown any effect in the genotoxicity frequencies.

4 DISCUSSION AND CONCLUSIONS

Considering surfaces contamination results, positive samples were found for all surrogate markers in both hospitals. These results implicate concern because health effects associated to exposure to carcinogenic, mutagenic, and teratogenic substances usually do not depend on a minimum dose but instead on a prolonged exposure. Therefore, it can be concluded that there is no safety threshold dose concerning exposure to these drugs being appropriate to apply the ALARA principle: keep exposure/contamination levels "As Low As Reasonably Achievable". Widespread contamination was also observed in other studies, despite the implementation of safety procedures for handling antineoplastic drugs (Castiglia et al., 2008).

These results can be explained once again by the fact that there are more strict safety and hygiene rules in preparation units when compared with administration units as demonstrated by the high number of organizations that research on this field

Table 2. Descriptive statistics of MN, NPB and NBUD in the studied population (mean ± mean standard error, range), p-value of the Mann-Whitney test concerning the association between exposure and genotoxicity biomarkers.

Occupation	n	MN BN Mean ± S.E. (range)	NPB Mean ± S.E. (range)	NBUD Mean ± S.E. (range)	MN MONO Mean ± S.E. (range)	MN MULTI Mean ± S.E. (range)
Controls	46	5.09 ± 0.89 (0–34)	0.11 ± 0.05 (0–1)	1.37 ± 0.32 (0–13)	0.41 ± 0.11 (0–3)	1.46 ± 0.22 (0–6)
Pharmacist	11	7.82 ± 1.30 (1–16)	1.09 ± 0.39 (0–3)	2.82 ± 0.58 (0–6)	0.36 ± 0.20 (0–2)	4.82 ± 1.90 (0–21)
P-value		0.029*	0.001*	0.009*	0.804	0.102
Pharmacy technician	6	10.83 ± 2.10 (4–19)	0.50 ± 0.22 (0–1)	2.17 ± 0.70 (0–5)	1.17 ± 0.31 (0–2)	4.50 ± 1.98 (0–12)
P-value		0.010*	0.013*	0.124	0.009*	0.111
Nurse	27	10.11 ± 2.05 (1–58)	0.48 ± 0.15 (0–3)	2.41 ± 0.57 (0–11)	1.78 ± 0.51 (0–9)	3.85 ± 1.02 (0–28)
P-value		0.001*	0.014*	0.073	0.053	0.218

developing constantly new rules and safety measures (NIOSH 2004; ISOPP, 2007, among others). In this case, the inappropriate surfaces cleaning together with the incorrect working procedures probably are contributing for the contamination found.

In what concern to genotoxicity assessment, the results showed statistical significant higher means for some endpoints studied between the three professions groups and controls ($p < 0.05$). These results, namely in what concern to micronuclei frequency, are corroborated by many others studies (Kopjar et al., 2009; El-Ebiary et al., 2011) that found also significant increase of micronuclei frequency in workers handling antineoplastic drugs.

The present study confirmed that there is surface contamination in the workplaces considered and the cytogenetic endpoint studied (CBMN) showed signs of an effect related with exposure. Since the genotoxicity may be due to combined effects of all or some of the antineoplastic drugs, it is not possible to attribute damage to any particular agent. Results of this study as well as previous investigations performed on subjects occupationally exposed to antineoplastic drugs using different genotoxicity endpoints suggest that mixtures of antineoplastic drugs in long-term occupational exposure may act as clastogens on the DNA molecule of somatic cells.

Since no occupational exposure limits have been established for airborne concentrations of antineoplastic drugs and for their concentration in the urine, there is no exposure level can be considered safe, and thus zero contamination should be the target. Exposure to these compounds should be avoided, and safety guidelines and protective measures like wearing masks, gloves, gowns, caps, protective eyewear and the preparation of drugs in biological safety cabinets are normally available in the workplaces in order to prevent exposure (Sessink et al., 1992; Gulen, 2011).

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Assessment of children exposure doses to ultrafine particles in primary schools

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ABSTRACT: Children attending primary schools may be largely exposed to the Ultrafine Particles (UFPs) present in the classroom's indoor air, which may lead to severe health consequences resultant from their increased susceptibility. Thus, this study aimed to estimate the UFP exposure dose rates in Portuguese children attending public primary schools. Ultrafine particles were sampled in 10 public primary schools located in Porto. Exposure dose rates were estimated for 488 children (aged 8 to 10 years) of the sampled schools. The estimated mean of exposure dose rates in children were $4.06 \times 10^8 \pm 0.11 \times 10^8$ part/kg.day. Specific indoor activities as well as outdoor environment conditions appeared to be associated with increased indoor UFP number concentrations and, consequently, with higher exposure doses in children attending those schools. Overall, children showed at least two times higher UFP exposure dose rates when compared to occupationally exposed adults (i.e. teachers and school staff).

1 INTRODUCTION

Currently, several guidelines and strategies have been developed in order to reduce the health risk caused by indoor exposure to particulate matter (WHO, 2005). For instance, the EnVIE project showed that source control approaches and adequate ventilation are the key elements to reduce health problems related with inadequate indoor air quality, including fine and coarse particulate matter pollution (Oliveira Fernandes, 2008). However, there are no regulations regarding the concentrations of Ultrafine Particles (UFPs) which are particles smaller <0.1 μm and s strong source of oxidative stress and lung inflammation, possibly causing the onset or exacerbation of asthma and other respiratory diseases. The strong toxicity of UFPs is often associated to their proficiency for penetrating cell membranes (Peters et al., 1997, Penttinen et al., 2001) and consequent carcinogenic activity (Stanek et al., 2011).

In Portugal, children attendance in primary school is compulsory and, in general, they spend at least 7 hours per day in these institutions, from Monday to Friday, which may be reflected as a large period of exposure to indoor UFPs. Moreover, children tend to be more susceptible to UFPs toxicity particularly due to their immature respiratory systems, reduced constitution and minor lung function (Schwartz, 2004). To evaluate the health risk resulting from UFP pollution, several studies have been assessing the dose rates of exposure to these particles in children (Buonanno et al., 2012, 2013, Mazaheri et al., 2014). Fonseca et al. (2014) reported UFP inhalation exposure doses for children estimated at 3 Portuguese preschools; the results showed that 3 to 5 years old children presented 4 to 6 times higher dose rates than adults with similar daily schedules. Since children in primary schools spend more time than those in preschools, it is possible that the exposure dose rates to indoor UFPs are also higher in these indoor environments, even if similar particle number concentrations are considered.

Therefore, the aim of this study was to estimate the UFP inhalation dose rates in Portuguese children (8–10 years old) attending public primary schools. Additional objectives of this work were: a) to estimate the exposure doses of UFPs in adults with similar schedule conditions; and b) to compare the different exposure doses between the populations of children and adults.

2 MATERIALS AND METHODS

2.1 *Sampling*

Ultrafine particles were sampled in 10 public primary schools (35 classrooms) located in the urban area of Porto (S1 to S10) during the heating season (between January and April 2014). More detailed information regarding the sampling sites is shown in Table 1.

The measurements were performed during a regular school day and under representative activities, conditions of occupancy and use of the classrooms (from 9:00 to 16:00). In general, the recess periods occurred from 10:30 to 11:00 and from 12:30 to 14:00. These were non-occupation periods and were not consider for the estimation of the exposure dose rates.

Two portable condensation particle counters (P-Track model 8525, TSI Inc., MN, USA) were used for the assessment of UFP number concentrations. The instruments were installed inside each classroom and were set to continuously measure during at least one school day. Logging intervals were set to 1 minute between each sample according to previously published studies (Norback et al., 2011, Zhang and Zhu, 2012, Fonseca et al., 2014). Further detailed characterization of the equipment has been previously reported (Matson et al., 2004).

The instruments were mounted on a flat surface at the height of the children's breathing zone (1.2 to 1.5 m) as far as possible from windows or doors as well as from major indoor sources of UFPs. A researcher supervised the sampling process and recorded relevant information.

2.2 *Exposure dose rate calculation*

In this study, 713 children attended the sampled classrooms. The children' legal guardians received an envelope with information regarding the project as well as a written consent form, in accordance with the Helsinki declaration. The UFP exposure dose rates were calculated for all 488 (aged 8 to 10 years old) that were authorized to participate in the study (66.8%). Children's UFP exposure dose rates was calculated using the age and body weight-specific formula presented as Equation 1, which has been validated in previously published studies (Ginsberg et al., 2005, Kalaiarasan et al., 2009, Castro et al., 2011, Fonseca et al., 2014).

$$D = \left(\frac{BR_{WA}}{BW}\right) \times C_{WA} \times OF \times N \tag{1}$$

In this equation, D represents the age-specific dose rate (part./kg/day); BR_{WA} is the age-specific

Table 1. Main characteristics of the sampled schools.

School	Building location	Cooking	Number of sampled classrooms	Classroom ventilation
S1	Low traffic; mixed residential and industrial area.	No	2	Natural ventilation (small grids; inoperable windows)
S2	Low traffic; residential area.	No	4	Natural ventilation (not facing the main street)
S3	High traffic; densely packed residential area.	No	4	Natural ventilation (windows do not face the main street)
S4	Low traffic; residential area; hospital in the proximity.	No	4	Natural ventilation (windows do not face the main street)
S5	Medium traffic and metro; densely packed residential area.	Yes	4	Natural ventilation (not facing the main street)
S6	High traffic; densely packed residential area.	No	4	Natural ventilation (facing the main street)
S7	Low traffic; densely packed residential area.	No	4	Natural ventilation (windows do not face the main street)
S8	Medium traffic; densely packed residential area.	No	2	Natural ventilation (windows do not face the main street)
S9	Medium traffic; densely packed residential area.	No	3	Natural ventilation
S10	High traffic and metro; densely packed residential area.	No	4	Natural ventilation

weighted average breathing rate (L/min); BW is the body weight of the children (kg); C_{WA} is the weighted average particle number concentrations (part./L); OF is the occupancy factor; N is the total time per day spent in the location of exposure (min/day).

The BR_{WA} is characterized by the intensity of the activity practiced at the time of exposure. Seeing as primary schoolchildren are normally seated during the time they spend in classroom (writing, studying, drawing, etc.), the "sedentary/passive" activity level was selected. The age-specific inhalation factors were retrieved from the US EPA exposure factors handbook (U.S. Environmental Protection Agency, 2011). Thus, BR_{WA} was considered as 4.8 L/min for 8 to 10 years old children. The BW of children was determined by a certified body composition analyzer (Tanita® TBF-300 A, capacity 200 kg, accuracy 100 g) operated by a trained nurse. Children were weighted barefooted and 1 kg was deducted from the measured weight to account the clothing. The platform and handle electrodes of the scale were cleansed with 96% alcohol after each measurement. C_{WA} was estimated using the UFP average number concentrations weighted by the real time that children spent inside the classroom and the OF was always considered as 1, since children kept their schedules and their respective locations tightly. Although children are compelled to stay at least 7 hours in primary schools, the total time per day spent inside the classroom represents only 5 hours of that time period since they have 2 hours of recesses each day. Therefore, N was considered as 300 min/day (5 hours).

For comparison purposes, UFP exposure dose rates were also estimated for adults in similar conditions (aged 21 to 60 years old). When concerning "sedentary/passive" activities, the BR_{WA} in adults was considered 4.2 L/min for ages between 21 and 30, 4.3 L/min between 31 and 40, 4.8 L/min between 41 and 50, and 5.0 L/min between 51 and 60 (U.S. Environmental Protection Agency, 2011). The average BW considered for all groups of adults was 70.8 kg according to the European region average body mass in 2005 (Walpole et al., 2012).

Statistical analysis was performed using SPSS Statistics v20 (IBM). Statistical significance was considered when $p < 0.05$.

3 RESULTS AND DISCUSSION

The statistical analysis showed no significant differences regarding BW between both genders ($p = 0.748$). Moreover, there were also no significant BW differences between the 10 schools ($p = 0.156$). These results suggest that, despite the differences in gender and location of the school, there are no major dissimilarities in the average BW of 8 to 10 years old primary schoolchildren.

The total mean (average and standard error of the mean) of UFP inhalation dose rates in children (8 to 10 years old) of 10 primary schools was $4.06 \times 10^8 \pm 0.11 \times 10^8$ part./kg·day. The information regarding the average inhalation dose rates in each school is summarized in Table 2. The results showed that exposure doses in children attending S5 were 1.2 to 4.8 times higher than those of other schools. These results may be associated with the increased production of UFPs resulting from the performed cooking activities; S5 was the only school in this study where meals for the children were directly cooked in the respective school building. These findings support previously published studies showing that cooking practices are significantly associated with increased UFP

Table 2. Average dose rates (D, part/kg.day) per school and age group.

School	Mean UFP number concentrations (part./cm³)	Average UFP inhalation dose rates (part/kg·day)				
		Children (8 to 10)	Adults (21 to 30)	Adults (31 to 40)	Adults (41 to 50)	Adults (51 to 60)
S 1	3.37×10^3	1.48×10^8	6.00×10^7	6.15×10^7	6.86×10^7	7.15×10^7
S 2	6.58×10^3	2.96×10^8	1.17×10^8	1.20×10^8	1.34×10^8	1.39×10^8
S 3	5.68×10^3	2.65×10^8	1.01×10^8	1.03×10^8	1.16×10^8	1.20×10^8
S 4	7.35×10^3	3.17×10^8	1.31×10^8	1.34×10^8	1.50×10^8	1.56×10^8
S 5	1.49×10^4	7.06×10^8	2.65×10^8	2.71×10^8	3.03×10^8	3.16×10^8
S 6	1.25×10^4	5.85×10^8	2.23×10^8	2.28×10^8	2.55×10^8	2.66×10^8
S 7	8.78×10^3	3.71×10^8	1.56×10^8	1.60×10^8	1.79×10^8	1.86×10^8
S 8	7.61×10^3	3.43×10^8	1.35×10^8	1.39×10^8	1.55×10^8	1.61×10^8
S 9	8.36×10^3	3.76×10^8	1.49×10^8	1.52×10^8	1.70×10^8	1.77×10^8
S 10	9.21×10^3	4.26×10^8	1.64×10^8	1.68×10^8	1.87×10^8	1.95×10^8

S—School; UFP—Ultrafine particles.

production (Zhang and Zhu, 2012). Schools S6 and S10 also presented dose rates above the average value, probably due to the closer proximity to roads with intense traffic, which are considered major sources of ambient UFPs that may penetrate to the indoor environment of the schools (Kulmala et al., 2004). Finally, S1 exhibited 1.8 to 4.8 lower UFP inhalation dose rates than the estimated mean. The lower traffic intensity in the school area and the inoperable windows (ventilation only promoted by small grids) may hinder the penetrance of UFPs from the outdoors, which consequently could lead to lower dose rates in S1.

To further comprehend the extent of UFP exposure in the analyzed schools, the dose rates of children were compared with those of adults. The results showed that the UFP dose rates increased with the increasing age of adults, being minimal in individuals aged from 21 to 30 years old and constantly rising as the age increases due to the higher inhalation dose rates, which is probably associated to the natural lung function loss resulting from the aging process (Harik-Khan et al., 1998). However, due to the children vulnerability and small body weight, they still showed 2.0 to 2.2 higher UFP exposure doses than the older adults (51–60). These results demonstrate the high susceptibility of children to UFPs and indicate that primary schools have an important role in the child's overall particle exposure.

Information regarding primary school children exposure doses to UFPs is scarce. In addition, the different study approaches and the dissimilar characteristics of the sampled indoor microenvironments hamper further comparisons. Therefore, the dose rates estimated within this work were not compared with other studies.

4 CONCLUSIONS

This is the first study estimating the UFP exposure dose rates for 8 to 10 years old children attending Portuguese primary schools. The results suggest that schools located near busy roads as well as schools with meals directly cooked in the building have higher indoor number concentrations of UFPs. Nevertheless, to further study the children total exposure in schools, the UFP exposure dose rates should be assessed in other areas, such as canteens and/or gymnasiums.

Children susceptibility to UFP exposure was supported by this study and, when compared to adult individuals in similar conditions, they had at least two times higher dose rates, even when compared to older individuals. Therefore, special attention should be given to the major sources of ultrafine particles in primary schools in order to minimize the exposure dose rates in children. Further investigations regarding building characteristics and sources of UFPs would be important to provide information to protect public health.

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Identification of the most critical areas in an industrial inner space regarding thermal comfort: Environmental ergonomics

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ABSTRACT: Individuals spend most of their time in work environments and because of this reason their workplaces should be provided with optimal work conditions in order to increase performance and avoid work accidents. Thermal discomfort is one of the causes of work dissatisfaction which lead to individuals behavior changes as well as works accidents. This paper aims to study a manufacturing industry inner space affected by heat thermal environments in order to identify the most critical areas regarding two thermal indexes, EsConTer and THI, in which their interpretations valorize workers thermal sensation. From the color maps developed to facilitate indexes analysis the most critical areas of the space in study were easily identified as well as the most critical workstations near those areas. The health and safety department of the industry in study valorized the results in order to develop measures that may improve the occupational health of the occupants due to the approximation of the indexes results to workers thermal sensation.

1 INTRODUCTION

Portuguese corporate structure is 99,5% sharped by SMEs (Small and Medium- sized Enterprises) and 6,36% by manufacturing industries (Instituto Nacional de Estatística, 2014) where occurs around 26% of all the work accidents (Gabinete de Estratégia e Estudos Ministério da Economia, 2013). Ergonomics is the scientific area concerned about workers workplace conditions in order to adapt the workstations to workers welfare needs, understanding the workers interactions with other systems to maximize human well-being and overall system performance (IEA, 2014; Teixeira, Talaia, & Morgado, 2014; Wisner, 1992); as well as minimize work accidents. This scientific area has gained more importance and followers as individuals spend most of their time in workplaces (Felix, Moura, Pereira, & Tribess, 2010) and because it keeps companies competitive. Even though Ergonomics is becoming popular, regarding the Portuguese corporate structure, SMEs are still not implementing its measures because they are not provided with financial and structural resources to invest in Ergonomic as some managers still do not associate ergonomics with efficiency and productivity (Santos, 2009).

From an Ergonomic perspective there are many factors that may be taken into account regarding workplaces analysis such as the interaction human being—machine, personal factors, tasks definitions, tasks needs, work environment, among others.

The thermal environment is one of the environment variables that should be taken into account. This variable is known as a set of thermohigrometric variables, such as air temperature, air relative humidity, wet bulb temperature, air velocity, among others, which directly or indirectly influence the human-being and its behavior and represent a key factor to control in occupational settings (Costa, Baptista, & Carvalho, 2014). In an inner space the thermal environment is highly influenced by all the resources that occupies it either humans or materials, like machines and tools, as well as its infrastructures. Nevertheless, as important as earlier mentioned resources, the outdoor environment is also a factor that should also be taken into account once as was referred by Gosling et al. (2014); Yao et al. (2009) the indoor environment is affected by outdoor atmospheric environment and because of that the HVAC equipment's (Heating, Ventilation and Air Conditioning systems) are used in different ways in each season. According to Cox (2005) a healthy environment is found when the combination of physical, chemical and biological properties do not cause or aggravate none of the workers diseases and ensure high levels of comfort and performance. As such, regarding those considerations the main goal of thermal environment study is to find the optimal environment conditions to spaces occupants', in this case workers. As referred by Schiavon et al. (2014) regarding the mechanisms/equipment's/methods to maintain thermal comfort for buildings occupants there is room for improvement.

This necessity in creating inner spaces which satisfies most of their occupants is considered a great challenge to design engineers, architects and building operators as the human-being thermal sensation is very subjective since each human's body react differently and because of that it differs from person to person (Leal & Neves, 2013).

Thermal sensation is the human thermal perception which according to thermal environment surround, triggers a human body reaction (Parsons, 2003). The skin temperature is considered by some authors (Kataoka et al., 1998; Zingano, 2001) as a reference temperature to evaluate human thermal sensation. A thermal comfort sensation is defined as a neutral sensation or the state of satisfaction of an individual when exposed to a thermal environment (ASHRAE, 2001; Chow, Fong, Givoni, Lin, & Chan, 2010). On the other hand a stress thermal sensation is the state of dissatisfaction of an individual when exposed to a thermal environment (Meles, 2012; Talaia, Meles, & Teixeira, 2013); When an individual are under extreme thermal environments, either hot or cold, the risk of failures and work accidents increase (Riniolo & Schmidt, 2006). Furthermore, many studies demonstrate a strong relation between comfort and productivity (Bluyssen, Aries, & van Dommelen, 2011).

In this case-study a SME manufacturing industry associated to the traditional glass industry of Marinha Grande (Portugal) was studied. This SME inner space is affected by heat thermal environment which was studied by thermal indexes in order to identify the most critical areas regarding thermal stress and their occupants (workers) thermal sensation. The methodology of this case-study intends to be a new technique of thermal environment analysis by using cheaper measuring instruments to study the thermal environment of inner spaces though thermal indexes which valorize its occupants' thermal sensation.

2 MATERIALS AND METHOD

This study was conducted between april and may of 2014 and the data collection was performed in the production area of the industry.

To identify the thermal critical areas from this inner space were firstly studied the thermal environment of the entire production area. Regarding that, the layout of the inner space was analyzed and 40 points of observation, i.e., the points in the space for gathering data, were defined randomly, just to facilitate authors' orientation during measurements. Two types of points of observation were defined, points of observation around the space in study (indoor and outdoor) and points of observation in the space in study. The defined points of observation around the space in study were crucial to understand their influence in the space in study. Through the points of observation positioned in the inner space in study two symmetric paths were done. These two paths were considered in order to understand the oscillations of thermal pattern in the study area over time and the influence of diurnal cycle in the thermal pattern of the inner space. So starting from these considerations the measurements were done in two instants, in the morning (around 10a.m.) and afternoon (around 03 p.m.).

In each measurement were collected values of air temperature and air relative humidity by the measuring instrument 'Center 317—temperature humidity meter'.

In order to guarantee valid data, weather charts, air temperature and air relative humidity graphics were downloaded from *Instituto Português do Mar e da Atmosfera* (IPMA) (https://www.ipma.pt/pt/) to authenticate outdoor collected data.

Furthermore, two thermal indexes were applied to evaluate data collection, the THI (Temperature-Humidity Index) and EsConTer index. The THI was created by Thom (1959) and later modified by Nieuwolt (1977), and is very applied thermal index regarding the approached field due to its simplicity. The calculation formula is:

$$\mathrm{THI} = 0{,}75T_a + T_a\left(\frac{RH}{500}\right) \tag{1}$$

where T_a is the air temperature (ºC) and RH the air relative humidity (%).

According to the subjectivity associated to thermal comfort, there are many intervals in literature review to interpret this index. In this case-study the limits referred by Talaia et al. (2013), which regard human-being thermal sensation were adopted. According to the authors, 21ºC ≤ THI < 24ºC is associated to a comfortable thermal sensation; 24ºC ≤ THI < 26ºC wind needed for comfort and THI ≥ 26ºC occupants feel too hot.

The EsConTer Index, a very new thermal index, was developed by Talaia & Simões (2009). This index has being suggest the particularity in interpreting, so far, more clearly and easily thermal comfort, once its results are associated to 7-point

ASHRAE thermal sensation scale (ASHRAE 55, 2004) by a color scale (Teixeira et al., 2014).

This color scale represents the human thermal sensation. As 7-point ASHRAE thermal sensation scale is limited by an interval from '–3' to '+3', symbolized by the colors of the scale extremes'. The remaining values are linked to intermediate values, being 0 value associated to thermal comfort sensation, linked to yellow color, equidistant to extreme colors of the scale. The EsConTer calculation formula is:

$$EsConTer = -3,75 + 0,103\left(T_a + T_w\right) \qquad (2)$$

where T_a(°C) is the air temperature and where T_w(%) the web bulb temperature.

Through algorithms developed using *Matlab* program, both of the applied indexes were interpreted regarding color maps which showed the thermal environment dynamic of the inner space in study. Visualizing the color maps trigged by *Matlab*, the most critical areas, i.e., the areas hardest hit by heat thermal stress, were identified. Furthermore, a zoom algorithm, also developed using *Matlab,* was applied in those areas in order to define in greater detail the zones of the space in study more susceptible to heat thermal stress.

3 RESULTS AND DISCUSSION

As mentioned previously data was collected during two spring months, nevertheless in order to facilitate results presentation the color maps represented in this paper are only associated to one day of measurements (randomly selected), the 10th of May 2014. Figures 1 and 2 represent the thermal pattern given by the applied thermal indexes, EsConTer and THI, respectively.

The color scale on the right side of color maps represents the variable in study, which have generated a color pattern. From both maps an intuitive and fast interpretation can be taken from the color each area has associated. In agreement with the

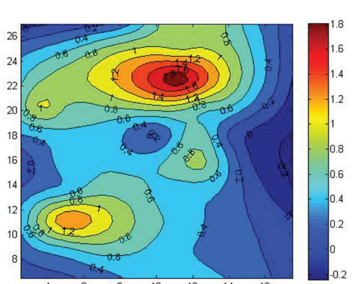

Figure 1. Thermal pattern—EsConTer index.

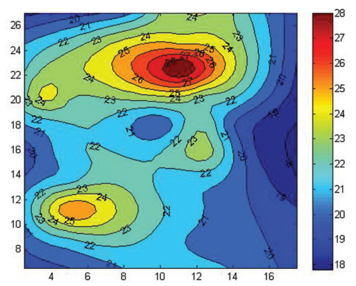

Figure 2. Thermal pattern—THI.

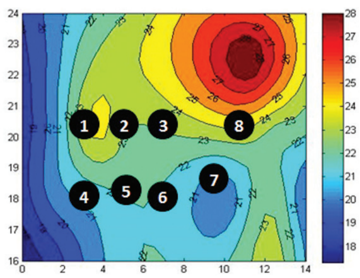

Figure 3. Critical areas and workplaces—EsConTer index.

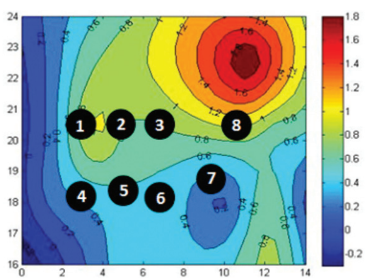

Figure 4. Critical areas and workplaces—THI.

industry layout the most critical area associated to darker red, around 1,6 and 1,8 regarding EsConTer scale and 27°C and 28°C regarding THI scale, represents the main heat source of the industry in study, the oven. According to mentioned values, from each thermal index interpretation, the same conclusion is taken; the occupants of this area were feeling hot. Furthermore, both color maps are very similar, with almost coincident thermal lines. So, the considered critical area of this industrial space was between 16 m–24 m regarding the y axis and 0 m–14 m regarding the x axis.

Moreover, to the defined critical area was applied a zoom algorithm, generating the color maps represented in Figures 3 and 4.

As previously, the color maps from both indexes suggest the same conclusions. This fact was demonstrated by the calculation of the correlation coefficient between both indexes, 0.9954, showing a strong agreement between EsConTer index and THI. The circles with number on both color maps represent the workstations most affected by heat thermal environments.

These workstations (1–8) are associated to activities related to the oven being the most critical workstations, 3 and 8 related to caneworking, and 1 and 2 heat to glass cutting and pressing. In these areas heat were intensively felt regarding workers' statements, clothes (light t-shirts and jeans) and behavior (frequent fluids intake and profuse sweating) in agreement with both graphics conclusions.

4 CONCLUSIONS

The results provided by this study showed that is possible to understand the thermal pattern of an industrial inner space by using cheap and easy tools. The color maps seemed to be an easy and a more intuitive way to interpret inner thermal environments, as from its axis scales and colors, the observer can visualize immediately the most uncomfortable areas/workstations in order to trigger faster corrective actions.

Besides that the EsConTer index and THI interpretations linked to human thermal sensation suggest to be very useful in order to comprehend the workers thermal sensation (predicted) and to create corrective measures adequate and closer to workers feelings.

Thus, the methodology applied showed to be an interesting way to understand industrial spaces, regarding thermal environment variables as well as to avoid work accidents/injuries caused by heat thermal environments, as the generated color maps predict workers thermal sensation.

The results of this study were valorized by the Health and Safety Department of the industry in study in order to develop measures that may improve the occupational health of the occupants.

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Safe workplace practices for handling nanowastes: An overview

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ABSTRACT: Nanotechnology is being presented as the third industrial revolution. However, in the absence of regulations and with limited and sometimes contradictory knowledge about the negative effects that nanomaterials could have on our health, questions arise as to the current safety measures being taken. In particular, this research takes into consideration the specific task of nanowaste manipulation because this is an activity which presents a high risk of exposure. The general objective of this review is the identification of the best practices and most common measures adopted when handling these by-products. A list of safe practices for dealing with nanowastes based on their characteristics is presented. Finally, it is concluded that knowledge in this area is limited and that the practices in place in organizations today are inconsistent.

1 INTRODUCTION

With nanotechnology it is possible to manipulate and control materials on the nanoscale in such a way that we can take advantage of the extraordinary properties which nanomaterials possess (Serena, 2010). These new qualities are useful in a huge number of nanotechnological applications in many different sectors and they are a source of economic and technological growth (Adlakha-Hutcheon et al., 2009).

Nevertheless the exposure to nanomaterials is nowadays one of the most important emerging risks at work (The European Agency for Safety and Health at Work (EU-OSHA), 2009), because a larger number of workers are being exposed to these materials daily and at the same time no international consensus exists regarding nanomaterial parameters and their toxicological effects (Savolainen et al., 2010). For example, it was found that carbon nanotubes have an even greater capacity to cause mesotheliomas than crocidolite asbestos (Poland et al., 2008; Takagi et al., 2008), although these finding were called into question because nanotubes are not absorbed through the lungs (Kane & Hurt, 2008). As a result of this uncertain situation many studies on the effect of nanomaterials have recently appeared. However, to date the exposure to nanomaterials of workers has been the aspect that has received the least attention by the scientific community (International Council of Nanotechnology (ICON), 2014).

Although much of current regulations can be applied to nanomaterials, new specific nanomaterials safety regulations will soon be implemented (European Commission, 2012). Currently preventing the risks at work in this area is not an easy task, mainly because traditional Industrial Hygiene principles cannot be followed (Tanarro, 2010). The best approach available is a qualitative assessment of the risks (Zalk et al., 2009) and the adoption of a preventive strategy from the perspective of fire, explosion and toxicity (Rosell & Pujol, 2008).

In the case nanowastes, the new emerging wastes, (Yan et al., 2010) there is a legal vacuum or loophole regarding how they must be managed and treated (NEPHH'S CONSORTIUM, 2012). In fact an official definition does not even exist, but in general we can distinguish between the following types: pure nanomaterials, items contaminated with nanomaterials (such as containers, wipes and disposable PPE), liquid suspensions containing nanomaterials and solid matrices with nanomaterials that are friable or have a nanostructure loosely attached to the surface that can reasonably be expected to break free or leach out, including wastes from decontamination processes and the debris from the clean-up of spillages or industrial accidents (including filters, wipes, absorbent mats and materials) (British Standards Institution (BSI), 2007; Department of Energy Nanoscale Science Research Centres, 2007; Environment Agency, 2005). In order to correctly handle and dispose of nanowastes specific regulations must be created, because nanomaterials certainly do not behave in the same way as normal wastes (Breggin & Pendergrass, 2007).

2 AIMS AND METHODOLOGY

The objective of this study is to bring together the currently recommended safe practices in the handling of nanowastes and to discover the practices used in different organizations. A methodology based mainly on the review of scientific literature, Scopus (Scopus, 2014) and Web of Science (Web of Science, 2014) has been used to this end.

3 SAFE PRACTICES AT WORK IN NANOWASTE HANDLING

There many situations in which workers can be exposed to nanomaterials (Deutscher Bundestag, 2008) and the handling of nanowastes creates a high risk of direct exposure (Musee, 2011; National Institute for Occupational Safety and Health (NIOSH), 2008).

The procedures and protection measures for handling nanowastes attempt to avoid entry into the body by inhalation or penetration through the skin, which are the main entry points (Marcoux et al., 2013). In addition to some general practices, other specific procedures must be implemented because the characteristics of the nanomaterial determine the type of exposure (Musee, 2011). The main practices, and prevention and protection measures for handling nanowastes are listed below (British Standards Institution (BSI), 2007; Ellenbecker & Tsai, 2008; Environment Agency, 2005; Environmental Defense-DuPont Nano Partnership, 2007; Hallock et al., 2009; Harford et al., 2007; Lawrence Berkeley National Laboratory, 2010; Nel et al., 2006; NEPHH'S CONSORTIUM, 2012; Occupational Safety and Health Administration (OSHA), 2008; Occupational Safety and Health Administration (OSHA), 2010; Purdue University, 2010; RECORD, 2012; Rosell & Pujol, 2008; Scientific Committee on Emerging and Newly Identified Health Risks, 2006; Stanford Linear Accelerator Center, 2009; Stanford University, 2009; Tanarro & Gálvez, 2009; U.S. Department of Energy, 2008).

Practices and general measures:
Administrative and work controls:

- Nanowastes should be treated as hazardous wastes and sent to a hazardous waste processing plant. Some authors and guides point out that if it is proven that the waste is not hazardous then it will not be necessary to take precautionary measures. Nevertheless, it is generally agreed that it is much better to adopt precautionary measures at present.
- Nanoscale material waste should be classified separately.
- Nanowastes should not be removed from the workplace without proper treatment.
- Nanowastes should not be put into regular waste containers or dumped down the drain.
- Nanowaste generation should be assessed. Besides needing an inventory of all nanomaterial waste that is shipped off-site, it should include the description, quantity, location and final disposal of all nanowastes. Products used on a daily basis should be tagged with RFID chips to facilitate the waste processing.
- Storage in waste containers: package nanomaterial-bearing wastes in compatible containers that are in good condition and afford adequate containment. Storage in plastic bags is also possible: when the bag is full, close it and carefully place it into a second plastic bag or other sealed container.
- The waste containers or bags should be stored in an area in which ventilation and atmosphere can be controlled. Checks should be run to prevent uncontrolled emissions. Also it is necessary to bear in mind that reactions may occur in the waste storage area.
- Label the waste container or plastic bags with a description of the waste and include available information on known and suspected properties.
- Contamination should be cleaned up and decontamination of equipment and the surfaces of all components in the installation must be evaluated to determine the most suitable processing: maintenance, removal or modification.
- Workers must know how to examine waste for signs of nanomaterials and should notify the person responsible.

Personal Individual equipment:

- The body should be protected using a waterproof Tyvek-type coverall and close attention must be paid to the correct fit of gloves and sleeves.
- Always use latex or nitrile gloves and double gloves should be used when the worker manipulates the waste for long periods of time. Moreover, the manufacture's instructions should always be followed and it is important to bear in mind the type of nanomaterial the worker will be in contact with when establishing safety procedures.

Practices for handling dispersed nanomaterials (liquid and dust) and friable solids:
Substitution:

- The risk of waste emission should be reduced by using nanomaterials embedded in matrixes, for instance in liquids.
- Damp laboratory wipes should be used to minimize particulate generation. With liquids, the wipes must be compatible with the solvents used in the dispersion.

Engineering controls:

- Wastes containing dry powder nanomaterials will be managed with proper ventilation until they are properly packaged and sealed for disposal.

– Containers and bags should be stored in a fume hood until it is full. Plastic bags should be antistatic in case of powdered material.

Personal Individual equipment:

– Eye and facial protection should be used depending on what was established in the risk assessment: safety glasses, safety goggles or face shields.
– When exhaust ventilation is not feasible, respiratory protection shall be used depending on the risk assessment: disposable FPP3-type mask or full- or half-face respirators.

Practices for handling material in solid matrices (non friable):

Personal Individual equipment:

– Nanoparticles in a solid matrix should have a low exposure potential for inhalation and eye exposure, but dermal exposure may exist if nanoparticles are on the surface.

Practices in the handling of nanowastes differ widely (Observatoire des Déchets Industriels en Midi-Pyrénée (ORDIMIP), 2009), for instance Gerritzen et al. (2006) found that the most common procedure for removing waste containing nanomaterials (including spills) was to contract a waste management company. On the other hand, Balas et al. (2010) found that only a minority (14.7%) followed a special procedure and that the majority (61.0%) used the same procedures for removing other chemical products. This is despite the fact that 81% of those researchers consulted indicated that nanomaterials should be handled as hazardous waste unless it has been clearly established they are not hazardous.

Furthermore another study brought to light the fact that little attention is given to the final storage of nanowastes (Helland et al., 2008a) or to risk assessment during their use and disposal (Helland et al., 2008b). The majority of the organizations interviewed by Lindberg & Quinn (2007) declared that they had not developed any special procedure for processing nanowastes. Then again it seems that awareness of the risks of nanomaterials would be a key factor in getting companies to implement nanospecific waste disposal practices (Conti et al., 2008).

4 CONCLUSION

After looking at the existing knowledge in this area, it can be said that regulations are lacking and information is scarce when it comes to dealing with exposure to nanomaterials. Consequently, it would be advisable to conduct new studies in the area of nanotoxicology and also to examine the current practices in prevention and work safety. The outcome of this research should be the basis for new regulations that would help Work Safety and Health professionals make decisions. The main contribution of this review is the identification of the practices that must be used to handle nanowastes correctly. To conclude, the measures recommended by the majority of the guides and authors are preventive in nature. However, most of the organizations interviewed do not apply those recommendations. Although future research is necessary, the lack of awareness regarding the risks is the main reason for not implementing the required safety measures.

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Subjective productivity of workers submitted to two different temperatures

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ABSTRACT: Environmental Ergonomics has been researching the effects of temperature on human performance for the purpose to understand how man reacts in different thermal environments. This paper presents the results of an observational study which evaluated the subjective productivity of office workers subjected to two different temperatures. The equipment *Confortímetro Sensu,* Hobo 03 and NASA TLX was used to measure the indoor environmental temperature upon subjective productivity through workload. After statistical analysis of the scores, the results showed that there is no statistically significant difference between the ambience; but at higher temperature the scores show greater variability. This sample suggests that the thermal conditions affect productivity of office workers, changing their performance.

1 INTRODUCTION

The effect of the environmental temperature over workers' subjective productivity, or over their perspective, is here presented after an applied research which analyzes statistically the scores of productivity of office workers using NASA TLX.

A research by Gaoua (2010) questions the effects of thermal conditions over cognitive performance. It states that these effects are still vague due to the methodological variances to evaluate whether the exposure to heat itself has an adverse effect over the cognitive function and in which environmental conditions these effects occur, highlighting the need for more research in this field.

It's known that the thermal conditions of an specific room can interfere in human beings health, welfare, performance and productivity as well, for it encompasses variables that sets up, or not, the thermal comfort.

Lan *et al.* (2010) state that there is no standard procedure among the Ergonomists to measure the workers' productivity. Scholars use analytical and subjective evaluations of performance to measure the productivity because it allows to quantify how much an individual has been requested, which is called human cost. That can be: physical, psychical, cognitive, emotional. The evaluation of mental workload involves psychical and cognitive aspects, not only from labor but also from personal environmental and social-cultural factors (Cardoso e Gontijo, 2012; Araújo, 2012; Lan *et al*. 2010; Lan *et al*, 2009).

This research has used thermal environmental conditions monitoring by the usage of two equipment: *Confortímetro Sensu*® and Hobo 03. Along with NASA—TLX evaluations, which measure the workload. The data were statistically grouped and analyzed.

The aim of this article is to present the results of the analysis, based on statistical parameters of the subjective productivity scores from eight workers in three different offices who perform their tasks in natural aerated work places, subjected to temperature variances, once experimental research have shown that thermal conditions can interpose human performance (Araújo, 2012, Lan *et al.* 2010, Cardoso e Gontijo, 2012).

2 METHODOLOGY

2.1 *Site*

All three companies, where the eight laborers work, are located in the same geographic region which has annual average temperature of 17°C, with average minimum of 13ºC and maximum of 25°C. These thermal characteristics foment the usage of buildings with natural ventilation systems, favorable to human comfort during sedentary activity (Lan *et al*, 2010 e Zhang, 2007).

2.2 *Research criteria*

The employees work under the same thermal environmental conditions in natural aerated offices. All of them are adapted to the task. The worker's metabolic rate is 70 W/m² for this task (ISO 7730).

The tasks performed by them have a bigger mental than physical workload. All protocols of *Comitê de Ética na Pesquisa* (Research Ethics Committee) were attended according to *Resolução 466/12 of Conselho Nacional de Saúde—BR*.

2.3 *Tools*

The subjective productivity was measured with NASA TLX—Workload, which evaluates the mental, physical and temporal demands as well as performance, effort and frustration. All these variables have been evaluated under the worker perspective. It is a worldwide used tool for this purpose (Nasa Ames Research, 1986; Lan *et al*, 2010; Cardoso e Gontijo, 2012).

Two other calibrated equipment, *Confortímetro Sensu®* and Hobo 03, were installed during work shifts and measured environmental thermal variables such as: indoor air temperature and speed, relative humidity and global temperature; data were collected every five minutes. No divergence could be observed within the collected data in none of the environments.

Data were analyzed with parametric statistics, t test, F-test and Levene, after checking the normality of the data, the independent variable is the temperature of the working environment and the dependent variable is the productivity of workers.

3 OUTCOME

The sample is composed by eight workers from three companies. The average age is 33 y. o., body weight 60.8 Kg. Among these, 62.5% are men whose average age is 27 y. o. and 37.5% are women whose average age is 43 y. o., 50% is graduated in a higher educational degree and 37.7% has at least the high school level, 62.6% have been working in the same function for over two years and 25% for over five years. Everyone works eight hours a day.

3.1 *Sample groups*

The cross-sectional study of productivity scores collected in different time periods was stratified into two distinct and independent groups, wherein Group 01collects the productivity of eight laborers working within an average room temperature of 17.18°C and Group 2 01collects the productivity of eight laborers working within an average room temperature of 25.97°C.

3.2 *Normality*

The normality of both groups was graphically verified through histogram, quadrants and boxplot; and they didn't show outliners, such as in charts 1 and 6. An analytical analysis of normality has also been done.

In Group 1, the analytical analysis of normality data were: K-S = 0.23132 with p-value 0.05>, Lilliefors with p-value >0.05 and Shapiro-Wilk = 0.90470 with p-value 0.05>, confirming the normality of the data for Group 1.

In Group 2, the analytic analysis of normality data were: K-S = 0.15275 with p-value >0.05, p-value 0.05> Lilliefors and Shapiro-Wilk = 0.90653 with p-value 0.05>, confirming the normality of the data for Group 2.

3.3 *Statistical parameters*

The statistical parameters of the study groups show a similarity between the averages of workloads and well-differentiated standard deviation, with larger amplitude values to Group 2, for which the average temperature was higher: table 1.

Therefore, statistical tests of hypothesis have been used to verify whether the subjective workload score of the office workers, with different environmental temperatures, has statistically divergent average and standard deviation.

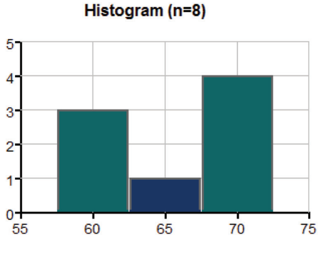


Chart 1. Histogram—Group 1.

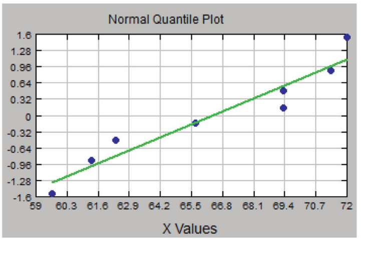


Chart 2. Normal quadrants—Group 1.

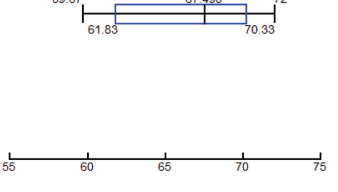
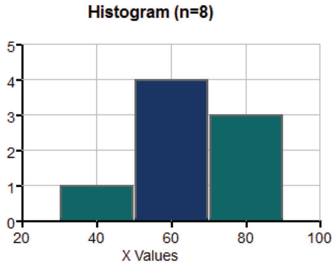
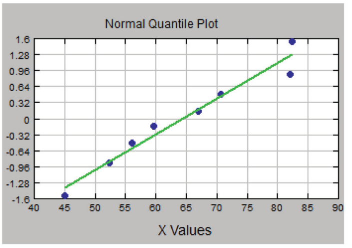


Chart 3. Boxplot—Group 1.





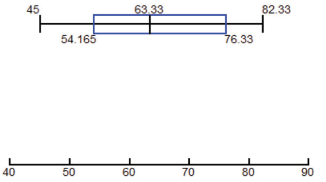


Chart 4. Histogram—Group 2.

Chart 5. Normal quadrants—Group 2.

Chart 6. Boxplot—Group 2.

Table 1. Statistical parameters of the sample groups.

Groups	Sample	ta. (°c)	Average (x)	Stand.deviat. (s)	Minimum	Maximum	Variance
Group 1	8	18.29	66.37	4.79	59.67	72.00	22.37
Group 2	8	25.23	64.37	13.59	45.00	82.33	64.37

3.4 *Hypothesis tests*

Scenario 01: Scores of subjective productivity among office workers, subjected to different environmental temperatures, has divergent average (μ).

H 0: $\mu 1 = \mu 2$ H 1: $\mu 1 \neq \mu 2$ (original statement)

Test T has been used, which is substantial against the deviation from normality, to verify that there is a significant difference between the averages of the groups assuming different standard deviation or variances, with significance level $\alpha = 0.05$, table 2 (Triola, 2013).

The Test T is not bilateral in the critical region. The null hypothesis of $\mu 1 = \mu 2$ is rejected. This is confirmed by the P-value = 0.70 and reliability interval, $\mu 1 - \mu 2$. (Triola, 2013).

Scenario 02: The scores of subjective productivity of office workers have a higher variation when workers are subjected to higher ambient temperature.

In the polygon chart, the scores of subjective workloads of workers performing their tasks with a temperature greater than 20°C appear to have standard deviation (s) greater than when the same workers, performing the same tasks, were working with temperature lower than 20°C.

H0: $s1 = s2$ H1: $s1 < s2$ (original statement)

F test has been used, which is not substantial against the deviation from normality, as it's about an affirmative over two standard deviations, two simple and independent random samples, and the data showed strict normality, table 3 (Triola, 2013).

Test of Levene has also been done, which is substantial against the deviation from normality, and also analyzes an affirmative over two standard deviations, two simple random and independent samples, figure 02.

Table 2. Test T: two-sample assuming unequal variances.

Stat t	0.39261
P(T <= t) two-flow	0.703744
Critical two-flow t	2.262157
Reliability interval	$-9.582737 < \mu 1 - \mu 2 < 13.58274$

Table 3. *F-Test*: two-sample assuming unequal variances.

F	8.029498
P(F <= f) uni-flow	0.006728
Critical uni-flow F	3.787044
Reliability interval 95%	$0.158 < SD1/SD2 < 0.788$ $0.025 < Var1/Var2 < 0.620$

As the sample statistic for *F test* = 8.02 lies in that critical region which is limited by *F critic* = 3.79; and as the *F test* and the *test of Levine* presents the p-value <0.05. The data support the original statement with 95% reliability, and concludes that for the sample studied, there is evidence to ensure that the score of subjective productivity of office workers presents greater variation when workers are subjected to higher environmental temperature.

4 ARGUMENT

A similar result was found in an applied research with temperatures between 18°C and 26°C. It was found that this temperature range hasn't queered the attention and memory of the subjects, allowing a good performance (Batiz, 2009).

In this research NASA TLX equipment presented good acceptance: data showed no spurious, all the evaluated subjects showed mental load greater than physical load. A similar research, applied in the same population, also identified that NASA-TLX tool is more sensitive in terms of dimensions, associated with mental load, and has had greater acceptance by the research subjects (Cardoso et al., 2012; Lan, et al. 2010).

In a similar experimental research it has been observed that the response time is independent from thermal comfort, but has nothing to do neither with the heat in the head nor with cold in the feet. No reasoning relates to the thermal environmental conditions, the concentration test presented better results with warmer temperatures. Yet, the concentration test presented better results in higher temperatures and warmer sensations and presented variability during the day (Aguilar, 2012).

The result of this research goes against the results of Aguilar (2012), since the average result of the workload remained similar, under the two temperatures observed, and presented an irrelevantly higher workload with higher temperature. This can be explained by the observation of Lan *et al.* (2009) research, which concludes that workers have to exert greater effort to maintain performance in thermal discomfort because of heat.

A laboratory research suggests that the burden imposed by the neurobehavioral tests used to evaluate productivity analytically, increases discomfort, once NASA-LTX is an important supplement for neurobehavioral measures in evaluating productivity (Lan, et al., 2010).

Therefore this applied research corroborates what the experimental researches have been showing. Thermal conditions of workspaces interfere in the performance and productivity of workers who perform activities with mental load greater than physical load.

5 CONCLUSION

This research evaluated the subjective workload scores of office workers subjected to an average temperature between 17.18°C and 25.97°C.

According to the data in this sample, the scores of subjective productivity of office workers did not alter their average performance, but presented a higher variation when subjected to higher temperatures, which suggests that the temperature can interfere in their productivity.

NASA TLX equipment, which was used to evaluate the productivity thought subjective workload, was accepted by all the subjects of this research.

The sample of this study does not represent the whole population of office workers, once it was composed by eight office workers from three different companies. Therefore, it is necessary to broaden the sample.

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Is the quality of information from worker to occupational health physician adequate for the purpose? A systematic review

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ABSTRACT: Preparing workers, through training, for the occupational health exam can lead worker and physician to a win-win scenario. What workers know about the purpose of their occupational health and safety exam, conducted by the occupational physician? Training workers to they can identify relevant matters related to their health and working conditions, could improve the performance of the medical exam? Could this help the physician, to be more effective in conducting the exam? Workers with more knowledge empower Small and Medium Enterprise (SME) to have more effectiveness on their procedures related to occupational health and safety system. Raise the awareness regarding the prevalence of injuries and diseases specific related to the professional group of the worker can be achieved by training all the intervenient to identify signs and report them to their occupational physician during the exam. Using selected keywords, a systematic review of English articles has been done, by searching electronic databases: "IEEE Xplore", "Informaworld (Taylor and Francis)", "PubMed", "SCOPUS" and "Web of Science". No articles related to training workers for the occupational health exam were found, but during research related information with the theme was found, and included in this review.

1 BACKGROUND

1.1 *Occupational health and safety trends*

The European Commission recognizes that investing in a high-quality work environment can make to fostering economic growth, boosting productivity and creating employment (European Commission 2013a). The same commission ignores Occupational Safety and Health (OSH) role when analyses the trends of workers, sectors, companies in Europe that is reported annually (European Commission 2013b). In European Union the Small Medium Enterprises (SMEs) represent 99,8% of the total of enterprises, and 66,5% of total of workers, 20 million of SMEs enterprises are responsible for the Occupational Health and safety of 87 million of workers and 44 thousands are responsible for OHS of 44 million of workers. Considering the numbers, presented, is possible to state that an SME is responsible in average for four OHS medical exams and an large enterprise is responsible in average for one thousand OHS medical exams. This balance help to understand the difficulties that SME have to face when they need to hire outsourcing services to develop the occupational health and safety activities.

1.2 *Occupational health and safety policy*

Framework developed to improve occupational health and safety performance (Cagno 2011) don't consider the medical exam as levers intervention, this impairs with one of the of the conclusions of the European Commission strategy applied during the year 2007 to 2012 (COWI 2013), that remarks that a new strategy should focus clearly on musculoskeletal disorders, stress and occupational cancer deaths and should target in particular the challenges related to the implementation of the legal framework with an explicit focus on SMEs and micro-enterprises.

This new strategy must consider all the levers, and the medical exam associated with training has potential to represent an important intervention, which can be transversal to all organizations, independent of their classification.

1.3 *Occupational health and safety interventions*

The interventions on organizations related to occupational health and safety, should refer to what universes that they can be applied, or identify the possible points of resistance when they are implemented in some type of organizations. The performance achieved is different, when interventions are applied in large enterprises, in Small Medium Enterprises (SME) or micro-enterprises. As reviewed by (Cagno 2011) this occurs because: the scarcity of human, economic and technological resources; the lack of capacity of SMEs to assess specific methodologies and control risks; the low level of occurrence of accidents and injuries a SME can experience lowers risk perception. When planning actual and future OHS interventions, the intervention should be select according the universe covered by the intervention.

The medical exam in occupational health and safety is compulsory regarding the size, type, nature of the organization, and the worker professional group can exists in different sizes of organizations, so no restriction regarding this important subject were considered in this systematic review. The methodologies regarding training are not covered in this systematic review, and in this specific matter, differences in performance could be expected, regarding the type of intervention (training methodology and format) defined.

2 MATERIALS AND METHODS

2.1 *Searching strategy*

The searching method was done with meta search available in the website of the library of the faculty of engineering of University of Porto. For searching purposes, keywords were defined, and used in combinations, to apply in the meta searches.

Our search included 22 Scientific Journals and 26 Databases.

The keyword combinations used were: "occupational medicine" + "training" + "exam". Two thirds of the records obtained were published before 2004, and because of that they were not revised, since most of the actual preoccupations are related to a new moment in Occupational Health and Safety (European Commission 2013a).

The results obtained from the sources, are in line to other review in the area of Occupational Health and Safety. The most relevant sources in this area of research, were the ones that returned more records.

3 RESULTS

The articles analyzed where collected in the following sources: Academic Search Complete, BioMed Central Journals, Highwire Press, IEEE Xplore, Informaworld (Taylor and Francis), MetaPress, Oxford Journals, PubMed, SCOPUS, The Chronicle of Higher Education.

No articles related to training workers for the occupational health exam where found. But pertinent information related to them was found. Four articles were included in the systematic review. The articles were grouped in three areas, articles conducting reviews, articles conducting experiments, and articles conducting training syllabus.

3.1 *Articles conducting reviews*

The first article (David 2011) is from Australia, and reports the process that introduces in 2011 a new curriculum in a Faculty for the training of occupational and environmental physicians. External and internal factors drove the Faculty to reexamine its core competencies and training processes, with the necessary reformulation of the original syllabus. On the base of this movement were the high failure rates for the exit examination within the Faculty, trainees themselves had concerns about the training program and content. Based on this and in the syllabus that remained largely intact until this latest development, the Faculty redefines the role and definition of occupational medicine practice to keep it contemporary. The article reviewed that almost at the same time there were major changes in other Faculties in Britain and in USA. This change, consolidate the definition of occupational medicine and environmental medicine, the first is a medical specialty where highly-trained specialists focus on the effects of work on health and (conversely) health on work, the second, environmental medicine is the prevention, research, investigation, assessment and treatment of human health impacts of industrial activities (including primary industry) on the environment beyond the confines of the industrial site. Author considers that some limitations, the new program may limit the development of the clinical reasoning among some trainees. Online enhancements are considered particularly important for trainees in remote areas.

The author remarks that this transformation is a statement of hope. Its strength can be realized only if trainees want to use it and become competent in its use.

3.2 *Articles conducting experiments*

The second article (Bersellini 2007) is from Britain, and reports a study divided in three experiments that test different adjustments and methods regarding information delivery to patients to assure that they comply to take the medicine, rise their awareness. To measure the effectiveness of information delivery, the authors used inquiries the collect the desired information. The population in each experience was divided in one control group, and two experiment group with different information transmitted. The total numbers of patients that participate in the three experiments were 454, 292, and 248 adult volunteers. The first experiment delivery simple information about the benefits of the medicine, the second deliveries same as the first plus additional information about the way that medicine acts on the human, and the last experiment delivers information like in the second experiment, but with adjustments and additional information about secondary effects, and their relative importance regarding the benefits.

The experiments provide fairly consistent support for the inclusion of benefit information in medicine information leaflets, particularly to balance concerns about side effects.

The inclusion of benefit information, whether in the form of a rationale or effectiveness statement positively influenced people's judgments, including their intention to take the medicine.

3.3 *Articles conducting syllabus*

The third article (Rijssen 2011) is from Netherlands, year 2011, and reports the systematic development of a communication skills training course for physicians performing work disability assessments interviews and plan an evaluation of the training course. The authors identified the necessity to improve the communications between the physician and claimants. To achieve this data were collected from questionnaire studies among physicians and claimants, a focus group study among physicians, a systematic review of the literature, and meetings with various experts. The systematic development was made according to the six steps of the Intervention Mapping protocol. A two day postgraduate communication skills training course was developed, and the physicians who participate in the training course were evaluated in a randomized controlled trial. The main research findings, were: social insurance physicians have little awareness of the effects of claimant behavior on their own communication behavior, and vice versa; Physicians are often unable to accurately assess claimants opinions about the communication and assume that claimants opinions are more positive than those opinions actually are, although most physicians reported that they explained their conclusions to the claimants, but many claimants reported that this did not happen; in interviews with claimant with a lower level of education, with little self-reported communication skills, and with little social support from family, friends, and acquaintances, physicians need to pay special attention to the exchange of information and their listening behavior; when physicians are transparent and clear, providing information about findings and conclusions, this may prevent unpleasant reactions from claimants and change their option that, the physicians conclusion are often unclear or difficult to understand. The authors present in the article the theoretical methods, practical, strategies, and materials needed to increase knowledge and skills for the physicians, which covers determinant and objectives like knowledge, awareness and skills of influences of own feelings, communication attuned to claimants, meeting claimants needs when discussing findings and in minimizing negative influences. One of the results of this work was the training course, denominated as, Professional Claimant Communication, because claimants in physician's opinion are the central point theme of the course.

3.4 *Articles conducting syllabus and experiments*

The fourth article (Jamil 2010) is from USA, year 2010, and reports a study where a group of family medicine residents physicians perceptions of a 4-week rotation in Occupational and Environmental Medicine (OEM) that combined lectures, worksite visits, and clinical placements between 2002 and 2008. For each course, 55 to 60 hours are allotted to didactic lectures; 9 to 12 hours are devoted to 3 to 4 site visits; and 16 hours are devoted to 4 clinic visits. Resident's physician's knowledge of key subject areas in OEM was measured at the beginning and conclusion of each rotation. Changes in resident knowledge of OEM measured by the pre and posttests were triangulated with residents' perceptions of the usefulness of the rotation. The perceptions of the usefulness of the OEM rotation were grouped into three main categories: knowledge, experience, and skill development. The results demonstrated significantly improved knowledge in key OEM subject areas.

The authors consider that is need to do in addition, a follow up survey of residents who attended the 1-month course, and explore the long-term perceived value of the OEM training on their family medicine practice.

Learning is analyzed a three different levels, knowledge/awareness, skills, and experience, each one is considered a fundamental part, with specific competences acquired during and after the training.

4 DISCUSSION

There are barriers between physician and workers, they can be experience during the interaction with workers, and this may influence the communication between physician and worker and vice-versa, and physicians meet workers needs for information and empathy in their communication behavior when they discuss their findings without compromising the assessment (Rijssen 2011). In one of the article reviewed (Jamil 2010), is mentioned by a physician "I really did not understand what an occupational physician did. Now I have a better understanding how OSHA, NIOSH [National Institute for Occupational Safety and Health], EPA [Environmental Protection Agency], industrial hygienists, occupational medicine physicians all contribute to patients'/employees' health on different levels." This statement is in fact, inline with the general impression that Occupational Health and Safety Medicine is not universally understood, and needs to be promoted near the workers, so they can contribute to a more engaging occupational medical examination.

One of the learning needs of workers is developing the knowledge/awareness of Occupational Medicine.

Developing a program, that comply with the learning needs of workers, it's expected that after being the training applied, the worker's that already have been submitted to an occupational medical examination, express different behaviors relative to the past occupational medical examination.

The analyses and discussion of this differences sustained by the workers, represent the learning objective, that was accomplished by a learning processed developed specifically to a group of workers that can be associated has having something in common, necessary for the effectiveness of training.

The skills will be levered by training, and in the next regular occupational medical examination, something different is expected regarding the communication between worker and occupational medicine physician.

5 CONCLUSIONS

Occupational medical assessments to workers are performed in many countries, these assessments include face to-face interviews, and communication is one fundamental key in the process and content of the assessment.

Physicians require specific communication skills, because the face-to-face contact with their patients is an important source of information. A physician-tailored communication skills training course.

Every learning objective should have a 'scope of learning' section to define the boundaries of learning.

The training should include a concept of a spiral curriculum where trainees revisit core competencies that evolve through the period of training.

The concept of learning needs exists, and must be considered in the learning process, where trainees, worker's and physician's can have the possibility to do something together to improve the health and safety of the worker and its organization, independently of being enterprises or not.

This systematic review needs to continue, with new research areas, for example look in other's activities similar approaches to the one that we are trying to resolve here.

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Hazard and operability (HAZOP) study: A systematic process to identify potential hazards and operability problems

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ABSTRACT: Safety in chemical and petrochemical industrial plants plays an important role due to its potential impact on society, Bhopal and Seveso disasters are examples of the negative impact that a chemical accident may have on society. This paper aims to apply the technique described as Hazard operability Studies (HAZOP) to a LPG (Liquefied Petroleum Gas) storage and distribution facility, property of one of the largest Portuguese petrochemical industries. This study made possible the identification and elimination of possible faults to the original plant design and operability problems which could result in accidents that can compromise plant safety and lead to a major disaster, even when there are no accidents recorded and the plant is apparently working in a safe way. The HAZOP method revealed its full potential in identifying hazards and operability problems.

1 INTRODUCTION

Industrial facilities, much due to its complexity and size, are potential sources of problems which may reach catastrophic levels influencing all society. As history sadly reminds us, there are several cases of accidents in industrial installations. Consequently risk assessment in an initial stage of a chemical plant design, as well as during its life time, is essential to identify potential hazards and creating the opportunity of implementing safety systems to avoid major damages (Kletz, T. 2009).

Among the petrochemical industries the increasing concern in safety, led to one of the major industries, the British company ICI, in 1963, to put in place the conception of an analytical method that would allow the study of possible hazards and operability problems, in order to eliminate or correct them, thereby making the facilities and the respective operation safer (Kletz, T. 1999). Since then, this method named as HAZOP (hazard and operability study), has evolved to became the reference for the sector. The International Electrotechnical Commission published IEC 61882: 2001—Hazard and operability studies (HAZOP) Application guide, providing guidelines, which became a benchmark since then for the preparation those studies.

The HAZOP method is widely used over the past 30 years becoming a reference when applied to petrochemical industries, specially after IEC 61882:2001 publication. The word HAZOP arises from the junction of the first 3 letters of word Hazard and the first 2 letters of the word Operability. It is a creative, structured and systematic method for identifying deviations from the design intent or normal operation in industrial installations, allowing the identification of potential hazards and operability problems, their causes and consequences and finally proposing measures to eliminate or mitigate them.

This study aims to apply the HAZOP method to an entire LPG (Liquefied Petroleum Gas) storage and cylinder filling facility in Portugal, composed by a tanker loading and unloading bay, two pumps, one compressor, four storage tanks, two cylinders filling stations and storage. The main operations consist of unloading the tankers to the storage tanks and furthermore cylinders filling operation.

By applying the HAZOP method at this Facility, based on the IEC 61882:2001 regulation, it is expected to achieve a higher level of safety ensuring a safer operation of the entire plant.

2 METHOD

The methodology applied, followed, the IEC 61882:2001 regulation, which is the actual standard used internationally for the conduction of HAZOP studies. The development of the study followed a rigorous structure and was divided into four main stages:

- Definition—Scope and objectives, Responsibilities and select the team;
- Preparation—Plan, collect all data, choose the recording style, estimate the time, arrange the schedule and organize all the study;

- Examination—Divide the system into nodes and elements, examine each element for deviations, identify possible causes, consequences and protections, propose recommendations;
- Reporting and follow-up—Record on worksheets, sign off records, produce the report and the follow-up actions, re-study where and if it is needed, issue a final full report.

2.1 *Definition*

One of the main advantages of the HAZOP is the use of a multidisciplinary team, so everyone can contribute with their knowledge and experience. The team should be as small as possible, in order to perform a better communication and ease of agreement, usually should be composed for at least four members and should not pass seven.

For this study the team was composed by a safety engineer who played the role of team leader, a SHE expert, a mechanical engineer, an electrical engineer, an instrumentation engineer and the responsible of the installation in order to represent all elements involved in the normal operation of the LPG storage.

2.2 *Preparation*

During the preparation it was necessary to structure, choose the methods, and collect all the data and information available in the project, with applicability to the study. The data collected and subject to use, was previously sent for licensing purposes, to the DRE (Direção Regional de Economia) and was composed by the main Piping and instrumentations diagram (P&ID), the general layout and all particular specifications of pumps, compressor, tanks, valves and pipes.

For the recording procedure, a manual registration sheet adapted to the particular case was created based on IEC 61882:2001. This sheet contained 11 columns which comprised the following fields: a sequential numbering, Element, Guide Word, Deviation, Possible Cause, Consequence, Safety Measures, Risk Assessment, Recommendations, Remarks and the responsible for the action.

2.3 *Examination*

Due to the size and complexity of the plant it was essential to divide the installation into nodes (or pats) in such a way that the intended function and operation of each part could be adequately defined. The objective was to make the study fluent and easy, allowing better hazard identification and an efficient work planning.

For this study the facility was divided into six nodes as described below:

1. Tanker Load or unload (loading bay);
2. Pumps and Compressor (pump house and isolation valves);
3. Storage (storage tanks);
4. Transferring (LPG transfer between tanks);
5. Cylinders filling (filling stations for 19 Kg and 95 Kg cylinders);
6. Others (cylinders storage and others).

Therefore all nodes were subdivided into its main parts.

A list of pre-established guidewords was used to simulate scenarios in the minds of the team. Each guideword was applied to specific process parameters to analyze how the process could deviate from its intended operation and what the effects would be. Each deviation is considered a departure from the design intent, some of those plausible or credible others not.

The list of HAZOP guidewords applied to each parameter of the nodes is shown in Table 1.

The method used to identify the deviations was the "element first", which consists on selecting an element, applying to it all the guidewords and then moving on to the next one. This method has the main advantage of driving the team focus on an element at a time, enabling the exhaustive analysis

Table 1. Guide words meanings and applied parameters.

Guide words	Meaning	Parameters			
		Flow	Pressure	Level	Temperature
No	None of the design intent is achieved	x	x	x	–
Less	Quantitative decrease	x	x	x	–
More	Quantitative increase	x	x	x	x
Reverse	Logical opposite of design intent	x	–	–	–
Part of	Some of the design intent is achieved	x	–	–	–
As well as	Qualitative modification	x	–	–	–
Other than	Another activity	x	–	–	–

of all possible deviations for that element before proceeding to the next one.

The causes and consequences of the deviations were then identified for all nodes. As an example, considering "no flow" as possible deviation, the "inlet valve close" could be identified as being the cause and "pressure increase" as the consequence.

For each deviation the existing safety mechanisms were identified in order to verify the effectiveness to mitigate or eliminate them. As an example for a deviation due to a "no flow" event the existence of the following safety mechanisms should be identified: limit switches in the valves or flow meters and pressure transmitters to avoid the lack of flow.

In order to eliminate or to minimize the occurrence of the detected deviations, recommendations were proposed by the team. The recommendations were based in addition to redundant and passive safety equipment as well as electrical and logical interlocks with a low cost of implementation based in proven solutions already tested in an industrial environment, comprising a well-known efficiency, and also a positive balance between the effectiveness and cost of implementation. The recommendations were classified in accordance to the priority defined by the team.

Although not mandatory in the HAZOP method, this study comprised a risk assessment to all deviations detected. Risk assessment was performed through the use of a risk matrix already used in similar industries which included the combination of probability (possibility that the event occurs) and severity (as a consequence of the event). For the risk assessment criteria, four levels of probability were defined: very unlikely/remote, likely/possible, probable and frequent. For severity were defined also four levels: reduced, moderate, high, very high/catastrophic. The designation of risk parameters took into account the probability of occurrence, the measures implemented, historical events, potential injury to persons, to materials, to the environment. The combination between the four levels lead to four types of risk, grouped in two levels, acceptable/not significant, which even after adopting definitive measures, may continue to exist, and the not acceptable/significant, which cannot exist being mandatory to introduce some measures in order to pass to acceptable levels.

2.4 *Reporting and follow-up*

For this purpose it was created a follow-up sheet for each group of deviations in order to control the entire path until the implementation by the plant responsible.

In order to verify that after being implemented, these measures would not lead to new deviations, a restudy and review of those parts should be made. As recommendations for this study do not imply any changes to the process functions, but only addiction of auxiliary safety systems to reduce risk to acceptable levels, there was no need to make a second review of the nodes.

At the very end the final report was made by the team leader including all the information and distributed for all parts involved.

3 RESULTS AND DISCUSSION

At the end of the HAZOP study, the way how deviations are distributed can be seen. The plant was divided into 6 nodes, subdivided in 36 components which in turn were divided into elements or parameters. The components, deviations and recommendations per node are shown in Table 2.

The node with more components is the fifth, however the node with more deviations was the fourth. This reflected the high number and higher complexity of the valves between the storage tanks. Those are subject to human operation and possible errors in addition there are no safety equipment or any alarm to prevent unsafe operation. The installation of manual valves limit switches as a recommendation can eliminate most of those deviations.

Risk assessment, allowed to achieve a quantitative evaluation of the deviations according to the distributions shown in Chart 1.

Table 2. Components, deviations and recommendations per node.

Node	Nº components	Nº deviations	Nº recommendations
Node—1 Load or unload tanker	7	23	20
Node—2 Pumps and compressor	8	34	34
Node—3 Storage	4	32	20
Node—4 Transferring	6	48	35
Node—5 Cylinders filling	9	15	14
Node—6 Others	2	7	5
Total	36	159	128

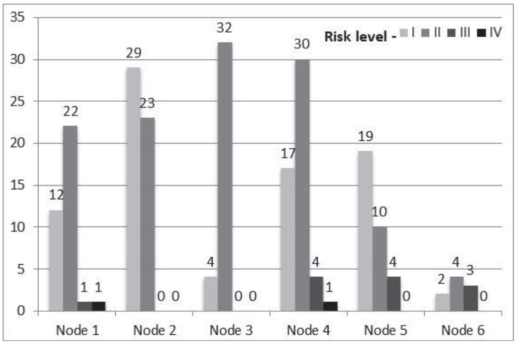

Chart 1. Distribution of risks.

Table 3. Recommendations per node and deviation.

Recommendations	Nodes	Deviations
1. Staff specific training	2	6
2. Tanker load or unload should be assisted by operators	1	1
3. Interlocking between SCULLY ground system verification and the start the pumps and compressor	1	1
4. Install limit switches on valves	2	37
5. Interlocking between limit switches and the start the pumps and compressor	2	33
6. Install check valves	1	2
7. Electrical interlock for the pumps do not work simultaneously	1	1
8. Automation or manual assistance for transporting 95 Kg Cylinders	1	2
9. Gas and fire detectors should be installed in strategic places at the	1	2
10. Local emergency shutdown push buttons should be installed in the pumping area and filling station	1	1
11. ATEX study for the entire installation. The installed equipment should be in compliance with the area classification	6	42

Risk level IV, classified as very high or catastrophic, was found in the nodes one and four. In node one, there is a risk of fire or explosion due to a lack of ground connection for the tanker during the load and unloading process which may lead to electric discharges. In the fourth node, due to a possibility of having liquid LPG in the gaseous phase pipes, there is a risk of a catastrophic failure in the compressor.

Risk level III, classified as high, was found in the nodes one, four, five and six. The deviations that produce this type of risk levels are mostly related to possible ruptures in pipes, valves, storage tanks and injuries to the workers that can occur from the operation.

Risks levels I and II, classified as very unlikely or remote and likely or possible were found in all nodes these risks are caused by several circumstances and since they are classified as acceptable there are no need of further detail.

In order to control or eliminate all the hazards found, recommendations were made. It was created a group of 11 recommendations according to the distributions shown in Table 3.

Recommendations for Risk level IV were to install ground system verification in the node one and check valves in the node four.

All recommendations proposed in the study lowered the risks to acceptable levels.

Some faults in the original design of the plant can lead to severe risks, however the predominant cause of this high number of deviations is related to human intervention in several critical operations. In this type of industry it's not acceptable to rely only in human behavior, safety equipment must be installed, to prevent unsafe human operation.

4 CONCLUSIONS

We can conclude that the HAZOP is an extremely useful tool in the evaluation of an LPG storage and distribution facility which made possible the overall evaluation of the current state of the plant and many hazards and operability problems that can lead to major accidents.

The method also revealed the advantage of working in a group which promoted a higher synergy of the individuals, and increased the creativity to the identification of possible hazard scenarios and the proposal of control measures to its mitigation.

It was concluded that even when a plant without any events registered during its lifetime can have hidden hazards on its conception that can occur at any time, leading to terrible accidents. Therefore is indispensable as early as possible a study to identify and correct potential hazards and operability problems to ensure a more secure installation and safer operations. Nevertheless, It is essential that the HAZOP recommendations are implemented in order to eliminate those potential hazards, improving and increasing the overall safety of this particular facility.

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The approach of ergonomics on the analysis of the use of physical space for pedagogical activities at the children's school of the Federal University of Paraíba

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ABSTRACT: ***Background***: School environment plays an important role in the physical, cognitive and social development, once it is there where children are able to carry pedagogic and playful activities with their peers under the guidance of specialized professionals.

Purpose: To analyze the adequacy of physical space of classrooms for the development of pedagogic activities in a school for children.

Methods: It has been used the Ergonomic Analysis of Work method through the use of interactional, observational and documental analysis methods.

Discussion: The inadequacy of the physical space of classrooms causes frequent layout changes, accident risks, waste of time and increased workload of the teachers, which may interfere in the performance of students.

Final Considerations: Adequate physical space for developing pedagogic and playful activities in schools has become an essential feature for the development of children, therefore the analysis of pedagogic activities and their relationship is fundamental to guide the creation of projects and also for the setting of designing guidelines for schools.

1 INTRODUCTION

The individual's behavior is influenced by several environmental and personal variables. Concerning the environment, it must be considered not only physical space but also the social space where the individual builds his experiences (Kolb & Kolb 2005).

Physical space has a direct impact on the behavior, stimulating or inhibiting it (Elali 2003). According to Davies et al. (2013), physical space must be used in a flexible way so as to stimulate the creativity of children. For that purpose the ambient must be spacious, with the least amount of furniture and also considering aspects such as lights, sound and temperature and how these features influence the perception of individuals (Elali 2003; Davies et al. 2013).

Relating to the social environment, Cordazzo et al. (2010) explains that the social interaction enables the child to acquire abilities such as communication and emotion regulation. Such social interactions provide models to be used in future interactions, thus being part of the cognitive development and the interaction with the physical world. Among the social environments of the child, the school is one of the most important ones for although the amount of pedagogic activities reduce the moments of free interaction, it comprises a group of spaces where the child interacts with a large amount of individuals of the same age (Cordazzo et al. 2010; Davies et al. 2013; Elali 2003).

The physical space of school, according to Elali (2003), is based on the current pedagogic and political context. However, the pedagogic methods more often than not undergo changes in a much faster speed than the changes in the constructed space may take place. For that reason, the building projects must take into consideration the necessities of the space for the pedagogic activities and the variables.

Because of that, analyzing the physical space of classrooms and schools and their usability for pedagogic activities is fundamental to understand its interference in the process of learning and in the workload of teachers. The aim of the current paper is to assess the physical space used by teachers and children during the pedagogic and playful activities in the classroom in a school for children and thus, to suggest improvements aiming at a better performance.

2 METHOD

The methodology used was based on the Ergonomic Analysis of Work—WEA, a structured set of analysis determining the work activity of people in an organization, allowing the modeling of real activity in its own context (Guérin et al. 2001; Vidal 2012). The demand of this research features a provoked demand, process in which the researchers aim to develop a study to identify problems that may be transformed into real demands coming from and/or authorized by the organization (Saldanha 2012). The process of constructing a demand is described in Saldanha et al. (2012). The actors involved in the social construction were the School Principal, the teachers and the staff of the studied school.

The research was carried through observational methods (total of ten situated observation using film and photography records) and interactional (total of eight conversational action and provoked and spontaneous actions) as well as documental analysis. The collected information through conversational actions along with the collective analysis were transcribed through the matrix of commentary inclusion (Vidal 2012). The analysis of the activity has enabled to obtain data that was submitted to constant restitutions and validations.

3 RESULTS

The school of basic teaching is part of the Campus I of the Federal University of Paraíba (UFPB)—Brazil. It is a field of training, experiences and educational practices of teaching, extension and research for teachers and students from the under graduation and post graduation courses, which defines it as a mutual space. The school has two shifts—morning and afternoon. It has 30 employees, out of whom 12 are people in charge of preparing meals, cleaning and organizing. There are also 18 teachers. In the year 2013 it had 167 students with ages varying from 2 to 9 years old enrolled in groups from kindergarten to ninth grade of fundamental teaching. The distribution of the number of students by teacher is done according to the age of the children and following the Education Law (*Lei de Diretrizes e Bases*) of National Brazilian Education.

The school occupies an area of 1494, 35 m², with classrooms, patios, restrooms and administrative areas (figure 1). There are two closed spaces, the toy room and classroom 6, not used due to inadequacy and maintenance problems.

The classrooms were the place with the highest number of complaints on physical space issues, lack of space to perform pedagogic activities besides reports of accidents, which made those areas the chosen ones for the analysis.

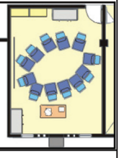
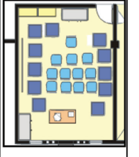
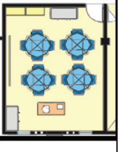
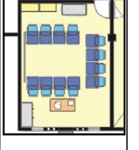
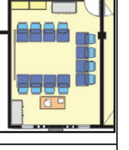
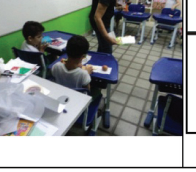
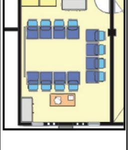
It has been identified that 5 out of the 8 available classrooms are not in accordance with the rules established by the edification code of the state of Paraíba—Brazil, which defines the minimum area of a classroom to 30 m². Classroom number 5 has been identified as the one with the highest number of students per m², 0,57 pupils/m², thus it is the most critical classroom for developing pedagogic activities (Table 1).

Figure 1. School floor plan. Source: Personal file (2013).

Table 1. Classroom characteristics.

Classroom	Age of students	Number of students	Classroom dimension	Student/m²
1	2	10	37,84 m² (9,3 × 4,35)	0,264271
2	2	10	36,98 m² (2 classrooms 4,35 × 4,35)	0,270416
3	3	14	26,10 m² (6,0 × 4,35)	0,536398
4	4	12	26,10 m² (6,0 × 4,35)	0,45977
5	5	15	26,10 m² (6,0 × 4,35)	0,574713
6	Not occupied		26,10 m² (6,0 × 4,35)	X
7	7	12	31,14 m² (6,77 × 4,6)	0,385356
8	9	15	29,11 m² (6,77 × 4,35)	0,515287

Table 2. Relationship between pedagogic activities and layout.

Activity	Activity and layout description	Image	Layout
Reception	Activity: Stimulate students to describe what they did at the weekend and inform the activities to be developed during the day or the week. Layout: Circular Aim: To provide better interaction and participation to all students.		
Reading/ Film	Activity: The teacher stands in front of the students holding a book in one of her arms. As she reads the book, she moves the book toward the students to show them the pictures. When showing films de layout remains the same, though the teacher sits at one side. Layout: Desks are grouped in the center of the classroom while the tables as set aside by the walls. Aim: To gather students to facilitate their view of the teacher and the object to be seen(book or screen)		
Games/ Plays	Activity: Students are separated in groups to play games. Layout: Furniture is separated in "islands". The pedagogic materials (games) are disposed on the tables. Aim: Facilitate the control on each activity and stimulate the notion of group and cooperation among students.		
Class using the White board	Activity: The White board is a very used tool in regular classes. It is through its use that children are stimulated to write and participate in class. When the activity is associated to exercises in books/notebooks the board is used for visual memorization and orientation. Layout: The desks are placed in a U-shape facing the White board. Aim: To provide interaction between students and the board and to allow the teacher to move around easily among all the desks. Students still need to turn their heads to visualize the White board.		
Painting/ collage	Activity: Each student is given the material to be used in the task (paper; images and glue or paint). With the help of the teacher the activity is done individually by each student according to a theme presented. Layout: The desks are placed in a U-shape facing the White board. Aim: To facilitate the access of the teacher to all desks.		
Having a snack	Activity: Children eat their snack in the classroom. The desks are covered and the food is placed on them by the students themselves with the help of the teacher if necessary. After the meal children are allowed to leave the room to play in the patio, the park or the covered patio. Layout: The desks are placed in a U-shape facing the White board. Aim: To facilitate the access of the teacher to all desks.		

In room5, it was observed that pedagogic activities are performed through the adaptation of space and resources. Among the adaptations there are the layout changes needed for each activity, the use of the space of the corridors and restraining of some activities such as the ones which involve a lot of moving by the students (Table 2). In this room it has been reported accidents/incidents like falls and hitting the furniture.

4 DISCUSSION

It has been observed that 5 (62,5%) out of the 8 available classrooms do not match the minimum area for as classroom, 30 m², as determined by the code for building in the State of Paraíba—Brazil. However, the code does not take into consideration the number of students and the age of pupils occupying each classroom.

Figure 2. Proposal for changing the physical structure of each classroom. Source: Personal file (2013).

It has been observed that the physical space of the classroom are not suitable for the activities, requiring constant adaptation of the layout. That increase the workload of teachers, especially the physical load, causing loss of time, risk of accidents/incidents, affecting the dynamics of activities, which may adversely interfering the performance of students.

Observa-se que os espaços físicos das salas as de aula não são adequados para as atividades.

The impact of space may be demonstrated through observables: number of room layout (at least 4 times a day); number of times the teacher moved to another room to fetch extra materials (at least 2 times a day); occurrence of accidents/incidents in the classroom. Considering the problems detected in the school studied, the current research suggests three recommendations at short, medium and long term, respectively.

1. Short-term—Classroom Layout: Simple changes can minimize teacher moving to another room, such as: a) replacing vertical lockers for suspended cupboards and shelves; b) placing the teacher's table near the entrance; c) Carrying pedagogic activities that use the same layout in a sequenced way. Such changes provide a better use of the space and a reduction in the number of layout changes every day.
2. Short term—Adapting the existing spaces: Spaces such as the toy room and the patios—covered and uncovered, can become an extension to the ludic activities suggested by the school.
3. Long term–Classrooms structural changes: A refurbishing Project aiming to enlarge the areas of the classrooms, thus increasing each room in 13,45 m² and also keeping the same number of classrooms being used. At the moment there are four classrooms but only three have been used. Such refurbishing will allow a better use of the space by defining zones for regular classes (1) playful activities (2) and places to keep materials—books and toys (3) (Figure 2)

5 FINAL CONSIDERATIONS

An ambient which is adequate to ludic and pedagogic activities is fundamental to obtaining results both in terms of performance and in the reduction of accidents and occupational diseases. The inadequacy of school ambient designs may cause harm to the development of students.

Another arguable issue is the lack of guidelines to measure space accordingly to school level. The minimum area measure each classroom is questionable if it does not take into consideration the different pedagogic activities for each school level and also the maximum amount of students in each classroom, as discussed by Magro (2012) who points the different pedagogic dynamics that besides distinct spaces, acoustic and thermal comfort characteristics and lighting. Wargocki Wyon (2013), also highlights that the absence of an analysis on the activity to measure spaces is very harmful for it interferes in the dynamics of the activities performed there, in the school and the student performance.

Therefore, it is recommended that the analysis of the activities should be performed to guide reforms and to adequate the physical space in schools and the use of analysis of reference situations (Daniellou 2002), when building new schools so that children may have adequate environment to develop physically, cognitively and socially.

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Characterization of workers' noise exposure of Portuguese industry

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ABSTRACT: This study aimed to characterize the industrial workers' noise exposure. The analysis was carried out using data from noise exposure assessment bulletins, prepared under the *Prevenir* program. This study covered eight sectors of Portuguese industry. The results showed that the sectors with higher levels of noise are the metallurgy and metalworking and also the wood and furniture. The quieter sectors are the textile and clothing industry, jewellery and watchmaking and chemical industry. Regarding the attenuation provided by hearing protection available to workers from the evaluated industries, the vast majority use earplugs with excessive attenuation.

1 INTRODUCTION

Noise is an important risk factor for workers, affecting their physical, psychological health and their security, while lowering the quality of work and productivity (WHO, 2009).

According to the 2007 Eurostat survey on occupational accidents and work related health problems, 8.6% of workers in the European Union (EU), suffer from health problems related to work. Exposure to noise and vibration are important factors affecting workers health, with respectively 4.13% and 6.66% of work health related problems. One fifth of European workers have to use their voice to be heard for at least half the time they spend at work and 7% of them suffer from hearing difficulties related to work (European Agency for Safety and Health, 2005).

Exposure to high intensity noise, whether for long or short periods has a progressive impact on the listener, affects their health and assume proportions that progress to physiological and mental disturbances which in turn may also result in deafness, an occupational disease.

The elimination or reduction of excessive noise is a legal obligation to the employer. A safer and healthy environment for workers decreases the absenteeism and promotes the increase of productivity and profitability. However, the low cost and simplicity of implementation of ear protectors, made this option the most preferred and used (Arezes, 2002).

The *Prevenir* program was developed between 2005 and 2011 by AEP (Portuguese Business Association) in partnership and financial support of POAT/FEDER. Under this program, a wide range of companies from eight industrial sectors, characterized in Table 1 according to the data obtained from the National Institute of Statistics (Eurisko—Estudos, Projectos e Consultadoria, S.A., 2011) have been evaluated in several occupational and safety aspects including noise exposure. The objective of this study was to analyse the data from the noise bulletins supplied by AEP within the program.

Table 1. Characterization of industrial sectors in Portugal.

Sector	Nº of companies	Nº of workers	Turnover (EUR million)
Food and drinks[a)]—FD	10 835	111 408	15 181
Rubber and plastics[a)]—RP	1 236	24 762	3 083
Ceramics and Glass[b)]—CG	1 216	28 964	2 142 979
Jewellery and watchmaking[a)]—JW	975	2 991	167,6
Wood and furniture[c)]—WF	15 981	141 201	3 359 476
Metalworking and metallurgy[d)]—MM	19 817	181 678	14 670 846
Chemicals[a)]—CH	876	14 218	4 204
Textile and clothing[c)]—TC	19 031	200 713	–

[a)]Data for 2008; [b)]Data for 2007; [c)]Data for 2005; [d)]Data for 2002.

2 METHODOLOGY

The Decree-Law nº. 182/2006, from 6th September, (transposing the directive 2003/10/EC) defines the minimum mandatory requirements regarding the workers's exposure to risks legitimized by noise.

For these purposes, the decree-law establishes the exposure limit values and upper and lower exposure action values, related to daily or weekly personal exposure of a worker and the sound pressure peak level values compiled in Table 2.

If upper and lower action values, for daily or weekly exposure levels or sound pressure peak, are reached or exceeded, appropriate preventive measures should be adopted in order to reduce noise levels and enhance the safety of workers.

Data collected covered 279 industrial companies from 8 different sectors, with 5101 workplaces and 10846 workers evaluated. The study consists in an analysis of data from the noise evaluation reports with the main objective to conclude which sector is the most noisiest and dangerous to Portuguese workers' ear health in the Portuguese industry. Another important objective was to compare the results between the workplaces' noise levels and workers' daily noise exposure. The last important objective was to analyse if the attenuation that the ear protectors supplies is adequate.

Thus, the following independent variables were studied: Workplace (referred as WP), workers (denoted by WK) and, in order to complete the study, the attenuation of earplugs (designated EP).

Table 2. Lower and upper action values, and daily exposure noise limits values for workers.

	$L_{EX, 8h}$ dB(A)	L_{Cpeak} dB(C)
Lower Exposure Action Values (LEAV)	80	135
Upper Exposure Action Values (UEAV)	85	137
Exposure Limit Values (ELV)	87	140

The sample used for noise levels analysis in workplaces and the noise exposure of workers of Portuguese industry is characterized in Table 3.

3 RESULTS

In a general note it is stated that there is no workplace, and therefore no workers, with the Lcpeak parameter close to lower action value, whereby the achieved values refer to LAeq parameter (in the case of workplaces) or LEX, 8H parameter (for workers). Table 4 summarizes the results obtained for the noise levels per workplace for each industrial sector, based on the amounts stipulated legally. In 55% of the workplaces, the noise levels determinates that the workers should use appropriate personal protective equipment, being mandatory the use of hearing protection in 31% of workplaces in the Portuguese industry.

Table 5 summarizes the results obtained for the workers' exposure to noise in each industry in accordance with what is legally stipulated. Based on the analysis of the results it can be concluded that 63% of the workers should use ear protectors, being mandatory the use of this protection equipment to 33%. Companies should conduct risk assessment, the adoption of measures to prevent or control the risk, perform appropriate control measures and monitoring the health of their workers in order to prevent workers being not harmed by activities with excessive noise levels.

Figures 1 and 2 show the percentage of workplaces and the exposure of workers to noise, respectively, whose noise levels are lower or higher than UEVA, in different industrial sectors. In the wood and furniture sector, as well as in metallurgy and metalworking, most workplaces have noise levels above 85 dB(A). In the others industrial sectors studied,

Table 3. Characterization of the sample analyzed in the study.

Sector	N.º of companies in the program	N.º of companies assessed by WP	Nº of WP evaluated	% of the total sample	N.º companies with exposure assessment WK	Nº of WK evaluated	% of the total sample
FD	40	40	711	13,9	39	1833	16,9
RP	40	41	922	18,1	39	2225	20,5
CG	40	40	719	14,1	35	1794	16,5
JW	20	20	157	3,1	18	175	1,6
WF	40	39	798	15,6	38	932	8,6
MM	40	40	753	14,8	40	415	3,8
CH	20	19	250	4,9	19	547	5,0
TC	40	40	791	15,5	40	2925	27,0
Total	280	279	5101	100	268	10846	100

Table 4. Results of workplaces' noise levels for each sector according to the levels legally established.

	< LEAV		≥ LEAV– < UEVA		≥ UEVA– < ELV		≥ ELV		Total	
Sector	Nº WP	%	Nº WP	%	Nº WP	%	Nº WP	%	Nº WP	%
FD	350	49	154	22	44	6	163	23	711	100
RP	486	53	238	26	68	7	130	14	922	100
CG	360	50	226	31	50	7	83	12	719	100
JW	100	64	33	21	8	5	16	10	157	100
WF	150	19	215	27	102	13	331	41	798	100
MM	169	22	186	25	80	11	318	42	753	100
CH	151	60	58	23	9	4	32	13	250	100
TC	549	69	140	18	24	3	78	10	791	100
Total	2315	45	1250	25	385	8	1151	23	5101	100

Table 5. Results of noise exposure upon workers in each sector according to the values legally established.

	< LEAV		≥ LEAV– < UEVA		≥ UEVA– < ELV		≥ ELV		Total	
Sector	Nº WK	%	Nº WK	%	Nº WK	%	Nº WK	%	Nº WK	%
FD	493	27	572	31	222	12	546	30	1833	100
RP	826	37	715	32	256	12	428	19	2225	100
CG	550	31	716	40	241	13	287	16	1794	100
JW	112	64	30	17	16	9	17	10	175	100
WF	8	1	398	43	127	14	399	43	932	100
MM	0	0	0	0	83	20	332	80	415	100
CH	284	52	190	35	20	4	53	10	547	100
TC	1785	61	522	18	163	6	455	16	2925	100
Total	4058	37	3143	29	1128	10	2517	23	10846	100

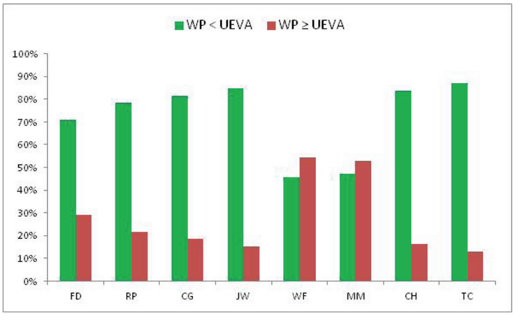

Figure 1. Percentage of workplaces with noise levels lower or upper than 85 dB(A).

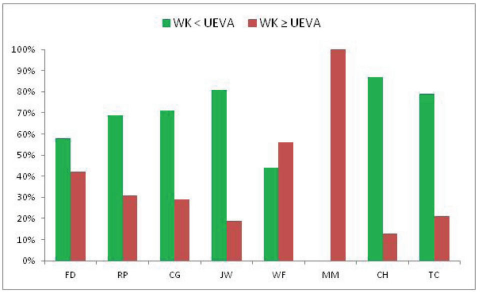

Figure 2. Percentage of workers with noise exposure levels lower or upper than 85 dB(A).

the vast majority of the companies' workplaces (over 70%) have noise levels below 85 dB(A). The sector of the metallurgy and metalworking clearly stands out from the other sectors, because all workers are exposed, daily, to noise levels greater than or equal to 85 dB(A). There are workers who perform activities with noise levels achieving LEAV, for which suitable hearing protectors should also be made available as well as proceed to conduct audiometric tests, according to the periodicity legally established.

To complement the characterization of noise exposure, the effective daily exposure also was

Table 6. Choose/verification of earplugs according to NP EN 458: 2006.

$L_{EX,8h\ effective}$ dB(A)				
< 65	65 a 69	70 a 74	75 a 79	>80
Excessive	Acceptable	Satisfactory	Acceptable	Insufficient

Table 7. Results obtained by analyzing the attenuation of the available earplugs.

Sector	Nº of WK evaluated	Nº of exposed WK	% of exposed WK to noise	% WK exposed < 65	≥ 65–< 70	≥ 70–< 75	≥ 75–< 80	≥ 80
FD	1833	1439	78,5	65 (929)	24 (345)	10 (143)	1 (21)	0 (1)
RP	2225	1406	63,2	64 (898)	20 (281)	12 (174)	3 (44)	1 (9)
CG	1794	1298	72,4	55 (720)	30 (387)	8 (110)	6 (81)	0 (0)
JW	175	128	73,1	97 (124)	3 (4)	0 (0)	0 (0)	0 (0)
WF	415	415	100,0	45 (186)	26 (108)	15 (64)	10 (43)	3 (14)
MM	932	936	100,4	6 (60)	19 (179)	29 (274)	31 (288)	14 (135)
CH	547	284	51,9	51 (144)	34 (96)	12 (35)	2 (6)	1 (3)
TC	2925	2127	72,7	81 (1720)	8 (177)	8 (160)	3 (57)	1 (13)
Total	10846	8033	74,1	59,5 (4781)	19,6 (1577)	12,0 (960)	6,7 (540)	2,2 (175)

analysed, when workers use the earplugs that are available to them (LEX, 8h effect) in order to verify if they provide adequate attenuation.

To verify if the earplugs used by exposed workers in their daily activity provide adequate attenuation, it was attempted to follow the criteria defined in the standard NP EN 458 2006, which are presented in Table 6. Thus, Table 7 shows the percentage of workers which are effectively exposed to different classes of noise values. It appears that, with the exception of the noisiest industries, most workers who use (or should use) earmuffs have at their disposal ear protectors with excessive attenuation.

4 CONCLUSIONS

The sectors of Portuguese industry with higher levels of noise are the metallurgy and metalworking, and wood and furniture. Regarding the noise exposure, the problem is also on the sector of the metallurgy and the metalworking, since it is the sector with the highest percentage of workers exposed to higher noise levels. All workers in this sector are exposed to noise levels equal to or greater than the upper exposure action value, whenever performing working activities in noisy places, all of which are required to wear hearing protection equipment.

In general, it can be conclude that the percentage of workers exposed to high noise levels is higher than the percentage of noisy workplaces. This is because many of them operate both less noisy equipment and other noisier, due to the high versatility of Portuguese industry working activities.

With regard to the attenuation provided by the available earplugs, it is concluded that the vast majority of workers use ear protectors with excessive attenuation. It is suggested greater adequacy of earplugs that could be available for workers, including information and guidelines for their usage, so as to maximize the utilization rate of this personal protection equipment by workers and thereby reduce the risk to their health and the appearance of professional deafness.

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Naturally occurring radioactive materials: A method for assessing the risk of exposure

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ABSTRACT: Naturally Occurring Radioactive Materials (NORM) are materials that are found naturally in the environment and contain radioactive isotopes that can cause negative effects on the health of workers who manipulate them. Present in underground work like mining and tunnel construction in granite zones, these materials are difficult to identify and characterize without appropriate equipment for risk evaluation. The assessing methods were exemplified with a case study applied to the handling and processing of phosphoric rock where one found significant amounts of radioactive isotopes and consequently elevated radon concentrations in enclosed spaces containing these materials.

1 INTRODUCTION

1.1 *Health effects of low doses of ionizing radiation*

It is widely accepted by the scientific community that the risk of negative effects occurs on the health of workers as a result of their exposure to low doses of ionizing radiation. Sometimes this exposure results from the proximity or handling radioactive materials that occur naturally in the environment. It is therefore of utmost importance to identify these radioactive materials, assess their danger to exposed workers and to take measures to protect them against this exposure.

A significant danger to the health of workers who perform activities in underground or poorly ventilated locations results from exposure to high-energy alpha radiation emitted by radioactive dust that can be inhaled, swallowed or absorbed through the skin, capable of destroying the internal tissues not protected by human skin.

Furthermore, the radon present in the air, as result of manipulation of NORM materials containing radium, will generate other radioactive elements in their natural radioactive decay process, namely polonium, bismuth and lead. These radioactive elements can associate with existing dust in the air, and when inhaled, these particles can stick to the airways of the lung. The alpha radiation associated with these radioactive elements can cause irreparable damage to the tissues of the lungs, including the development of cancer. The gamma radiation emitted by radioactive isotopes is capable of causing, directly or indirectly, the formation of ions. The resulting ionization chemically alters the atoms and molecules of living tissues and can cause cell mutations (Nunes, 2010). The gamma radiation emitted by radioactive isotopes in materials also contributes to the total radiation dose received by the worker that can also be significant.

1.2 *Exposure to NORM*

Epidemiological studies on miners indicate an increased incidence of lung cancer from exposure to radon in mines with high radon concentrations (Roscoe et al., 1989). In Ontario uranium mines, miners mortality for lung cancer is significantly higher than expected for the population (observed = 152, expected = 67). The mortality from lung cancer is clearly associated with the exposure of workers to the descendants of short-lived radon (Kusiak et al., 1993).

Smoking and simultaneous exposure to radon are usually associated with a significant increase in the incidence rate of lung cancer, however, epidemiological studies conducted in miners of uranium mines in Beaverlodge indicate that the increased risk is due almost only to the exposure to short-lived radioactive progeny of radon (L'Abbé et al., 1991).

The report EUR 15448 of the European Commission (European Commission, 1995) expressly states that processing and treatment of waste in the phosphate industry are associated with radiation levels of concern for workers and the public. The level of protection for these groups should be more similar to the protection level that corresponds to the state of the art in other industries, including the nuclear industries (Schmidts & Krüppers, 1995).

According to Directive 96/29/EURATOM when carrying out work involving exposure to natural radiation sources which can result in an annual effective dose higher than 1 mSv, these workers should be considered exposed and the requirements of surveillance, monitoring and radiation protection must be applied.

In the case of the processing of phosphoric rock, worker exposure can occur in areas of mining, transportation, loading and unloading of the raw material in the manufacturing industries and in the waste produced and accumulated along the industrial units. Uranium is associated with phosphate and in some mines the ratio is a thousand pounds of phosphoric rock for a pound of uranium (Santa Quitéria's Mine—Brazil).

In 1997, only two phosphate facilities in Louisiana produced 950,000 kg of commercial uranium, which accounted for about 16% of the uranium produced internally in the USA. The Department of Energy (DOE) refers to these facilities as "Nonconventional Uranium Plants" (Connett, 2003).

In the USA during the Cold War, the potential manufacturing of uranium in the phosphate industry was not publicly disclosed, even among workers who were unknowingly exposed to large amounts of radioactive material. It was recently reported to the United States government that in the years 1952 to 1962 in Joliet, Illinois, about 1 million kg of uranium were produced. According to reports published in the local paper, the incidence rates of cancer in former factory workers, especially the "Building 55" where uranium was processed, are abnormally high (Connett, 2003).

The determination of the radioactivity present in NORM can be performed in the laboratory through gamma spectrometry by determining the amount of radioactive nuclides present in samples of the materials under consideration. Detectors which function as transducers of the interaction of gamma radiation with matter can be used to measure external gamma radiation. Electrical impulses are generated and then processed by electronic equipment; intended to, generally, count these impulses for the various ranges of energy present.

2 MATERIALS AND METHODS

2.1 *Exposition in the phosphate industry*

In the manipulation of phosphate rock, like the manipulation of other NORM, the following sources of ionizing radiation capable of causing harm to workers can be identified:

- External radiation range from the raw materials, finished products and wastes containing amounts of radionuclides and higher concentrations to normal activity, namely, the radionuclides ^{238}U, ^{232}Th, ^{235}U or series.
- Alpha radiation from radioactive dust associated with high concentrations of airborne dust caused by the fragmentation of the rock. Existing airborne dust presents a danger to the health of workers due to the possibility of inhalation, ingestion and skin absorption of radioactive elements present in these powders.
- Alpha radiation from radon and its radioactive progeny accumulated in enclosed or poorly ventilated areas and associated with high concentrations of dust in the air spaces. These areas with high concentrations of radon and high levels of dustiness pose a high risk to the health of workers.

The proposed method to assess the risk of exposure to NORM is summarized in the following steps:

1. Identify the NORM, determine its radioactivity and which radioactive isotopes are present in these materials.
2. Know in detail all phases of handling of NORM, identify types of exposure present, both in normal operations or in special cleaning, maintenance and repair of equipment and areas with more significant radiological hazards.
3. Assess worker exposure to external gamma radiation, the inhaled and ingested radioactive dust, and alpha radiation from radon and estimate the total dose of ionizing radiation to which workers may be exposed.
4. Identify workers who may be particularly sensitive to small doses of ionizing radiation.
5. Compare the values obtained with the maximum allowed values indicated in legal standards.
6. Design appropriate measures of prevention and protection of workers.

The methodology presented is applicable, with some adjustments, to all activities where ionizing radiation of natural origin is present, in particular, spas, caves, mines, coal power plants and underground workplaces in general.

2.2 *Determination of radioactivity present in NORM*

The most common radioactivity detectors on the market can be grouped into three types:

1. Gas Detectors ampoules (type Geiger-Mueller)
2. Scintillation detectors
3. Semiconductor detectors

For measuring the concentration of dust in the air from phosphate rock, air suction pumps are used, using the gravimetric method for weighing the deposited dust collection filters.

Various methods may be used to determine the concentration of radon in the air. The choice depends on the available measurement, direct or subsequent reading and of the sampling time of the equipment performing the measurements. Generally, measuring the concentration of radon in a particular environment is based on the count of alpha particles emitted by radon and its short life descendants.

It is important to distinguish whether the method measures the concentration of radon gas or other measured characteristic elements associated with the descendants of radon.

As a function of the sampling time can be classified into the following types:

Instantaneous Methods—The measurements taken from air samples collected over short periods of time, generally between 1 second and 20 minutes. This allows for the use of simple and low cost equipment and rapid results are obtained. However, in the case of point measurements it is necessary to carefully choose the conditions carried out so that the results are statistically representative of the situation we want to characterize. Generally these methods are used to perform initial recognition studies to identify input paths of radon from the ground or to assess the effectiveness of corrective actions taken.

Method for continuous reading—Force the passing of a constant flow of air through a detector suitable for a longer period of time, thereby evaluating it in continuous gas concentration. This allows for the study of the fluctuations in real time concentrations and may associate them with activities that were held throughout the measurement period.

Integrators methods—Usually passive type detectors that collect information about the average concentrations during periods of up to days, weeks or months, with three months as a typical value of integration period more commonly used. It is the most economic and the most widely used method since it is suitable for studies of inspection and recognizing.

The principle of operation and the equipment most commonly used for measuring the radioactive radon and its descendants can be classified as follows:

Cells scintillation consists of metal cylinders, with a clear end, covered on the inside by a uniform layer of zinc sulfide activated with silver, which is sensitive to alpha particles. Air samples are introduced in its interior previously in vacuum, and after reaching the equilibrium measures the number of flashes of light with a photomultiplier tube to determine the concentration of radon in the air.

The Geiger-Mueller counter commonly known as Geiger counter radiation detector is the best known. Consisting of a gas-filled tube with a wire connected to a high voltage (500 to 1000 volts) which collects the electrical current produced by ionization of gas resulting from the incidence of ionizing radiation. It can detect alpha, beta and gamma radiation, not being able to distinguish

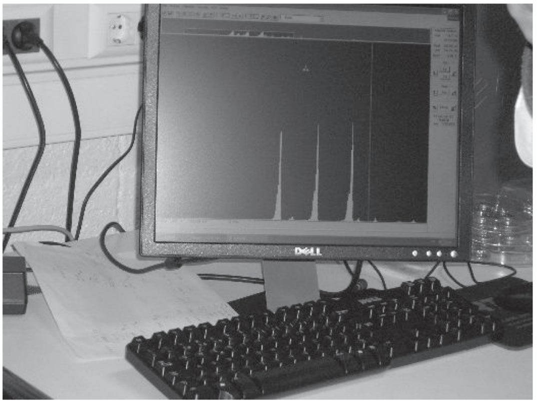

Figure 1. Measuring gamma radiation in a sample of phosphate rock and a result of spectrometry performed in the ITN.

Table 1. Activity of radionuclides present in the phosphate rock on the country of origin.

Country of origin	Measured quantity	Activity of radionuclides present (Bq/kg)			
		^{40}K	^{226}Ra	^{232}Th	^{235}U
Tunisia	Ae—Specific activity	30	381	52	22
	U—Expanded uncertainty	8	21	4	4
	Total	38	402	56	26
Syria	Ae—Specific activity	24	845	15	49
	U—Expanded uncertainty	14	49	4	6
	Total	38	894	19	55
Morocco	Ae—Specific activity	13	1254	19	77
	U—Expanded uncertainty	10	62	3	8
	Total	23	1316	22	85
Senegal	Ae—Specific activity	34	1604	26	106
	U—Expanded uncertainty	14	82	9	14
	Total	48	1686	35	120

between them or measure this energy. Because of these limitations it is used only to estimate the radioactivity present, generally dose and dose rate count ionization. It is a device with high sensitivity and suitable for the measurement of low levels of gamma radiation which is estimated to be present in the workplace to be analyzed (in the order of mSv/h).

Scintillation detectors are devices that emit light when exposed to ionizing radiation. The light is converted into electrical impulses that are processed by electronic circuits.

Sodium iodide is used as one of the detector materials that emits light (scintillation photons) when it absorbs the ionizing radiation. The resulting light is amplified by a photomultiplier.

For accurate measurements of the energy and intensity of x-rays and gamma radiation, solid state (semiconductor) detectors consisting of silicon or germanium cooled to liquid nitrogen temperatures of about –200 ° C to reduce the electronic noise generated by the semiconductor to acceptable levels are used. Silicon detectors are used for measuring X-rays to 20 keV of energy and germanium are used in the range of 10 keV to a few MeV.

For illustrative purposes, Figure 1 shows the Gamma meter existing at ITN (Instituto Tecnológico e Nuclear) where measurements of gamma radiation of phosphate rock were made as well as an identification of the radioactive isotopes by gamma spectrometry.

3 RESULTS AND DISCUSSION

The first point of the proposed methodology is to identify the NORM, determine its radioactivity and which radionuclides are present in these materials. In the case of the present study the radioactivity of the phosphate rock used for the production of agricultural fertilizer has been analyzed. This was carried out by measuring the radiation activity and identification of the radioactive isotopes in samples of phosphate rock used in the manufacture of fertilizers by gamma spectrometry performed in the ITN laboratory. The amount of radioactive isotopes present in phosphate rock samples from Tunisia, Syria, Morocco and Senegal was thus determined and the values shown in Table 1.

The obtained values indicate that the samples of phosphate rock have a significant radiological activity, varying greatly according to their provenance. Phosphate rock from Senegal has, for example, a radioactivity of the radionuclide ^{226}Ra that is over four times that of the Tunisian phosphate rock, a situation which also holds approximately in the case of radionuclide ^{235}U.

Still can be seen that the values measured at ITN for radionuclide ^{226}Ra are fairly consistent with those given in the literature (1554 Bq/kg) found in phosphate industry in the USA for radiological activity from phosphate rock (Birky et al., 1998).

4 CONCLUSIONS

The phosphate rocks analyzed revealed significant levels of radioactivity and with large differences according to their provenance. For example, the phosphate rock from Senegal has a radioactivity caused by the radionuclides ^{226}Ra and ^{235}U more than four times that of the phosphate rock from Tunisia. The presence of ^{226}Ra (the parent radon) in the material analyzed indicated the existence of significant concentrations of radon in indoor spaces where these materials are handled and stored.

This hypothesis was confirmed since levels of radon concentration higher than 400 bq/m^3 associated with high levels of dustiness were found in several locations and thus constitute a significant risk to the health of exposed workers (Estevez, 2012). It is therefore of utmost importance to identify the NORM and evaluate the hazard posed to workers handling them.

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Ergonomic analysis of the shaping post in the injection sector of a footwear industry

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ABSTRACT: The footwear industry has risk factors associated with the development of musculoskeletal disorders. The objective of the study was to perform an ergonomic analysis at the workstation of shaping, in the injection sector of a footwear industry, using the technique Ergonomic Workplace Analysis (EWA). The results allowed the selection of the risk factors requiring intervention: posture, repetitivity and force application. The most demanding tasks were selected for the application of two methods: Strain Index (SI) and Rapid Upper Limb Assessment (RULA). The SI application revealed that the tasks have serious risks of musculoskeletal disorders and the RULA application showed the need of immediate intervention for the task of shaping and soon intervention for hammering. The assessment provided by the two methods can be used in a complementary way to estimate the risk. The introduction of mechanical aids in "shaping" may contribute to a safer task.

1 INTRODUCTION

Throughout the ages, the constant evolution and change of working conditions associated with economic globalization and technological innovation has been evident (Uva *et. al*., 2008). This evolution, often unsustainable, characterized by an increase in workload, effort, flexibility and quality requirements, causes visible effects on the health of the workers, on their psychosocial dimensions and also on their productivity (Afonso, 2013). Among those effects stands out Work-related Musculoskeletal Disorders (WMSDs) that, according to EU-OSHA (2010), became the most common occupational disease worldwide, and are often reported by workers from the EU-27 (Eurofound, 2007).

In Portugal there is few data available about the prevalence of WMSDs, despite they are included in the list of occupational diseases. There is also a legal obligation to notify them (Afonso, 2013). The socioeconomic impact of WMSDs on the different economic sectors, particularly in manufacturing, is still notorious (EC, 2010). In the specific case of footwear industry, there is still a Taylorist/Fordist organization system, which inherent risk factors are recognized as preponderant for the onset of WMSDs by several studies (Afonso, 2013).

The ergonomic job analysis aims to identify and assess the WMSDs risk factors (Serranheira, Lopes, & Uva, 2005). Currently there is a great diversity of evaluation methods (David, 2005). These methods and tools of ergonomic analysis show the risk level to which the worker is subject when performing a given activity. Through them one can diagnose situations that impair the workers health, awkward postures and repetitive movements (Shida & Benedict, 2012).

The main objective of the study is to perform an ergonomic analysis of the shaping workstation, on the injection sector of a footwear industry, using the generalist technique Ergonomic Workplace Analysis (EWA). Other objectives of the study are: (1) characterize the WMSDs symptoms by the application of a questionnaire; (2) depending on the results obtained both from the questionnaires and from EWA analysis, verify the need for application of more specific methods of ergonomic analysis.

2 METHODOLOGY

A strategy divided into 4 stages was defined to carry out the study: (1) characterization of the area and sample population (2) selection of the workstation; (3) evaluation of symptoms associated with WMSDs; (4) application of EWA and in case of being necessary, selection and application of methods of expert ergonomic analysis to assess the risk.

2.1 *Characterization of study population*

For the characterization of the study population and workstation, was created and applied one diagnostic sheet. Other information was also collected both through direct observation and through interviews with the Health and Safety professional of the company.

2.2 *Selection of the job*

The selection of the workstation was made based on direct interviews and systematic observation of all workstations and also through the collection of information about WMSDs complaints reported by workers.

2.3 *Assessment of symptoms associated with musculoskeletal complaints*

To confirm the WMSDs complaints, the translated and validated version of the Nordic Musculoskeletal Questionnaire, by Mesquita *et. al.* (2010), was applied. The questionnaire was applied to workers belonging to the workstation under study. The treatment of the questionnaires was conducted through descriptive statistics of the Excel 2013.

2.4 *Application of EWA*

Once indicators of potential ergonomic problems were detected, the application of the generalist technique EWA (FIOH, 1989), was initiated. In a first step, a systematic description of the workstation tasks was done and subsequently was established the duty cycle and the elementary tasks that compose it.

The information collected in situ was recorded in the checklist created for the purpose, which includes the points provided in the EWA Guide. The information was also gathered through direct observations, video footage, photographs and structured interviews to the worker.

To obtain the subjective worker evaluation was performed an interview focused on each EWA item using the qualitative scale: good (++), weak (+), poor (–) or very bad (––).

Subsequent to the application of the EWA technique, if it was identified the need for intervention in the workstation, more specific methods of ergonomic analysis were used.

2.4.1 *Selection of the appropriate methods and techniques of ergonomic analysis*

The risk factors of WMSDs identified through EWA method, complemented with the WMSDs symptomatology reported, allowed to select the most demanding tasks, namely: shaping footwear with a shoehorn and hammering with a steel hammer.

In this sense, to specifically assess the risk of WMSDs in the selected tasks, and meet all the justifications already described, two evaluation methods were selected: RULA—Rapid Upper Limb Assessment, according McAtamney & Corlett (1993) for the evaluation of upper limbs, wrist, neck, trunk and lower extremities; and SI—Strain Index, proposed by Moore and Garg (1995) for the evaluation of the distal parts of the upper limbs.

These two methods assess identical anatomical regions and according to Serranheira & Uva (2006), they are indicated to the study of the upper limbs and distal upper limbs. However, the RULA method also assesses anatomical regions that are not covered in SI, but that are relevant for the tasks under study, such as the trunk. For the applying of the methods of ergonomic analysis, extreme postures were selected for each task, ie, those rated as more painful by the workers.

3 ANALYSIS AND DISCUSSION OF RESULTS

3.1 *Characterization of study population*

The study was conducted in a footwear industry, namely in the injection sector 4. The company has 185 workers, 16 exclusively in the injection 4 sector. The company works 16.5 h/day, in two shifts: 06 h–14 h and 14 h–22 h.

3.2 *Selection of the workstation*

The interviews with the Health and Safety professional revealed the major complaints reported by the workers. This analysis was important in choosing the job of shaping footwear industry in injection 4. The work cycle in shaping footwear encompasses the following tasks: (1) Choose the pair of shoes in the cart; (2) Transporting the footwear to the PT; (3) Attach the way the tabletop support; (4) Shaping the shoes with the aid of a shoehorn (5) Hammering the shoes with the help of a steel hammer and hit the shoe on the workbench; (6) tying of laces (7) Repeat steps (3) to (6); (8) Passing pair of shoes for the following position; (9) Walk toward the basket for selection of new pair of shoes.

Regarding to the workstation selected, there are two male workers with an average age of 45 ± 4 years, which work in the company for 24 ± 4 years on average. They have a history of wrist injuries and surgical interventions. These have been decisive characteristics for selecting this workstation. Additionally, it was taken into consideration that the job of shaping shoes requires evident physical strength, repeatability, and awkward postures, which are considered risk factors for WMSDs according to Serranheira & Uva (2006).

3.3 *Assessment of symptoms associated with musculoskeletal injuries*

The analysis of the questionnaires showed that problems associated with wrists/hands were reported by 100% of the respondents. Note that the respondents reported symptoms in the wrists/hands that underwent surgical intervention, and this expression was evident both in the last 12 months, and 7 days, with an average intensity of pain of 7.5 (greater intensity of manifested pain). The problems reported at the level of the wrists/hands may be intrinsically related to the nature of the task, more specifically: physical demands, required effort and repetitiveness of the task. This questionnaire allowed to confirm the reported complaints and the direct observational analysis for the tasks with higher requirements.

3.4 *Application of the general technique EWA*

For better characterization of the shaping station, the duty cycle was defined, decomposed into elementary tasks that allowed direct observation and facilitate the application of the technique EWA. Through the analyst's assessment it was found to achieve higher scores on the following items: workspace, postures and movements, repetitive work and noise. With respect to the workspace, it was aggravated because of several aspects: the height of the working plane is higher than the elbow height; there is not enough legroom (depth); lack of free space behind the workers; excessive requirement of force (shaping and hammering); and high sound pressure levels. With regard to the postures and movements, worsening occurred due to the need to apply considerable force with the arms, executing fast movements, the lifting of the arms above shoulder level and the extreme lateral tilt of the trunk required in some tasks. The repeatability of work achieved a score of 4 for a period of 1.10 minute per cycle. Finally, the daily noise exposure at that workstation was $L_{EX,\,8h} = 91$ dB (A).

Regarding the evaluation of the employee, some differences were encountered. The highest scores were verified for: posture and movements, accident risk, work content, restrictiveness of labor, difficulty in making decisions and repetitiveness of work. Although there are converging evaluations, such as the posture and movements and repetitiveness of work, the divergences observed in other items could be related to the importance and relevance of that workstation for the worker, or even unawareness and/or lack of training on risk factors for the development of WMSDs.

The results obtained by EWA technique allowed to identify risk factors for WMSDs such as posture, repetition and force application. EWA also enabled to identify situations needing improvement, namely: (1) the workspace, increasing the feet area and the space behind the worker; (2) adjust the height of the bench at the workstation, avoid lifting the arms above shoulder level for the application of force; (3) decrease noise levels; (4) train and inform the workers about WMSDs major risk factors, its origin and how to prevent them.

3.5 *Application of the Strain Index (SI) method*

The application of SI showed that both tasks have serious risk of Upper Limbs Musculoskeletal Disorders (WRULDs), although the shaping task presents a higher score. In the specific case of the shaping task, for the risk reduction it would be necessary to intervene, essentially on the intensity of effort and on the posture of the hand/wrist, using for example, a mechanical aid for pressing the shoe into the form. The introduction of this measure would eliminate the effort and also the intensity of stance. Combined with the eliminating of the task of hammering it could be possible to obtain a more secure job.

3.6 *Application of RULA method*

The application of RULA method was based on the analysis of the upper limbs and wrist, followed by the analysis of the neck, trunk and lower limbs. Considering the side which found the application of force, that is, right side in the task of hammering and left the task of shaping. The upper limbs which apply force were analyzed, namely the right upper limb for the task of hammering and the left upper limb for the task of shaping.

A rating of 7 was obtained on the task of shaping, which is associated with the suggestion of "immediate action and research is required" and the task of hammering obtained the rating of 5, which is associated with the "careful investigation is needed and changes are soon to be introduced". Overall, the application of RULA method, for the two tasks, were influenced by postural analysis of the upper limb and wrist in the final risk score. It was also noted the important contribution of the postural analysis of the neck, trunk and lower extremities, mainly in the task of shaping. In this task, there is a sharp side slope of the trunk that is presented as an extreme posture. The RULA method just considers an aggravation of "+1", regardless of the angle of the slope. According to Serranheira & Uva (2006), in RULA method, the possibilities for postural assessment may be inadequate in situations where "extreme positions" are identified or outside the intersegment angles of comfort. Nevertheless, the use of "extreme position" observed in the study, can also, according to the same authors, imply error by not taking into account the respective time in this posture. Considering the results, it appears that the tasks of the forming station require urgent improvements to reduce the risk of developing WMSDs.

In addition to the recommendations already mentioned throughout the study, it is recommended to consider adequate break times, corporate wellness sessions and implementation of rotating to request different muscle groups.

3.7 *Comparison of RULA and Strain Index methods*

By the obtained results one can verify a certain discrepancy in the risk level obtained through SI and RULA methods, for the same tasks. Similar discrepant results were also obtained in other studies, as is the case of Serranheira & Uva (2006).

The disagreement in the assessment can be justified by the fact that the SI method evaluates only the distal part of the upper limbs, and the RULA method evaluates upper limbs, neck, trunk and lower limbs. According to Serranheira & Uva (2006), the RULA method primarily evaluates postural aspects in the performance of the activity, and for jobs/tasks where there is more strength application these authors indicated that the SI method should be used.

Besides the aspects mentioned, the SI method also contemplates the duration of the effort and the daily duration of the task unlike RULA method. In terms of effort evaluation, the SI facilitates the analysis through apparent effort, in the impossibility of measuring the weight or force needed to perform the task, The RULA method considers static and dynamic work unlike SI. According Serranheira & Uva (2006) the final outcome of the wrist and upper limb obtained by the RULA method, can be interpreted only at the level of the upper limbs, making a direct comparison with the SI method possible.

4 CONCLUSION

The ergonomic analysis has shown the existence of symptoms associated with WMSDs in the workstation under study, and, by applying the EWA methodology it was possible to identify risk factors including: posture, repetition and force application. The tasks of hammering and shaping are the most painful in an ergonomic point of view.

The results obtained by application of SI and RULA methods demonstrated that the tasks have serious risk of developing WMSDs and immediate intervention is necessary for the task of shaping and for the task of hammering intervention is also mandatory. By introducing a mechanical assistance to the task of shaping, it is possible to reduce the risk and therefore, it would be possible to classify the task as safe. The hammering task should be eliminated.

The differences found between methods, result in complementarity information, so future research in this area could lead to the development of a tool that considers the gains of each method, providing a better estimation of the risk of WMSDs.

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Eye blinking as an indicator of fatigue and mental load—a systematic review

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ABSTRACT: Eye blinking has been documented as a measure related to cognition and as an indicator of fatigue. The aim of the present study was to verify the influence of fatigue and/or mental load in eye blinking and the monitoring techniques used. The search was performed over 62 databases through integrated and metasearch methods. A total number of 2253 records were identified and 21 studies were included in the review. These 21 studies refer eye blinking detection. 13 of the 21 included studies examine eye blinking and fatigue; 8 of the 21 included studies examine eye blinking and mental load. The included studies used EEG, EOG, eye tracking and video camera systems as monitoring techniques. The relation of environmental climatic conditions and the use of eye blinking as an indicator are not usually investigated. From all these studies, evidences have revealed that eye blinking is a useful fatigue and mental load indicator.

1 INTRODUCTION

The interest in the working conditions and efficiency of the labor force in various contexts has been increasing lately partly due to the high stress levels imposed on individuals. Loss of alertness associated with fatigue is a concern for any organization or system that requires reliable sustained control and/or monitoring by human operators for an efficient and safe operation (Van Orden et al., 2000), thus it is important to monitor fatigue. The use of Electroencephalographic Activity (EEG) (Makeig and Jung, 1996), Electrooculographic (EOG) techniques (McGregor and Stern, 1996), eye activity measures (Stern et al., 1984) and task performance (Wierwille et al., 1994) have been proposed as methods for objective alertness and fatigue monitoring. Eye blinking is a psychophysiological measure connected to cognition that has been proposed to assess mental fatigue (Stern et al., 1984). Eye blinking frequency depends on environmental conditions (Wolkoff et al., 2005), such as temperature and Relative Humidity (RH) and also lighting conditions (Clapp and Hively, 1997; Wolkoff and Kjærgaard, 2007). Some authors say that high RH reduces the eye blinking frequency (Kay et al., 1990; Tsubota et al., 1997). Other studies suggests that RH below 20% may have negative effects on the eye blinking rate (Clements-Croome, D., 2008; Rozanova et al., 2009), and directly affect tear film stability. Here are summarized the results of the undertaken systematic review of the published literature on the influence of fatigue and/or mental load in eye blinking and the related monitoring techniques used.

2 METHODOLOGY

Preferred Reporting Items For Systematic Reviews And Meta-Analyses (PRISMA) criteria were applied for this review (PLoS_Medicine, 2009). The initial approach comprised an integrated meta-analysis search on the SDI database (*Serviço de Documentação e Informação FEUP*) for each type of item/resource on the 34 associated scientific magazines and on 28 databases namely Informaworld (Taylor and Francis), Scopus, Web of Science, Springer, IEEE Xplore, PubMed, Science Direct. The reports selection process had two distinct phases.

Initially, by defining key-words aiming at limiting the search to the rather specific theme under study, focusing on words such as, "Eye blink", "EEG", "Blink", "Artifact", "Rate", "Fatigue", "Frequency", "Blink frequency", "Video", "Image capture", "Environmental conditions", "Mental load", "Temperature", "Relative Humidity", which in groups in the databases with the appropriate Boolean operator 'AND'. This way a total of 2111 studies were identified. A total number of 904 duplicated studies obtained in different databases were removed. Next, the most interesting results were identified by removing: all the 800 studies prior to 2010 in order to focus on the most recent studies; 237 studies whose titles were considered not appropriate; 130 studies whose abstracts appeared to be non-relevant; 3 studies written in languages other than English. On the resulting 37 studies the key search words (namely "Cognitive load", "Video display terminal", "Fatigue detection", "EOG", "High frame rate camera", "High-speed camera" and "Image processing") were intersected with the initially defined key-word "Eye blink" obtaining 119 studies. On these studies, 25 were duplicated, 64 were prior to 2010, 2 had inappropriate titles and 1 had a non-relevant abstract, and were removed resulting in 27 selected studies. Together with the initially 37 selected, these resulted in 64 studies with full text that went then through a careful analysis for the application of the eligibility criteria. Finally, the eligible studies were those that simultaneously dealt with mental fatigue and/or mental load, eye blinking, EEG or EOG analysis and also those that dealt with mental fatigue and/or mental load related to eye blinking, respectively 6 plus 7 studies summing up to 13 studies.

The second selection phase consisted on the examination of the referred 13 studies bibliographic references allowing the selection of 23 studies probably interesting for the present study based on the relation of their title with eye blinking. Based on the same criteria as above (except the prior 2010 criteria) only 8 studies were selected. Together with the previously chosen 13 completed a total of 21 studies. Selection details of all relevant articles are shown in Figure 1.

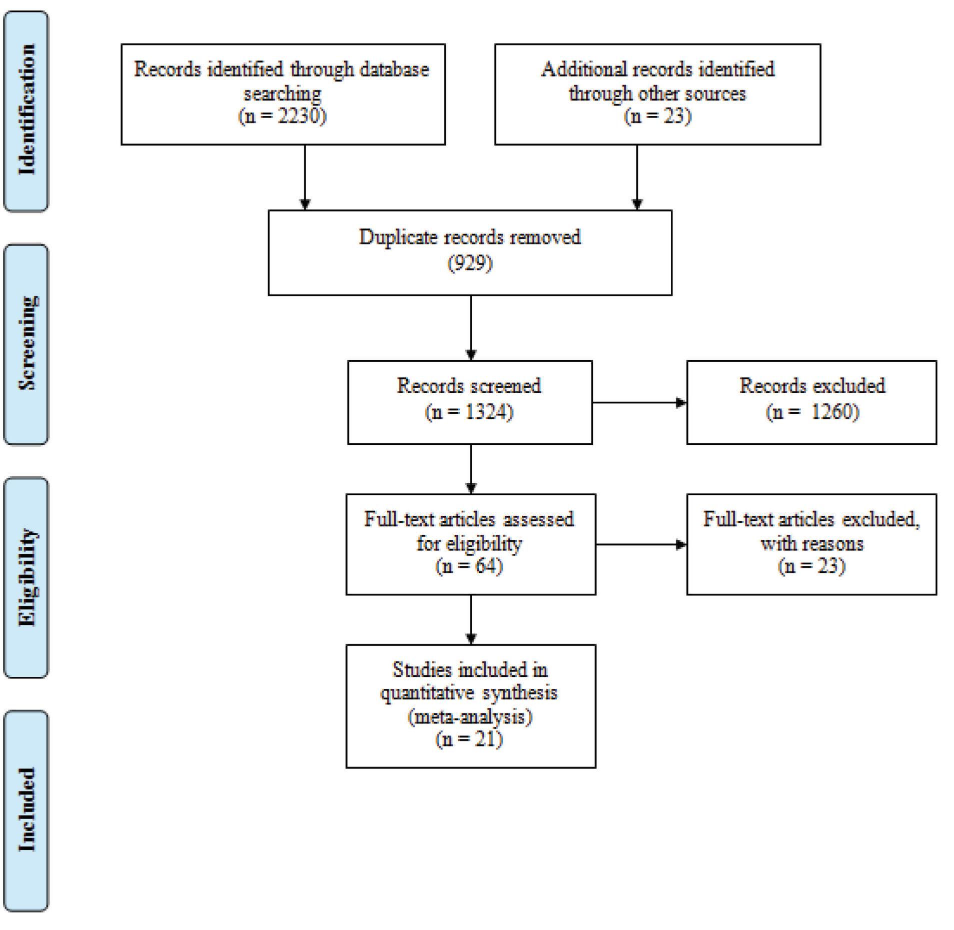

Figure 1. Information flow through the different phases of the systematic review.

3 RESULTS

Adhering to PRISMA guidelines, studies meeting the inclusion criteria were critically appraised and summarized in evidence Tables (Table 1, Table 2 and Table 3). The selected 21 studies referred eye blinking detection. 13 of the 21 included studies examined eye blinking and fatigue; 8 of 21 included studies examined eye blinking and mental load. Only 1 of the included studies used EEG as main technique, 5 used EOG and 4 used both of these techniques. 6 of the included studies have also used eye tracking techniques and 4 used video camera systems. It is to notice that the use of EOG is more common for studies of eye blinking and its relation with fatigue or cognitive response is in effect. Those articles that used EEG did not reject eye blinking as an ocular artifact. It was verified that only one study included control of temperature (Morris & Miller, 1996), which reveals the generic lack of information on the environmental conditions in which the studies took place. Environmental conditions are an important factor in eye blinking frequency (Clapp and Hively, 1997; Wolkoff and Kjærgaard, 2007) and by not controlling these variables there might be underlying reasons for the results It was included an article review (Stern et al., 1994) due to its relevance on the present study. Many studies used eye blinking s as an indicator in various different contexts aiming to monitoring the worker performance and fatigue level namely while driving vehicles (Van Orden et al., 2000; Recarte et al., 2008; Schleicher et al., 2008; Kim et al., 2011; Benedetto et al., 2011; Borghini et al., 2012; Hsieh and Tai, 2013), flying planes (Stern et al., 1994; Wilson et al., 1994; Morris and Miller, 1996), flight traffic control (McIntire et al., 2014), on medical interventions (Jiang et al., 2013, Zheng et al., 2012). There also appears to be an inverse relation between difficulty of task and eye blinking frequency (Caffier et al., 2003; Wolkoff et al., 2005; Wilson et al., 1994; Zheng et al., 2012; Wascher et al., 2014). It is to be noted that each subject has a specific eye blinking pattern with intra—and inter-individual variability of varying degree (Stern et al., 1994; Caffier et al., 2003; Schleicher et al., 2008; Benedetto et al., 2010).

Table 1. Summary of studies descriptions.

Authors	Country	Population size	Test duration	Demographic data	Age (years)
Benedetto et al., 2011	ITA	15	–	20/20 vision or corrected to normal	31 ± 4
Borghini et al., 2012	BEL	–	2 days, 2pm–5pm	Experienced drivers	–
Caffier et al., 2003	GER	60	20 min	Healthy	31.9
Chen and Epps, 2013	AUS	22	2 h	–	–
Fukuda et al., 2005	USA	8	60 min	Undergraduate students	20 ± 2
Holland and Tarlow, 1972	USA	25	–	Undergraduate students	18–21
Hsieh & Tai, 2013	TPE	30	–	–	–
Jiang et al., 2013	CAN	5	–	–	–
Kim et al., 2011	KR	2	20 min	–	–
Kurylyak et al., 2012	ITA	5	10 am; 12 pm	–	–
McIntire et al., 2014	USA	19	40 min	Military and civilian; healthy	26.89
Morris & Miller, 1996	USA	10	4,5 h	20/20 vision without contact lenses; healthy; trained Air Force Pilots	36.1
Nakano et al., 2009	KH	18	–	Healthy, 20/20 vision or corrected	22–31
Pedrotti, et al., 2011	ITA	24	30 min	Undergraduate students	26 ± 4
Recarte et al., 2008	ES	29	–	Undergraduate students	18–23
Schleicher et al., 2008	GER	138	2 h	–	33.4 ± 11.5
Stern et al., 1994	USA	–	–	–	–
Van Orden et al., 2000	USA	29	2 h	–	23.1
Wascher et al., 2013	GER	10	160 min	Healthy, 20/20 vision or corrected	23.5
Wilson et al., 1994	USA	10	–	F-4 Pilots, with experience	–
Zheng et al., 2012	CA	23	–	Surgeons with experience	34.8 ± 9.3

Table 2. Summary of all studies that used EEG or EOG analysis and its characteristics.

Authors	EEG/EOG analysis	Sample frequency	Filter	Analyzed channels	Rhythm brain waves
Borghini et al., 2012	EEG	200 Hz	40 Hz (low-pass); 1 Hz (high-pass)	61 channels (F3, Fz, F4, P3, Pz F3/P3, F4/P4, Fz/Pz)	Alpha, theta
Fukuda et al., 2005	EOG	–	100 Hz (low-pass); 60 Hz.	–	–
Hsieh & Tai, 2013	EOG	1 kHz	–	Fp1 or Fp2	Alpha, beta, delta, theta
Morris & Miller, 1996	EOG	100 Hz	0.05–50 Hz	2 channels	–
Nakano et al., 2009	EOG	100 Hz	–	–	–
Pedrotti et al., 2011	EEG + EOG	1000 Hz	–	32 channels + 4 channels	–
Schleicher et al., 2008	EOG	–	–	–	Theta, delta, alpha
Van Orden et al., 2000	EEG + EOG	60 Hz	–	–	–
Wascher et al., 2013	EEG + EOG	1000/250 Hz	0.5 Hz (high-pass); 30 Hz (low-pass)	28 channels + channels	Theta, alpha
Wilson et al., 1994	EEG + EOG	1000/1600 Hz	16 Hz (low-pass)		–

Table 3. Study of fatigue or mental load, eye blink frequency and visual capture.

Authors	Fatigue/ mental load	Eye blink frequency (eye blink/min)	Capture visual/device
Benedetto et al., 2011	Mental load	58; 32; 38; 46; 43; 70	Eyetracker
Borghini et al., 2012	Fatigue	–	–
Caffier et al., 2003	Fatigue	16.33 ± 1.64 (alert); 15.8 1.79 (drowsiness)	Yes
Chen and Epps, 2013	Mental load	–	2 webcams with 2 LED
Fukuda et al., 2005	Mental load	–	Video camera
Holland and Tarlow, 1972	Mental load	19.38 (correct tests); 23.33 (incorrect tests)	–
Hsieh & Tai, 2013	Fatigue	–	Small camera CCD
Jiang et al., 2013	Mental load	6.9 (±3.2)	2mini-cameras; eye tracker
Kim et al., 2011	Fatigue	Subject1: 2D-26.1;3d- 20.2; 3 Dplus-19.55; Subject 2: 2D-13.1; 3D-9.85; 3D- 13.37	Infrared video camera
Kurylyak et al., 2012	Fatigue	–	Web camera HP
McIntire et al. 2014	Fatigue	–	Eye-Com; 2 infra cameras
Morris & Miller, 1996	Fatigue	–	–
Nakano et al., 2009	Fatigue	16.6 (Video 1); 24.2 (Rest); 15.1/16.6/18.2 (repetition) 20.0 (Video 2);	Yes
Pedrotti, et al., 2011	Fatigue	–	Eyetracker camera
Recarte et al., 2008	Mental load	42.66 (cognitive task)	Video camera
Schleicher et al., 2008	Fatigue	–	Video camera
Stern et al., 1994	Fatigue	–	–
Van Orden et al., 2000	Fatigue	–	Video camera; eye tracker
Wascher et al., 2013	Mental load	25.1 ± 4.68 (Physical task); 16.43 ± 4.18 (Cognitive task); 14.20 ± 4.44 (Rest)	–
Wilson et al., 1994	Fatigue	10.7 ± 3.7	
Zheng et al., 2012	Mental load	6.4 ± 5.8	Eyetracker; 2 cameras

4 FINAL CONCLUSIONS

The results of the present review show the application of eye blinking as a feasible indicator in order to assessing human fatigue and/or mental load. It is also used as a reliable predictor in different study areas, e.g. driving vehicles, flying planes, air traffic control, medical procedures, which can help monitoring task performance and safety operations. It was also concluded that the study of climatic environmental conditions, an important factor in eye blinking frequency, and the simultaneously use of eye blinking as an indicator of fatigue are generically not investigated. There also appears to be an intra– and inter-individual variability as well as an inverse relation between the task difficulty and eye blinking frequency, being the blinking pattern a function of task duration.

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Assessment of the level of noise in gyms for sports in a college in the city of Curitiba

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ABSTRACT: The aim of this study was to verify whether the noise level found in gyms of school sports practice lies within the levels established by the Brazilian regulatory standard. For this analysis two gyms considered as major generators of noise were selected, and the sample was composed by two teachers of technical procedures for volleyball and basketball. For the measurement of occupational noise, we used a dosimeter of the instrutherm brand, dos 500 model, and the collection was performed for one hour lesson in each gym with classes composed of thirty students. The knowledge of these responses, and the dose designed for eight hours of occupational exposure bring an important indicator of the risk of teachers exposed to these environments, and suggestions arise for the implementation of new security policies and prevention in the educational environment.

1 INTRODUCTION

Ergonomics is a field which seeks to adapt the work to men, considering psychosocial aspects, and one of the study focuses is the identification of the risks that may jeopardize the health of the workers. Considering the physical risks, the noises are present in many work activities, and the professionals in turn are being poorly oriented on the levels to which they are exposed and how to take preventive measures. The sound is considered a complex mixture of different vibrations, and it can be measured on a logarithmic scale whose unit is the decibel (dB). The level of discomfort depends on the level of intensity of the noise, which can interfere directly in the execution of the job and cause irreversible damage to the workers (Iida 2005).

In Brazil, the NR-15 is the standard that defines maximum exposure levels without the need for the use of Personal Protective Equipment (PPE) or Collective Protective Equipment (CPE) and it states that a continuous noise of 85 dB is the maximum tolerated for an exposition for 8 hours of a daily work journey. Above these values, the exposure time should be reduced, or control measures must be adopted, because thus it begins to present risks to workers (Lombardi et al. 2011).

In addition to the damage to the auditory system, high sound pressure levels undertake much intelligibility of speech, causing the broadcaster to expand the volume of his/her voice considerably, intensifying his/her efforts in order to be understood. This whole process of intensification of the voice may be causing harmful effects to the vocal health (Ribeiro et al. 2010).

This situation has been drawing attention to the teaching activity, in which teachers should overcome the many competitive noises to provide their classes and be clear, requiring greater vocal effort and triggering vocal changes (Almeida Filho et al. 2012). These noise levels depend on individual exposure level, type of noise, kind of exposure, and local characteristics (Quintilio et al. 2013), as for example the material that comprises the rooms, the geometry, the materials used in the construction, and the sound environment around these buildings (Almeida Filho et al. 2012).

Studies show that the presence of agents that are toxic or injure the ears can cause Noise-Induced Hearing Loss (NIHL), which makes the periodic monitoring of the levels of environmental noise for a mapping of the areas of greatest risk relevant.

Thus, the present study aims at investigating the levels of noise emissions in school gyms so that preventive measures can be prescribed.

2 MATERIALS AND METHODS

The study is characterized as descriptive, because it aims at establishing characteristics of the study population and relationship between its variables (Gil 2010).

The School evaluated is part of a federal public education network of the city of Curitiba—Paraná state, Brazil, covering from the 6th year of Elementary School to the 3rd year of High School.

Regarding the framework for the practice of physical activity, the school has two gymnasiums.

The Basketball gymnasium is 575.00 m^2 of built area and 594 m^2 of covered area; it is a masonry building, containing two rooms for material storage and male and female toilets. Now, the Volleyball gymnasium is a metal and masonry construction with 556.00 m^2 of constructed area and 608.00 m^2 of covered area, containing accommodation for delegations, staff room and male and female toilets.

Two teachers who act directly in these two workplaces participated in this research. For the assessment of occupational noise it was used a dosimeter of the Instrutherm brand, DOS-500 model, strictly calibrated by the CAL 3000 calibrator device, from the same vendor, and both with calibration certificate. Following the recommendations of NR-15 (Brasil 1978a), and considering the workplace as a continuous noise generator, the dosimeter was aet up for an "A" compensation circuit, "SLOW" response circuit, due to the characteristics of the noise in the environment; rate of Exchange (duplicity) set to "q = 5" and integration threshold at "80 dB (A)."

The tolerance limits displayed in the NR-15 are presented in Table 1.

During data collection, the dosimeter was coupled to the teachers' pants tracksuit, and the sensor (microphone), next to his ear, according to NR-15 (Brasil 1978a). The microphone had foam in order to decrease the effect of the wind on the measurements of sound pressure levels.

After an hour of work of each faculty member in the two gymnasiums studied, each with 30 students in activity, the data collected have been compiled, and the dose of noise dosimeter was supplied, (Leq) in dB (A) and the dose value in percentage (%), as well as the designed dose (Leq) for 08:00 of occupational exposure. The equivalent sound pressure level (Leq) is the weighted noise level over the measuring period, i.e. the continuous sound pressure level.

Table 1. Tolerance limits for continuous or intermittent noise (NR-15 Annex 1).

Level of noise dB (A)	Maximum allowable daily exposure
85	8 hours
86	7 hours
87	6 hours
88	5 hours
89	4 hours 30 minutes
90	4 hours
91	3 hours 30 minutes
92	3 hours
93	2 hours 40 minutes
94	2 hours 15 minutes

The noise assessment was held in two locations used for the practice of physical activity, the basketball gymnasium and the volleyball gymnasium, considered as a great source of continuous noise by the two teachers who work in two shifts of daily work.

3 RESULTS

The teachers studied work with the School for eighteen years directly in the gyms assessed with the modalities of volleyball and basketball according to the school curriculum, as well as in extracurricular representative sports teams training in Collegiate Games.

When data collection began, the teachers reported that after delivering their classes they would feel a sore throat, sometimes headache, and feit quite tired after the end of the work shift. The volleyball teacher had already established hearing loss in mild degree, in previous audiometry tests.

The teachers never held a noise dosimetry in their work environments and are unaware of the values to which they are exposed to on a daily basis, and they also were not advised that the occupational noise can be harmful to their health, and that they are regulated by the Ministry of Labor and Employment.

The teacher evaluated in the basketball gym was exposed to noise levels between the values of 67.9 dBA to 96.1 dBA, remaining 20 minutes above 85 dBA (Table 2), during a class of sixty minutes (33.33% of the time).

The assessment of the level of noise in the basketball gymnasium shows us that, for a daily workday of 8 hours, the limit of noise exposure is within the standards of the regulatory standard, which establishes the maximum permissible daily exposure according to the reference values given in Table 1.

However, it is important to note that noise levels above 80 dB require taking action measures according to the NR-6, which states that the worker should use personal protective equipment (PPE), i.e. a hearing protection (Brasil 1978b). The basketball teacher reported that the height of the

Table 2. Noise level analysis of Teacher A in Basketball gymnasium.

Exposure time	Dose value	Real time Leq	Leq projected for 8 h
20 minutes	11.01	69.0	83.61

Table 3. Noise level analysis of Teacher B in Volleyball gymnasium.

Exposure time	Dose value	Real time Leq	Leq projected for 8 h
26 minutes	13.34	70.4	93,76

gymnasium should be higher—the site is eight feet tall—and he believes that it can intensify the noise during classes, as well as the scarce space of movement outside of court.

According to the teacher, the optimum situation would be that the gym was built with a minimum of twelve feet tall. However, due to the fact that it is a school founded in 1958, probably there was no concern at the time with ergonomic environmental factors.

The dosimetry results for volleyball gym show us an index even higher for a journey of eight hours per day. The teacher remained exposed between the values of 67.1 dBA to 100 dBA, remaining thus 26 minutes above 85 dBA (43.33% of the time), in a lesson with duration of 60 minutes.

The same way that the volleyball teacher, the basketball teacher also stresses the low height of the gym as an important factor of intensification of noises in his/her classes. The gym was originally an amphitheater, and was subsequently adapted for sports activities. The height displayed is also eight feet, and for the sport practiced there, it should be twice as high, i.e. sixteen meters.

This case is even more troubling than the last one, because the teacher already mentioned hearing loss, and thus remains under the risk of noise without protection.

Exposure control measures to high levels of noise should be started when the exposition reaches the level of action, i.e. 80 dBA, in order to minimize the probability that exposures to environmental agents surpass the limits established (Brasil 1994).

4 DISCUSSION

The environmental conditions are one of the variables that have been featured in publications, due to the damage that they can bring to the health of the workers and the loss of productivity when performing labor activities in inappropriate locations (Farias & Nascimento 2012). Therefore, in Brazil there are several regulations which seek to protect the health of the exposed workers. However, it is still common to find sites that have never been monitored, and workers exposed to inadequate levels of noise, especially in schools. In this research, the average level of volleyball gym noise exceeded the values stipulated by the regulatory standard, undermining the teaching conditions of the teacher in their workdays, since he/she remains in the workplace for eight hours a day.

Because of that, he/she has vocal discomfort and feels tired, corroborating with the study conducted in two classrooms of the 5th and 6th year in the city of Coimbra, Portugal (Ferreira 2010), in which the teachers surveyed expressed the same discomforts after delivering their lectures.

As for the basketball teacher, action measures should have been adopted in accordance with the NR-6. The lack of adoption of measures also justifies the tiredness reported after the end of their lectures, as well as vocal distress, being the use of Personal Protective Equipment (PPE), such as the ear plugs and the microphone, important preventive measures to be adopted.

According to the responses of the teachers, it was found that they feel the damage caused by noise without however demonstrating concern about its prevention. They are also unaware that there are rules governing this matter, as presented in the survey conducted in a private school in Viçosa, Minas Gerais, in 2010, in which the teachers were also unaware on the daily exposure limits to noise according to an assessment on the environmental noise (Ribeiro et al. 2010).

Teachers who reported working in noisy environments (Butler, Hammond & Gray 2011) presented more change in vocal intensity, corroborating with the findings of the other two studies (Macedo et al. 2012; Servilha & Ruela 2010), in which the noises in the school environment associated with an unsatisfactory acoustics can be considered a risk for vocal issues.

By knowing these risks, policies can be implemented in order to close or minimize such risks within the workplace (Butler, Hammond & Gray 2011).

Prevention programs are intended to establish some basic safety rules in the workplace. On the other hand, an Occupational Risk Prevention Program does not appear to be part of the agenda of our schools, as it systematically occurs in business organizations.

This recklessness may occur due to the misunderstanding that the teachers in the school environment are also workers. Meanwhile, the high and frequent noises affect teachers' general health, as well as hearing and vocal health, and interfere with the quality of teaching (Jaroszewski, Zeigelboim & Lacerda 2007).

5 CONCLUSION

The results of this study showed agents that are toxic or injure the ears to professionals who work in these gyms daily for more than eighteen years; as well as the ignorance on their part on maximum levels of daily exposure. In addition, it shows that the regulatory standards are not being applied.

Assessing noise emission levels in school gyms in the practice of physical activities is an important mechanism for the implementation of public policies on occupational diseases prevention professionals submitted to environments that have higher risk of noise. That is why there are standards and for the same reason they should be applied.

We believe that this study might contribute to physical educators regarding the prevention and control of Noise-Induced Hearing Loss (NIHL), as well as vocal problems within the scope of employment. More than promoting preventive campaigns together with teachers, there is a need to invest in measures that will promote a healthy working environment to its employees.

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Ergonomics applied to the cycling with the utilization of two protocols for the saddle height adjust

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ABSTRACT: The objective of this survey was verify the impact of the saddle height adjust in the system men-bicycle in the low back pain of cyclists with the support of electromyography. It was done a survey descriptive with 35 cyclists that analyzed by the electromyography three protocols: (a) of reference (REF), (b) P1, based in Burke; and (c) P2, where the saddle height was adjusted by the knee flexion. It was utilized the equipment EMG System do Brasil. As main results, related to the low back pain referred, the average before the ergonomics adjusts was 4,77 ± 1,61, after 30 days was reduced to 0,97 ± 0,89 with p = (p = 0,000) and after five months again the reduction for 0,14 ± 0,36 with p = 0,023. Comparing the positions between REF and P1, resulted by the saddle adjust, was found a significantly difference for the low back zone (p = 0,006). In the low back region, were analyzed the muscles: erector lumbar, erector thoracic and quadrates lumborum, but only for the erector thoracic muscle was found a significantly difference (p = 0,025) when compared the protocols REF and P1.

1 INTRODUCTION

The ergonomics is an interdisciplinary science that has as main objective to adapt the work to the psychophysiological characteristics of the human being. One of it applications is in the prevention of musculoskeletal pathologies like the low back pain, one of the most prevalent (Ulbricht, 2003). There are several predisposing factors for the low back pain, like postural, physically heavy works and prolonged stay in the seated position, and associating these factors we have the cycling activity. Studies demonstrates that most part of the cyclists presents postural imbalances, including inside the high yield, however, the proper posture should be adjusted looking for a balance between comfort and performance, but this isn't always possible to obtain (Burke, 1994; Martins et al., 2007).

The improper posture, due the inclination angles of the trunk, as in the other work activities, increases the risk for the development of musculoskeletal disorders, once that changes the muscular recruitment characteristics, especially in the low back zone and inferiors members when pedaling, what turns relevant the investigation of the pain and discomfort claims in the vertebral column (Adams; Burton, 2006; Martins et al., 2007).

For a better diagnostic of low back pain, the surface Electromyography (EMG) have been used, evaluating the muscle fatigue and providing information about the standard of muscular activation, leading to a better diagnostic and providing practical information for the treatment of associated deficits with the low back pain (Kankaanpaa; Taimela; Airaksinen, 1998; Roy; Luca; Casavant, 1989). In the cycling, by monitoring of the electric standard activity of the muscles involved in the movements from the pedaling is possible to obtain information about the behavior of the neuromuscular system (Li; Caldwell, 1998; Moritani; Muro; Nagata, 1986). With the technological development, the use of high precision mediation instruments is more and more usual in clinic practices, among which the electromyography stands because is an available method in the market for more than 40 years and has bigger objectivity and accuracy to register the electric activity of a muscle or a muscular group, and this way helping the diagnostic of musculoskeletal injuries (Rigler; Podnar, 2007).

This way, the general objective of this propose was verify the impact of ergonomics adjustments in the men-bicycle system in the low back pain of cyclists with the support of the electromyography.

2 METHODOLOGY

It was done a descriptive exploratory survey, with 35 cyclists, all of them professional triathletes, males, with age between 18 and 35 years, presenting complaints of low back pain/discomfort, practicing the activity at least for a year, with a volume of weekly training equal or superior to four hours. It was excluded from the survey the ones that had done already a spinal surgery, in physiotherapy treatment and owning bikes that don't have saddle height regulation. This survey was approved in the Committee of Ethics and Research under the number CAAE: 13372413.6.0000.5547 in April 2013.

The collection of anthropometric and electromyography data was done in a transversal way, in two subsequent steps: for body mass determination and individual stature and, was measured the horse height, which corresponds the distance of the floor to the crotch (pubic shymphysis) of the cyclist. The collection protocol for this measure established that the cyclist should be standing, with the shoe that uses for pedaling, and holding a book in the inguinal region between the legs, to indicate the maximum height. The evaluator measure the distance in centimeters from the ground to the highest point in the book and this distance corresponded to the horse height. In the next step was done the electromyography evaluation.

Regarding the data collection of subjective perception of the pain intensity, this was the variable of longitudinal follow-up in the survey, utilized as buoy for the quantification of the impact caused by the ergonomic adjust of the saddle. It was utilized the Visual Analogue Scale (VAS), which the athletes quantify their pain/discomfort in a scale from 0 to 10, zero corresponding to any pain/discomfort at all, and ten representing the presence of a severe pain/discomfort (Norris, 1971), in three moments: when arrived for the evaluation, after thirty days of use of the adjusted bicycle and after five months of use.

The specific muscular recruitment analysis was done starting from the body position during the dynamic gesture of pedaling. It was selected two protocols described in the literature, comparing the regulation used by the athlete spontaneously, called REF, which was the position that they were used to. The protocol proposed by Burke (1994), here denominated P1, had as principle the saddle height adjustment based in a equation that multiplies the horse height by the constant "1,09". This way was calculated a distance, in centimeters, of the pedal center until the top of the saddle, when the pedal was aligned with the seat tube (Burke, 1994). The other protocol applied was proposed by Holmes, Pruitt and Whalen (1994), and denominated here as P2. In this one, the calculus of the seat height was related to the knee flexion, in a way that, when the pedal was in the Inferior Motor Point (IMP), the lower point of the pedaling cycle, the cyclist should maintain a knee flexion between 25º and 30º, in a angle formed by the greater trochanter, the lateral condyle and the lateral malleolus.

It was done electromyographic evaluations for each one of the protocols utilized, and for that, the athletes utilized their own bicycle, coupled to a training roller of the brand Tranz X Jd-113, with the rear wheel fixed to the roller, allowing your movement. Each collection had duration of thirty seconds, for each one of the protocols. It was followed the SENIAM recommendations, and the evaluation was done during the pedaling cycle, with the athletes wearing light and proper clothing and leaving the low back zone free. It was utilized a equipment from the brand EMG System do Brasil model 1600-U12, of 16 channels, and surface electrodes of Ag/AgCl, in bipolar configuration, positioned 3 cm of the motor point towards the fibers orientation of the analyzed muscle. The reference electrode stood located in the spinous process of C7. The sampling frequency was of 2000 Hz per channel. In each one of the three protocols, it was analyzed the low back muscles: Quadrates Lumborum (QL), lumbar spine erector (EL), and Erector of the Thoracic spine (ET).

To analyze the registers obtained by the proposed methodology application, it was made a descriptive and exploratory analysis. The inferential statistic had as purpose the identification of relations between the variable. The *Kolmogorov-Smirnov* test was applied to verify the type of data distribution and for the data with abnormal distribution was applied the nonparametric statistic, with the test of Wilcoxon for analysis pre and post ergonomic adaptations. For registers with normal distribution, were applied parametric analysis, being used the test t paired in the comparison between the muscular electromyography in the different protocols, and the test of correlation of Pearson for verification of relation between the electromyography activities and the bicycle adjustments. All the statistic procedure were done in the software: *Statistical Package for the Social Sciences* (SPSS) version 17, being assumed as statistic significance values of $p < 0,05$ (Maroco, 2007).

3 RESULTS

The sample was constituted by 35 man, with average age of 26 ± 4,97 years, average weight of 45,03 ± 6,34 Kg and average height of 1,79 ± 0,05. Regarding the training data, the cyclists presented an average of 5 ± 1,91 years of practice, they used to train an average of 4 ± 1,51 days per week, roamed an average weekly mileage of 200 ± 176,26 Km. As for the bicycles, the average size of the frame was of 54 ± 2,90 cm (according to Chart 1).

Table 1. Anthropometric data relating to cyclists and triathletes and data relating to training.

	Average	Standard deviation
Age (years)	26,00	4,97
Weight (kg)	75,03	6,34
Height (m)	1,79	0,05
H horse (cm)	83,54	3,24
T training (years)	4,00	1,51
Daily km (km)	50,00	24,88

Table 2. Average values obtained in the electromyographic analysis for the low back muscles between the protocols evaluated (μv).

	Lumbar erector	Thoracic erector	Quadrates lumborum
REF	18,27 ± 15,24	19,43 ± 14,36	21,17 ± 15,23
P1	13,00 ± 7,69	13,46 ± 11,39	15,77 ± 15,18
P2	14,03 ± 9,71	13,43 ± 11,5	16,27 ± 14,94

Table 3. Average values obtained in the electromyographic analysis for the muscles in the low back region between the protocols evaluated (μv).

	Lumbar erector	Thoracic erector	Quadrates lumborum
P1	12,04 ± 4,73	15,12 ± 12,29	19,88 ± 11,93
P2	16,82 ± 9,43	19,03 ± 8,44	21,40 ± 19,45

As regards of the referred low back pain, classified by the EVA, the pre ergonomics adjustment average was of 4,77 ± 1,61. In the reevaluation step in 30 days after implementing the adjustments, the values related were reduced to 0,97 ± 0,89, being the statistically significant difference (p = 0,000). After five months, only fourteen athletes participate of the reevaluation of the pain/discomfort complaints and also were found significant differences between the initial pain and the final pain (p = 0,023), and the average found was still lower (0,14 ± 0,36). These values represented the significant improvement of the pain, after the adjustments of the seat proposed by the protocols of this study.

For each one of the protocols were evaluated the quadrates lumborum, lumbar erector and thoracic erector muscles, quantifying the electromyographic registers.

Comparing the positions between REF and P1, resultant of the seat adjustment, it was found a significant difference for the low back region (p = 0,006). These results show that the regulation presented a positive impact in the athlete efficiency, which correspond to a lower muscular recruitment for the performance of the same work. In REF the region electromyographic registered an average of 19,62 ± 9,64 μv, in P1 17,26 ± 7,63 μv and in P2 18,32 ± 8,15 μv. The same comparison between the results for REF and P2 didn't show a mechanic efficiency for the low back region (p = 0,086).

Of the low back muscles evaluated, when compared to the protocols, only was found significant difference (p = 0,025) for the thoracic erector muscle, between REF and P1, which in P1 was registered the lower averages, corresponding to a lower index of muscular fibers recruitment (Chart 2).

The protocol denominated REF, in all of the cyclists, presented the highest average of signals for all the muscles evaluated, what means a larger muscular recruitment in a whole, and this way, was excluded this regulation. Therefore, the ergonomic adjustments, related to the seat height, were recommended in an individual way for each athlete from the verification of the minor muscular recruitments, taken between the protocols P1 and P2.

This way, P1 was recommended to 22 athletes, while P2 was indicated to the other 13. Regarding the pain report, in P1 pre adjustments average was of 4,55 ± 1,57 and after thirty days 0,91 ± 0,81; while in P2 the averages were highest in pre 5,15 ± 1,68 and post1,08 ± 1,04, however wasn't found significant differences between the protocols.

When compared, the averages of the electromyographic registers of the low back region, it wasn't found significant differences, however in P1 was registered the lower average I the region of 15,58 ± 6,31 μv, while in P2 the average was of 19,08 ± 8,75 μv. In the analysis of each one of the muscles evaluated, also wasn't found significant differences between the protocols, although the component numbers of each one of these groups had been very disparate, as we can see at Chart 3.

Once that the low back pain complaints was the longitudinal axis that clarified about the best ergonomic recommendation, due the important impact that the pain causes in the sportive performance of the cyclist, a good adjustment protocol should be sensible enough to reveal excessive lumbar muscle recruitment, undesirable in this case. The studied protocols considered the analysis of each one of the low back region muscles, identifying with precision that the quadrates lumborum muscle presented larger recruitment of muscular fibers in both protocols, while the lumbar erector muscle showed lower recruitment, also in both protocols.

4 CONCLUSION

The general purpose of this research was verifying the impact of the ergonomic adjustments in the men-bicycle system in the low back pain with support of the electromyography. The ergonomic adjustments showed proper to impact positively in the pain symptoms, showing that after the ergonomic recommendations, the athletes reduced the low back pain reports. It was possible identify the muscles with larger recruitment, and this way, contribute for the professionals in the area and for the cyclists with an improvement in their life quality arising from the reduction of the low back pain.

Comparing the positions between REF and the resultant protocols of the seat adjustment, was found a significant difference for P1 ($p = 0{,}006$). As to the analysis of each muscle in an isolated way, only for the thoracic erector muscle was found a significant difference ($p = 0{,}025$) when compared to the protocols REF and P1.

However, it was identified that the quadrates lumborum muscle presented the larger recruitment in all of the evaluated cyclists, and then, treatments and trainings in the future should focus this muscular group.

Furthermore, it was noticed that all of the professional cyclists evaluated in this study, presented inaccuracies in the seat adjustment, demonstrating the ignorance between the ergonomics for the correct adequacy for the men-bicycle system. This ergonomic application, besides to increase the security, the satisfaction and the welfare of the cyclists, also looks for reaching a better yield in the pedaling.

It is necessary highlights that the regulation in the seat height is between the main position adjustments made by the cyclists, and this apparently simple mechanic regulation can take to a modification in the standard of muscular activation. These alterations occur due the change of the strength angle production of the involved muscles in the pedaling movement and they can help in the prevention of musculoskeletal injuries between the athletes of this mode.

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Thermal comfort—worker perception in a codfish packaging industry

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ABSTRACT: Any human activity is influenced by the working environment in which it is developed. The opinion of employees is, nowadays, an important factor to consider because their perception may be related to their behavior. The satisfaction of all individuals housed in a thermal environment is an "almost" impossible task because a thermally comfortable environment for one person may be uncomfortable for another. Therefore, it would be ideal to create a thermal environment that satisfied the largest number of workers. As such, the evaluation of thermal comfort implies a certain degree of subjectivity and requires the analysis of two aspects: physical (thermal environment) and subjective (state of mind of the individual). This study aims to analyze the pattern of thermal sensation of a packaging section of quick-frozen desalted codfish, discover the location of the most vulnerable workstations to thermal stress and assess the real thermal sensation of workers. The data were collected using a measurement instrument named "*Center 317—temperature humidity meter*". For the analysis of thermal sensation the follow indexes were applied: Temperature Humidity Index (THI), Thermal Comfort Scale (*EsConTer*) and Predicted Percentage of Dissatisfied (PPD). A set of standards were created for each variable and the results obtained indicate the most vulnerable workstations. Intervention strategies were considered.

1 INTRODUCTION

Currently, the relationship between workers and their work environment is increasingly important, because it leads to an increase of production, reduction of accidents and low absenteeism (Peinado & Graeml, 2007).

The thermal environment can be characterized as a set of thermal variables that influence heat exchange process between human beings and the environment. Within the scope of Architecture the thermal comfort is considered as the "satisfaction expressed when an individual is subjected to a certain thermal environment" (ISO 7730, 2005). Nevertheless, this definition implies a certain degree of subjectivity and requires the analysis of two aspects: thermal environment (physical aspects) and state of mind of the individual (subjective aspects) (Teixeira, 2014). The satisfaction of all individuals, housed in a thermal environment is an almost impossible task, because a thermally comfortable environment for one person may be uncomfortable for another (Djongyang *et al*, 2010). However, the main goal of thermal environment study is to find the optimal environment conditions to workers. As referred by Schiavon *et al* (2014), regarding the mechanisms/equipment's/methods to maintain thermal comfort for building occupants there is room for improvement. According to ISO 7730 (2005), the thermal discomfort may be caused by a cold or warm environment and for a thermal environment localized in a specific body part. A thermal environment is considered cold when the human body triggers its natural mechanisms to combat the cold. Hypothermia, which is a general condition caused by cold, is a thermoregulatory failure, and manifests as a widespread chill, leading to internal temperature decrease and blood pressure increase. The movements of the fingers and hands may also suffer appreciable deterioration, even with moderate levels of exposure. Chilblains, decreased manual dexterity and sensitivity reductions are elements to consider because a temperature below 8°C hands causes a decrease in sensitivity and tactile sensations and temperatures between 12°C and 16°C leads to a decrease in manual dexterity (Parsons, 1993).

This paper aims to analyze the pattern of thermal sensation of a packaging section of quick-frozen desalted codfish, discover the location of the most vulnerable workstations to thermal stress and the real thermal sensation of workers. For this analysis were applied the indexes, THI adapted by Nieuwolt (1977), *EsConTer* (Talaia & Simões, 2009) and *PPD* (ISO 7730, 2005).

2 MATERIALS AND METHODS

The field study was performed in a packaging section of quick-frozen desalted codfish in a codfish industry, i.e. a section of cold environment with an area of about 230 m^2. A set of thermohygrometric data were collected in 26 different observation posts, between January and March, using a measurement instrument named "*Center 317—temperature humidity meter*", for different types of packaging in order to discover a thermal pattern.

The THI index, developed by Thom (1959) and modified by Nieuwolt (1977) was used. This index uses the air temperature T (°C) and the relative humidity RH (%) and is calculated from the expression:

$$THI = 0{,}75\,T + T\left(\frac{RH}{500}\right) \tag{1}$$

where T represents the air temperature (°C) and RH the relative humidity (%). The comfort limits of THI were adapted by Talaia *et al* (2013).

The *EsConTer* index (Talaia & Simões, 2009) was also used in this study. It is based on a color scale (*Es*), considers the comfort sensation (*Con*) and is a Thermal (*Ter*) index, calculated using the followed expression:

$$EsConTer = -3{,}75 + 0{,}103\left(T + T_w\right) \tag{2}$$

where T represents the air temperature (°C) and T_w the dry-bulb temperature.

The *EsConTer* index uses a range of −3 to 3 values to show the thermal sensations of a very cold to very hot environment, witch is equivalent to the 7-point ASHRAE thermal sensation scale (ASHRAE, 2004). Regarding *EsConTer* results range was also applied the PPD index (ANSI/ASHRAE 55, 2013) in order to compare the results of both indexes, replacing PMV index by *EsConTer* index, as shown in formula:

$$PPD = 100 - 95^{\left[\begin{array}{l}-(0.03353\text{*EsConTer}^4\\ +\ 0.2179\text{*EsConTer}^2)\end{array}\right]} \tag{3}$$

This PPD index establishes a quantitative prediction of the percentage of thermally dissatisfied people.

3 RESULTS AND DISCUSSION

The workers of the section under study were all females with an age of 37.0 ± 12.3 years, weight of 64.2 ± 11.8 kg$_f$ and height of 159.0 ± 8.8 cm. Moreover, the study revealed that about 71% of workers referred that the hands were the body zone with greater discomfort, which is normal given the type of task, i.e., handling quick-frozen fish.

After collecting thermohygrometric data, an algorithm was designed in Matlab, which allowed to obtain the thermal standards for the packaging section. The abscissa and the ordinate axis represent a relative scale of the section space, i.e. the distance in meters. In addition, in the right side of the graphics appears a colors table that is associated to the values of the variable under study, which creates a color pattern.

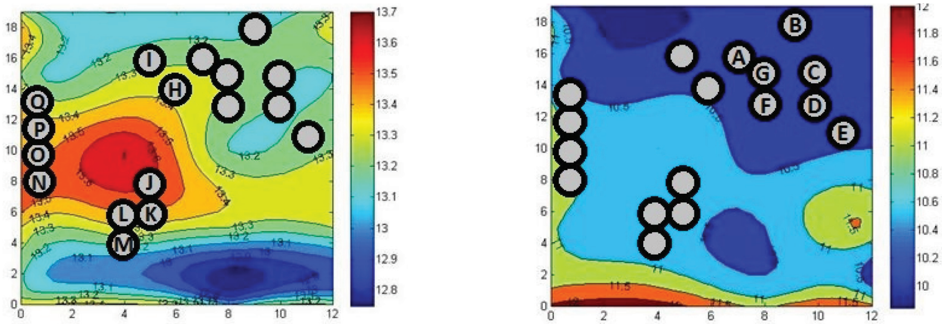
Next, the thermal patterns using the index *EsConTer*, THI, PPD and the temperature and relative humidity variables to different situations of packaging are presented. In figures 2 and 3 it is shown the standard for two different situations of packaging. Figure 4 and 5 shows the pattern of expected thermal sensation when applying the THI and *EsConTer* indexes. The results are in agreement, indicating an environment of slightly cold to cold and in need of heating.

By choice, the left side of each figure represents one situation of packaging and the right side represents another situation. The different situations of packaging are: sleeve wrapping quick-frozen desalted Traditional Cut Slice in a machine called ULMA (**A**) and packaging quick-frozen desalted Medium Slice in a classifier machine in boxes of 6.5 kg drained net weight (**B**).

The observation of the figures shows the workstations that are in operation when the circle has a letter. The absence of a letter indicates that the job was not operational.

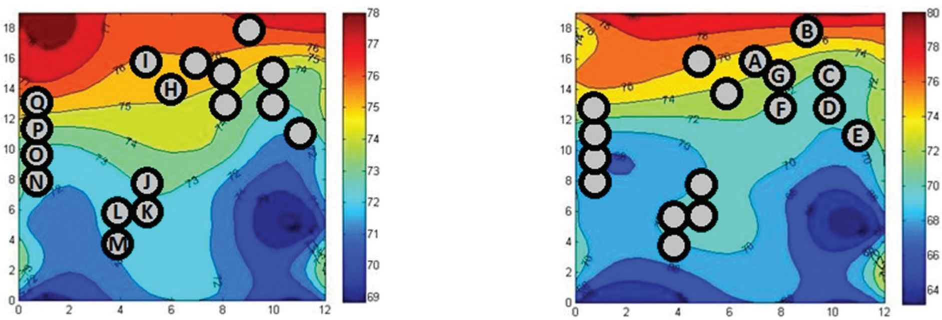
Figure 2 represents the variable air temperature in the space study for two different situations of packaging.

The observation of Figure 1 shows the regions with lower temperatures, i.e., regions in shades of dark blue. By comparing the two types of packaging we can verify that packaging B becomes the coldest thermal environment because the temperature range of values for packaging A is 12.7°C to 13.7°C and for packaging B is 9.8°C to 12.0°C. This can be explained by the fact of the packaging A machine has a furnace which can influence the thermal environment and thus the workers thermal sensation. However, analyzing this variable alone is insufficient, given that the relationship between the air temperature and the relative humidity is very important to the thermal environment perception. Thus, Figure 3



Air temperature (A) Air temperature (B)

Figure 1. Air temperature for packaging A and B.



Relative humidity (A) Relative humidity (B)

Figure 2. Relative humidity for packaging A and B.

represents the variable relative humidity in the space study for two different situations of packaging (A and B).

From the observation of Figure 2 it can be concluded that the regions (packaging A and B) with a higher relative humidity correspond to the same regions with the lowest air temperature, as expected. When the air temperature decreases, the relative humidity is higher. Thus, areas where it is noticed an increased thermal discomfort correspond to the upper part of the section under study, which leads to greater thermal discomfort in the workers located there.

To analyze the data the thermal indexes *EsConTer*, THI and PPD were applied. The results are represented in Figures 3, 4 and 5 respectively.

The observation of *EsConTer* index shown in Figure 3 shows that the area with greater thermal discomfort is associated to values of about −1.38 (packaging A) and of about −1.90 (packaging B). Regarding the THI index (Figure 4), the areas of greatest thermal discomfort are the same depicted in the *EsConTer* index (Figure 3), although evaluated on a different scale.

In THI index values of highest thermal discomfort reach 12.0°C (packaging A) and 9.4°C (packaging B), which means, according to the ranges defined in Table 1, 50% of these individuals were thermally uncomfortable.

The observation of *Esconter* (Figure 3) and THI (Figure 4) indexes show that the thermal sensation in the section in case of packaging A is slightly cold to cold. Some workers are located in the considered cold zone, these being the workers H, I and M. In case of packaging B the thermal sensation is cold. And some workers are located in the considered coldest zone, these being the workers A, B, C, D, E, F and G, which registered a thermal sensation very close to predicted.

The PPD index was applied to discover the percentage of unsatisfied workstations in the packaging section. The observation of Figure 6 shows that in case of packaging. A thermal discomfort is less that in case of packaging B, because in first case only 44% of workers are thermally uncomfortable and in second case 70% of workers are thermally uncomfortable. This means that different situations of packaging show different thermal sensations.

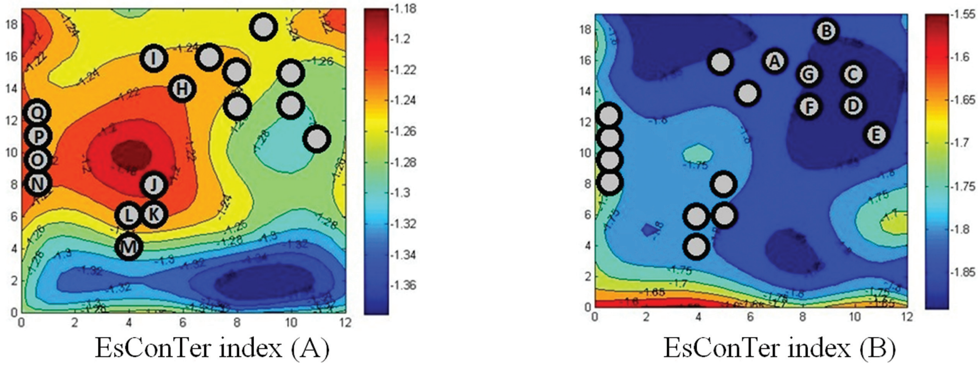


Figure 3. EsConTer index for packaging A and B.

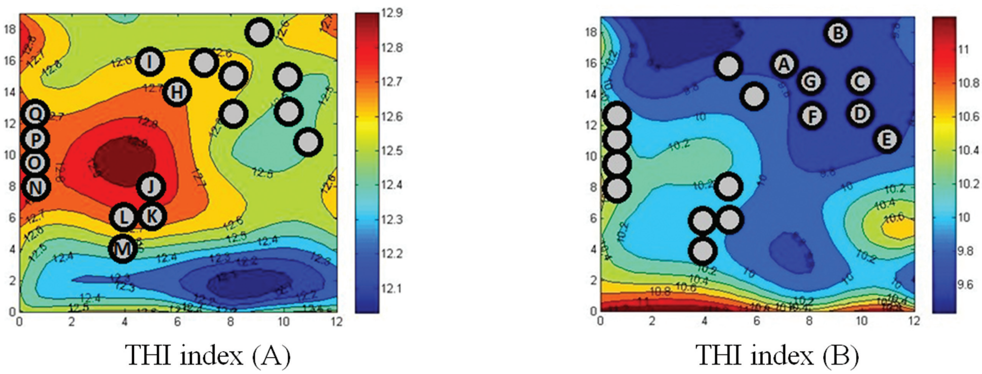


Figure 4. THI index for packaging A and B.

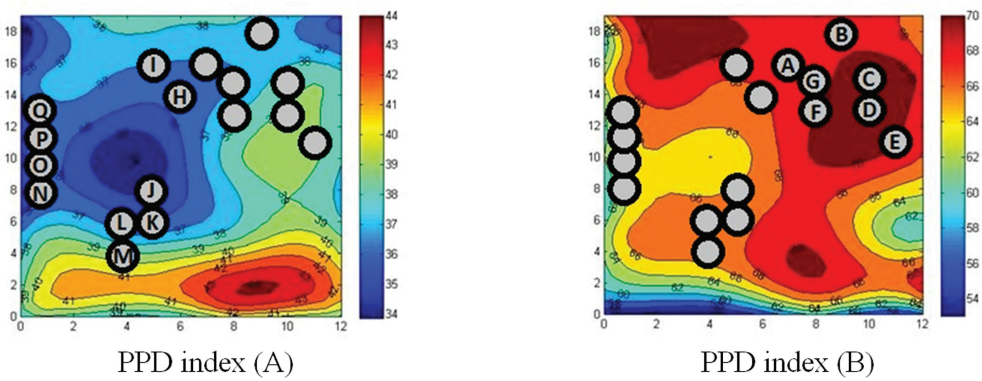


Figure 5. PPD index for packaging A and B.

The THI and *EsConTer* indexes show very concordat with respect to the area of increased thermal vulnerability area corresponding to darker blue color. The PPD index is also shown in agreement with previous indexes as the area but in this case corresponds to the area with a darker red color.

The thermal sensation felt by workers and indicated on the color scale developed by Talaia & Simões (2009) shows unequivocally that in (A) situation workers indicate thermal sensation values between –0.8 to –1.1 and in (B) situation between –1.3 to –1.8.

4 CONCLUSION

In a quick-frozen desalted codfish packaging section the pattern of a thermal sensation depends of the packaging process/type. The indexes used showed excellent agreement and the *EsConTer* proved an excellent tool to predict the thermal sensation of spaces and workers in a cold environment, allowing the adoption of intervention strategies to protect workers by improving the clothing, reducing fatigue which consequently leads to increase productivity and create the conditions for the workers satisfaction. The results obtained allowed to discover the expected and real thermal sensation of the workers. Moreover, at this moment another study is being performed in order to improve workers clothing for the different patterns of thermal sensation.

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A systematic approach for externalities in occupational safety through the use of the Delphi methodology

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ABSTRACT: Organizations should conduct an assessment of their occupational hazards with the regularity required by law and in order to design and implement preventive measures that are deemed necessary and sufficient to maintain the level of risk and the costs of prevention and the safety at the level considered acceptable by the organization. The design of preventive measures and the selection of measures to be implemented in an organization depend on various aspects and should take into account internal and external costs. In the present paper, an application of the Delphi method to the issue of externalities has been made. After three rounds it was possible to obtain significant findings and a better understanding of the problem of externalities in Occupational Health and Safety (OHS).

1 INTRODUCTION

For Varian (1992), the definition of externality is that the action of an agent directly affects the living conditions of another agent. Externalities can also be defined as: "the uncompensated impact of actions of one person over the welfare of a spectator" (Mann and Wüstemann, 2008). The focus on human welfare, primarily used as a synonym for human utility, is due to the traditional utilitarianism of economics.

When an organization performs a risk analysis integrated in the assessment of its Occupa-tional Health and Safety (OHS) management system, several steps are suggested to solve the problems identified. Usually, the organization makes a detailed analysis of the monetary impact (positive or negative) for the organization of each considered measures. However, it is also im-portant to perform an analysis of the impact of each measure in society, i.e., to measure the in-volved externalities. The measures taken by an organization in risk prevention may have an in-direct positive effect (positive externality) in society, while no action, due to the costs for the organization, may have significant negative effect for society (negative externality). It follows that these effects should be duly considered in decision making (Ramos et al., 2013).

Externalities are in fact of great importance in terms of costs of work accidents (HSE, 2012), so it is important to consider them when performing a cost-benefit analysis in Occupational Health and Safety (OHS). There are very few studies that allow to estimate the externalities related to workplace accidents (ILO, 2012).

The quest for economic sustainability of OHS is acquiring greater visibility and strategic weight in corporate management. The process of calculating or estimating the economic value of OHS is a very relevant topic, lacking greater depth, as confirmed by Cagno et al. (2013).

The Delphi method is a research technique particularly suitable when there is an incomplete understanding of the subject under consideration, as is the case of externalities in occupational safety (Okoli & Pawlowski, 2004; Ramos et al., 2012). Considering the scarcity of studies on externalities in OHS, an application of the Delphi method has been made to the issue of externalities. In the presented paper, the research methodology that has been followed and the main results that have been obtained are presented and discussed.

2 RESEARCH METHODOLOGY

2.1 *Delphi methodology*

The Delphi method allows gathering the views of the considered participants, typically a panel of experts on the study domain. This process is carried out by conducting a series of questionnaires, or rounds, on a specific topic or subject (Okoli & Pawlowski, 2004; Ramos et al., 2012).

Some of the characteristics of the Delphi methodology are the anonymity of the participants, the statistical representation of the distribution of results and the use of the feedback from the group to review the answers in a later round.

Thus, a selected group of experts is asked about future events in successive rounds anonymous and with maximum autonomy of the participants, with the goal of reaching consensus. In this research method, the results depend strongly on the quality of the questionnaire and the selection of experts (Okoli & Pawlowski, 2004).

The successive questionnaires are used to reduce the "interquartile interval", a measure of the deviation of the opinion of an expert from the opinion of the whole panel (median). The aim of the first questionnaire is then to calculate this deviation. If more than one or more rounds are required, a greater consensus is to be expected on each issue (Okoli & Pawlowski, 2004). According to Skulmoski et al. (2007), the process can be considered as being concluded when the answers are near the consensus, according to appropriate statistical methods.

The strengths and limitations of the Delphi methodology are defined in ISO/IEC 31010 (2009) as: anonymous points of view, more likely to express unpopular opinions, all opinions have equal weight (avoiding the problem of dominant personalities) and the experts do not need to be gathered in one place at one time. On the other hand there are some limitations: it is a laborious and time-consuming technique, may be characterized by poor internal consistency and reliability of opinions among experts, which can lead to low reproducibility of forecasts based on the results obtained. Results are sensible with respect to the ambiguity and reactivity of respondents and it is difficult to assessing the degree of knowledge of the participating experts.

2.2 *Delphi panel and questionnaire*

For this study, a panel of experts specialized in the area of OHS has been chosen. Initially, 29 experts, including 13 academic experts, 8 technical/professional experts and 8 experts in consulting/audit have been contacted.

The questionnaire has been developed with the purpose to be applied to a panel of experts with different backgrounds. It was expected that with three rounds it should be possible to obtain important conclusions and to have a better understanding of the importance of the Externalities in Occupational Safety.

In terms of externalities, the questionnaire had a total of 11 questions. For each question, the expert could choose the answer in a scale 1–5 (1 = very low, 2 = low, 3 = medium, 4 = high, 5 = very high); the possibility of answering "no opinion" was also available. The variables studied are discrete, categorical and qualitative of ordinal type. The detailed structure of the questionnaire has been presented in a previous publication (Ramos et al., 2012). The questionnaire has been previously validated with three experts before being sent to all members of the expert panel.

Three Delphi rounds have been performed.

2.3 *Methodology for the treatment of the answers*

For all the 11 questions, the following statistical parameters have been calculated: mean, median, standard deviation and inter-quartile range.

The Inter-Quartile Range (IQR) is the difference between the 3rd and 1st quartile in which lie 50% of core values. The higher the IQR, the greater the dispersion of the data. Thus, an IQR less than 1 means that more than 50% of all opinions fall at a certain point on the scale and shows that they have reached consensus (von der Gracht and Darkow, 2010). An IQR of zero indicates a perfect consensus among panel members.

The median indicates the degree of support of the group for each factor; if it is high, we can conclude that there is a high level of support from the group.

The statistical treatment of diagrams Extremes and Quartiles of the first and third round was done with the support of IBM SPSS 20 program.

3 RESULTS AND DISCUSSION

3.1 *Results of the first Delphi round*

In the first round we have had the effective participation of 20 experts, out of the 29 experts contacted. The results showed a good agreement (IQR $\leq$ 1) in 8 of the 11 questions.

Figure 1 presents the diagram of extreme quartiles and the first round "Externalities".

The circle and the asterisk in Figure 1 represent extreme cases. The circle represents the situation when the minimum or maximum value is lower or higher than 1.5 IQR but less than 3 IQR (case considered as "moderate outlier"). The asterisk represents the extreme cases, which are at a distance higher than 3 IQR (called "faroutlier" or "extreme outlier"). This notation follows the standard set in SPSS, as well as other programs of conventional statistics (Statistica, SAS, R, etc.).

3.2 *Results of the second Delphi round*

The second Delphi round was carried out in order to increase the consensus. In this round there were 9 questions with IQR $\leq$ 1 was 9 (including one with

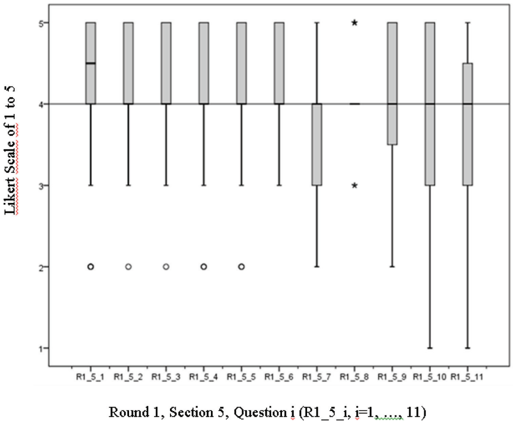

Figure 1. Diagram of extreme quartiles of the first round “Externalities”.

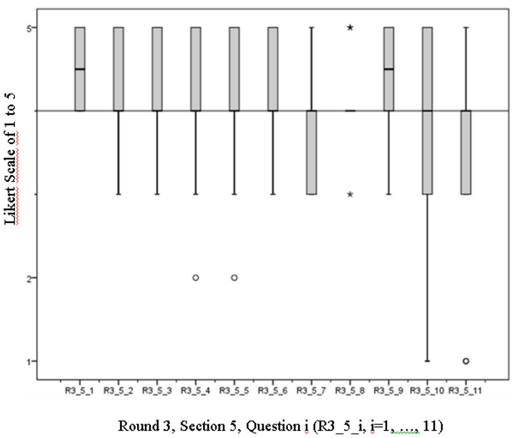

Figure 2. Diagram of extreme quartiles and the third round “Externalities”.

IQR = 0). The diagram of extremes and quartiles is very similar to the first round.

3.3 *Results of the third Delphi round*

In the third round the experts have been asked to reassess their responses, taking into account the results and also the comments made in the 2nd round. In this round, the number of issues with IQR ≤ 1 increased to 10.

The answers obtained by panel in the third round are shown in Figure 2. All the questions obtained a median of at least 4.0 (full line of Fig. 2).

Table 1 presents the statistical treatment of the results of the third and final round. For each question the following statistical parameters are presented:

Table 1. Summary of statistical results for externalities in OHS after the third round.

Questions	W	m	s	IQR
1. Implications in the family stability	4.5	4.50	0.52	1.00
2. Reduction of household income	4.0	4.29	0.73	1.00
3. Expenses accommodation and adaptation at home	4.0	4.21	0.58	0.75
4. Costs for the Society in terms of payment of costs of hospitalization, treatments and recovery	4.0	4.14	0.86	1.00
5. Costs for the Society in terms of social welfare payments to sick and injured workers	4.0	4.14	0.86	1.00
6. Costs for the Society in terms of reintegrating people into the labor market and in society in general	4.0	4.29	0.73	1.00
7. Indirect calculation of externalities, based on the costs of the plans and equipment for prevention and safety	4.0	3.71	0.61	1.00
8. Direct calculation of the externalities based on the caused damages	4.0	4.07	0.47	0.00
9. Reduction of the negative externalities through public measures (taxes, fines, legislation, etc.)	4.5	4.29	0.83	1.00
10. Reduction of negative externalities through private solutions in terms of the relationship between the company and the worker (codes of conduct, safety rules, etc.)	4.0	3.86	1.17	2.00
11. Reduction of negative externalities through awards/grants/tax deductions for legitimate businesses.	4.0	3.57	1.28	1.00

W: median. Positional statistical parameter: central value of those observed.

m: mean. Positional statistical parameter: the sum of data values divided by the number of observations.

s: standard deviation. Dispersion parameter: square root of the mean of the squares of deviations with respect to its median.

IQR: interquartile interval. Dispersion parameter: difference between third and first quartiles.

Table 2. Consensus criterion concerning the questions related to Externalities.

	Round 1	Round 2	Round 3
Number of respondents	20	19	14
Number of questions with IQR ≤ 1	8	9	10

3.4 *Global treatment and discussion of results of Delphi study*

After round 3, the expert panel found that questions 1 and 9 in Table 1 were extremely important (median equals to 4.5 or 5) with IQR = 1. Question 8 obtained the highest consensus (IQR = 0), with a median of 4.0. Table 2 presents the evolution of the opinion of the panel along the three rounds.

The number of experts has reduced along the rounds which is normal in Delphi studies and does not invalidate the results. In fact, according to Okoli & Pawlowski (2004), 14 is a good number of experts in Delphi studies (these authors suggest between 10 and 18 experts).

4 CONCLUSIONS AND FURTHER RESEARCH

The Delphi method is a research technique suitable when there is an incomplete knowledge on the subject under consideration, as is the case of externalities in OHS.

This methodology allowed to collect the assessment of selected experts through a survey specifically designed for this purpose and has been developed in three rounds, in order to increase the consensus among the group of experts.

The expert panel recognized the relevance of the implications for family stability, the direct calculation of the externalities based on the caused damages and the reduction of negative externalities through public solutions (taxes, fines, legislation, etc.). There was no consensus among the panel of experts on reducing negative externalities through private solutions in terms of the relationship between the company and the worker.

According to the issues highlighted by the expert panel, the externalities can be used to promote, support or to legislate on measures of prevention of occupational hazards. Indeed, the incorporation of the effects of risks and preventive measures in terms of cost to the company for the employees and the Society may be used to support the reduction of negative externalities through public measures such as taxes, penalties and more restrictive law.

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Occupational Safety and Hygiene III – Arezes et al. (Eds)

Musculoskeletal disorders among physical therapists—prevalence, characteristics and impacts of work—short review

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ABSTRACT: Although Physical Therapists (PTs) have extensive knowledge about body mechanisms and injury prevention, Work-Related Musculoskeletal Disorders (WRMD) are quite common among this population. The objective of this paper is to contribute with a systematic review on prevalence, characteristics and impacts of Work-Related Musculoskeletal Disorders (WRMDs) among Physical Therapists (PTs), investigate risk factors and identify preventive strategies used by PTs. PRISMA was used to create this paper and present the results. The search included 22 Scientific Journal editors and 26 Database surveyed between October 2013 and January 2014. This paper includes 10 articles, from 9 different countries, written after 2000, in English language, and having only physical therapists as target. Previous studies are not randomized; difficulty in translating variables. Most of the results are inconclusive. More studies are needed to understand association between age, working venues, areas of specialty, working hours and number patients/day with the prevalence of WRMDs.

1 INTRODUCTION

Work-Related Musculoskeletal Disorders (WRMD) are described as an injury resulting from a work related event (Salik, 2004: Alrowayeh, 2010) leading to death, loss of work time, loss of consciousness, work restriction or carrier change (Al-Eisa, 2012). Health care workers are vulnerable to sustaining WRMD during the course of their work routine (Adegoke, 2008; King, 2009; Al-Eisa, 2012). Several studies have documented that WRMD are frequently experienced by physiotherapists (PTs) (Cromie, 2001; West, 2001; Glover, 2002; Adegoke, 2008; King, 2009; Alrowayeh, 2010; Rozenfeld, 2010; Al-Eisa, 2012). WRMD include tendinitis, tenosynovitis, ligamentous rupture, subluxation, dislocation, contusion, strain and bursitis (Bork, 1996; Rugelj, 2003; Glover, 2005; Al-Eisa, 2012).

Studies reported a high prevalence of lower back pain but it is also common in other anatomical areas such as neck elbow, wrist and hand. Physical therapists are more susceptible to these lesions because of labor intensive tasks associated with their work (Rugelj, 2003; Salik, 2004; Adegoke, 2008; King, 2009; Al-Eisa, 2012). There is a large number of factors that can lead to developing WRMD, like manual handling which requires physical force to lift, push, pull, or move (Cromie, 2001; Alrowayeh, 2010; Al-Eisa, 2012). The physical therapy techniques that show increased risk are patient transfers, bending/twisting postures, manual therapy techniques, soft tissue mobilizations and physical job strain (Adegoke, 2008; King, 2009; Alrowayeh, 2010; Nkhata, 2010; Al-Eisa, 2012;). In Europe, manual therapy is widely practiced, but in Asia electrotherapy and exercises are the most commonly used treatment modalities (Nordin, 2011). Therapists with WMSD work more hours and spend more time in direct patient care than those without WRMDs (Glover; 2002; Salik, 2004; Adegoke, 2008; King, 2009; Rozenfeld, 2010). Therapists who spent more time performing manipulation or mobilization had more severe lower back and thumb symptoms than the therapists who spent fewer hours performing manipulation or mobilization (Cromie, 2010). A relation has been reported between sports physical therapy and symptoms on thumb and neck, between private practice and symptoms on wrist, elbow, thumb, neck and upper back and between pediatrics and symptoms on knees. Ninety-five respondents (17.7%) changed their specialty area of practice or left the profession altogether as a result of WRMDs (Cromie, 2010).

Physical therapists who routinely performed manual therapy were 3.5 times more likely to have had musculoskeletal symptoms in the wrists and hands than physical therapists who did not routinely perform manual therapy (Bork, 1996).

For each hour of additional work per week performing rehabilitation treatment is associated with a 5% increased likelihood of injury to the lower back and a 4% increased likelihood of injury to the shoulder/elbow areas. Another conclusion of this work is that the number of hours per week performing manual treatments is directly associated with an increased risk of WRMDs in the wrist/thumb and a decreased risk of WRMDs in the lower back with each hour of additional work per week performing manual treatment being associated with an 11% increased likelihood of injury to the wrist/thumbs and a 9% decreased likelihood of injury to the low back areas (Rozenfeld, 2010).

For example, females PTs had an increased risk of WRMDs in the neck/upper back and shoulders/elbow, with a 21% increased likelihood of injury to the neck/upper back and 13% increased likelihood of injury to the shoulders/elbow areas (Rozenfeld, 2010). In another study, by Glover (2005), female PTs reported a higher prevalence of lower back (45%), neck (14%), shoulder (7%) and wrist/hand (7%) injury than their male colleagues. Males suffered more upper back (18% versus 12%), knee (6% versus 3%), elbow/forearm (3% versus 1%) and hip/thigh (3% versus 1%) problems than females. Both females and males suffered similarly in relation to thumb injury (both 10%) (Glover, 2005).

The objective of this study is a systematic review in order to determine the prevalence, characteristics, and impacts of WRMDs among physical therapists and investigate risk factors and to identify preventive strategies used by Physical Therapists.

2 MATERIALS AND METHOD

This research was conducted between October 2013 and January 2014 within a universe of 8122 articles (8119 articles identified on database searching and 3 articles by references in other articles). We removed 2261 repeated articles and excluded 5710 (disagreed with the theme). We then elected 151 full–text articles (oriented to WRMDs and health professionals) and excluded with reasons 136 (not focused PTs). We included 15 articles in qualitative synthesis and 10 articles in quantitative synthesis (Table 1).

Table 1. General results from WMSDs in physical therapists.

Author	Country	Selected physical therapists	Strategy[1]	Time of experience	N.º selected	Number responses
1. Cromie (2000)	Australia	PT registered in the state of Victoria and resident in Australia	Validated[2]		789	536 (67.90%)
2. West (2001)	Australia	All PT on Queensland Registration Board list for 1997/98	Validated		412	217 (53%)
3. Salik (2004)	Turkey	PT members of the Izmir Branch of the Turkish Physiotherapy Association	Validated by Cromie	>2 years of experience	205	120 (58.50%)
4. Glover (2005)	United Kingdom	Members of the Chartered Society of Physiotherapy in the UK	Validated[2]		3661	2688 (73.40%)
5. Adegoke (2008)	Nigerian	PT practicing in the 26 accredited health institutions	Validated[2]	>1 year of experience	270	126 (45.50%)
6. Rozenfeld (2009)	Israel	All PT working in five rehabilitation centres and six outpatient clinics	Validated by Cromie	>1 year of experience	182	127 (70%)
7. Alrowayeh (2010)	Kuwait	PT of all nationalities in various specialties	Validated	>1 year of experience	350	212 (60.60%)
8. Nkhata (2010)	Zambia	PT registered in the Medical Council of Zambia	Semi structured		139	120 (86%)
9. Nordin (2011)	Malasia	PT of three main public hospitals in Selangor and Kuala Lumpur	Validated[2]		105	81 (77%)
10. Al-Eisa (2012)	Saudi Arabia	Egyptian and Saudi physical therapy association's membership list	Validated	>1 year of experience	200	162 (81%)

[1]Self-administered questionnaire; [2]Nordic Questionnaire;
*Prevalence of injury in last 12 months for more 3 days; **Prevalence of injury more in last 24 months.

This search included 22 Scientific Journal editors: ACM Digital Library, ACS Journals, Annual Reviews, ASME Digital Library, BioMed Central Journals, Cambridge Journals Online, CE Database (ASCE), Directory of Open Access Journals (DOAJ), Esmerald Fulltext, Highwire Press, IOP Journals, nature.com, Oxford Journals, Royal Society of Chemistry, SAGE Journals Online, SciELO—Scientific Electronic Library Online, Science Magazine, ScienceDirect, SIAM, SpringerLink, The Chronicle of Higher Education, Wiley Online Library and 26 Database: Academic Search Complete, AGRICOLA Articles, Arts & Humanities Citation Index, Beilstein, Business Source Complete, CiteSeerX, Compendex, Current Contents, Datamonitor, Energy Citations (DOE), ERIC, Inspec, Library, PsycArticles, PubMed, Science Citation Index, Science & Technology Proceedings, SCOPUS, Social Sciences Citation Index, Social Sciences & Humanities Proceedings, Source OECD, TRIS Online, Web of Science. The keyword combinations used were: "musculoskeletal disorders" + hospitals; "musculoskeletal disorders" + absenteeism; "musculoskeletal disorders" + "back pain"; "musculoskeletal disorders" + nurses; "musculoskeletal disorders" + "occupational health"; "musculoskeletal disorders" + "health care workers"; "musculoskeletal disorders" + "work related postures"; "musculoskeletal disorders" + epidemiology; "musculoskeletal disorders" + prevalence; "musculoskeletal disorders" + "risk factors"; "musculoskeletal disorders" + "upper extremity disorder"; "musculoskeletal disorders" + "physical therapists"; hospitals + absenteeism; hospitals + "back pain"; hospitals + "occupational health"; hospitals + nurses; hospitals + "work related postures"; hospitals + "upper extremity disorder"; absenteeism + "occupational health"; absenteeism + "work related postures"; absenteeism + "upper extremity disorder"; "occupational health" + "work related postures"; "occupational health" + "risk factors"; "occupational health" + "upper extremity disorder"; "physical therapist" + "absenteeism"; "physical therapist" + "occupational health"; "physical therapist" + "work related postures"; "physical therapist" + "risk factors"; "physical therapist" + "upper extremity disorders"; "physical therapist" + "upper extremity injuries".

Articles were included in which participants read and signed the informed consent approved by Ethics Committee before completing the validated self-administered questionnaire. Excluded any articles that study physical therapists and occupational therapists simultaneously (4 articles) and related incidence and not the prevalence of WRMDs (1 article).

3 RESULTS

In this systematic review were assessed 8122 articles. From these 2261 were repeated and 5710 were rejected because they did not fit the theme. Finally, 141 were excluded for not meeting the eligibility criteria. The final group included 10 papers from 9 different countries. The number of responses varies between 81 and 2688 (Table 1). With exception of Alrowayeh (2010) and Adegoke (2008) the percentage of female respondents is larger than the male respondents.

The minimum of age (mean) is 27.74 years (Al-Eisa, 2012) and maximum (mean) is 39.50 years old (Glover, 2005). Most physical therapists that responded to the surveys have been working for less than 10 years and less than 10 patients for day. Half of the papers reviewed don't have information

Table 2. Areas of body with symptoms related by physical therapists.

Author	Total responses	Neck	Shoulder	Elbow	Wrist hand	Thumbs	Upper back	Low back	Hip	Knee	Ankle foot
1.	n = 536	47.6%	22.9%	13.2%	21.8%	33.6%	41.0%	62.5%	7.3%	11.2%	7.1%
2.	n = 217	20%	10%	3%	14%			22%	3%	3%	2%
3.	n = 120	12%	14%	8%	18%		9%	26%	2%	8%	3%
4.	n = 2688	25.7%	14.8%	5.5%	12.5%	17.8%	18.4%	37.2%	4.8%	7.8%	4.1%
5.	n = 126	31.1%*	22.2%*	5.6%*	20.6%*	11.1%	14.3%*	69.8%*	6.3%*	15.9%*	9.5%*
6.	n = 127	45.5%*	42.2%*	16%*	35.7%*	33.9%	41.1%*	59.8%*	6.3%*	22.2%*	17.9%*
7.	n = 212	20.2%	12.6%	3.7%	10.8%		19%	32%	3.3%	10.8%	6.1%
8.	n = 120	25.6%	30.5%	7.3%	15.9%	2.4%	26.8%	52.4%	1.2%	9.8%	8.2%
9.	n = 81	46.5%	40%	8.6%	12%		44.8%	51.7%	17.2%	27.6%	24%
10.	Eg (n = 62)	25%	15.3%	4%	14.5%		7%	23.4%	1%	8%	4%
11.	Sa (n = 100)	29%	5%	1%	5%		12%	33%		13%	1%

*This results shows that the annual prevalence of WRMD in 9 anatomical areas and how can the same person feel the symptoms in different areas.

about the number of hours per day in direct patient care, but the results suggested between 6 and 8 hours. There is only one study (Alrowayeh, 2010) in which 71% refer 8 hours or more. No consensus exists about the area of intervention that causes more injuries, as results vary according to the study analysed. However the elected areas are Orthopaedics, General PT, Neurology and Pediatric. It's consensual that lower back pain is the main injury on physical therapists (Table 2). With the exception of Salik (2004) and Nkhata (2010) (in these two specific cases the second most affected area is the shoulder), the second most affected area is the neck. The first symptoms of WMSD appeared in first five years after graduation. Only 2 articles discriminate the type of injuries. Only 3 papers refer the strategies used by physical therapist.

4 DISCUSSION

After analysing the chosen papers it is interesting to verify that only one paper have been found in Europe (Glover, 2005). The higher prevalence of WRMDs in the female population is observed in almost all the papers, which may be explained by the number of female professionals.

According to the results there is a high prevalence of WRMDs in physical therapists. The pathology of the upper limb is present in all papers, being one of the leading causes of injury (neck, shoulder, hand, wrists and thumbs). Alrowayeh (2010) suggests an association between neck pain, shoulder pain and low back pain and sex (more common among the female).

Most PTs that responded to the surveys have been working for less than 10 years, having less than 10 patients for day but in 4 papers the responses about "*Treating large number of patients in a day*" is high, not saying the number (West, 2001; Glover, 2005; Adegoke, 2008; Nkhata, 2010). There is not a consistent opinion about relation between the areas of specialty and the WRMSDs. The most common tasks that reportedly cause WRMDs are: "*Performing repetitive tasks*", "*Maintaining position for a long period of time*", "*Performing manual therapy techniques*", "*Transferring a patient*" and "*Treating large number of patients in a day*". Some authors (Adegoke, 2008; Nkhata, 2010) suggested "*modify patient's position/my position*" and "*select techniques that will not aggravate or provoke my discomfort*" as the most copping strategies used by physical therapists. Glover (2002) states that the extent of WRMD among PTs suggests that their specialist skills and knowledge are not being used to prevent such injuries occurring. Consequently, it may be necessary to consider the frequency and content of training courses, particularly on younger members, to reinforce good practices in providing treatment which also protects practitioners from injury. Only 3 papers refer the strategies that physical therapist used most frequently to avoid injury: "*Avoid lifting*"; "*Change working position frequently*" and "*Use improved body mechanics*". "*Visiting a physician*", "*medication*" and "*rest*" are the others solutions. More studies are necessary to obtain consistent results.

One relevant limitation of this study is that the included studies were not randomized. On the other hand the difficulty to translate some variables and comparing them as, for example, "working while injured or hurt" and "Working when physically fatigued". Another relevant limitation of this study is that in some responses to the people don't choose the one area of injury that they considered to be the most significant' and choose all areas that have injury. Also when reporting the coping strategies to response to injury the respondents don't choose hierarchically the different modalities, but present all that they have used in no particular order.

5 CONCLUSION

Findings suggest that physiotherapy is a moderate-to high-risk profession for WRMDs. More studies are needed to understand association between age, working venues, areas of specialty, working hours and number patients/day with the prevalence of WRMDs. Given the limitations authors have found when performing analysis, suggest that a common framework of variables and study methodology should be created for this subject in order to obtain scientifically testable and comparable results among studies and, upon the creation of this framework, performing properly randomized studies on large populations across countries and cultures to accurately assess risk factors and identify preventive strategies used by PTs.

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Psychosocial risk factors in non-teaching staff—descriptive findings of three schools clusters of Santarém district

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ABSTRACT: This study contributes to identification of psychosocial risk factors in non-teaching staff. The study is exploratory and descriptive. It consists in descriptive statistics of responses to a questionnaire for identification of psychosocial risk factors (translated and adapted from *F-PSICO*), as well as in content analysis of responses to semi-structured interviews. The results show that the non-teaching staff needs to hide emotions and feelings and also that some of the situations that affect psychologically relate to relationships with co-workers. It is stated that *«there is no team spirit»* and that these relations are not satisfactory. With the day-to-day workload, these workers are forced to interrupt work and perform various tasks at the same time, dealing with a day-by-day of *«breakneck pace»*, *«intense»* and *«very full»* journey. Psychological demands, time autonomy, workload, relationships and social support are psychosocial risk factors that play an important role in the performance of these workers. Finally, some measures to control these risks were recommended.

1 INTRODUCTION

In the European Union, many workers report being exposed to psychosocial factors at work—these having significant consequences for workers, to workplaces and society (Kristensen et al., 2005). Mental health and well-being are matters of daily life, therefore, should be of general interest to all sectors of society (WHO, 2005). Psychosocial risks are related to the way work is designed, organized and managed, as well as with the economic and social context. They raise a higher level of stress and can lead to a serious deterioration of mental and physical health (EU-OSHA, 2007). Some psychosocial risks can be real problems for organizations and will clearly have a negative impact on worker performance (Celly & Suasnavas, 2012).

On the other hand, Psychosocial Risk Factors (PRF) are the conditions in a work situation and are directly related to the Organization, the work content and task accomplishment, and have the ability to affect both the work accomplishment and worker health (Martín & Yerro, 2002). Surveillance of PRF at work allows the development of policies and programs to prevent stress and promote physical and mental health and well-being of workers (Dollard et al., 2007).

In the literature review, no national nor international studies were found, specifically showing the concept and the identification of PRF affecting the school non-teaching workers. Instead, the published research has either concentrated on the psychosocial study of teachers, or poring over the remaining school professionals only focusing on their role in the organizational structure and not directly addressing the non-teaching workers, despite of their importance in the maintenance and running of school activities. Thus, this study intends to fill this gap in terms of identification of PRF in the non-teaching school staff. For this purpose, the research hereby presented aims to identify situations of professional risk, to characterize the effects of occupational psychosocial risks, to identify preventive measures for these risks and to evaluate PRF in non-teaching staff of three clusters of schools in the Portuguese district of Santarém.

2 METHODOLOGY

This is an exploratory and descriptive study. The convenience sample, out of the school clusters in Santarém district, consists of 155 individuals of non-teaching staff of three school clusters.

The quantitative focus of the study involves the application of a questionnaire to identify PRF. This questionnaire is divided into two groups: Group I includes socio-demographic characteristics (gender, age, marital status, underage dependents, distance from home to workplace, academic qualifications) and professional information about the respondents (their bond to the institution, working hours, duties performed, school of work and tenure); Group II consists of the questionnaire *F-PSICO—Escala de valoración de los riesgos psicosociales* from the Spanish *Instituto Nacional de Seguridad e Higiene en el Trabajo* (which we adapted and translated), this choice being justified by the parity between Spanish and Portuguese realities at both socio-economic situation and the education system, and also because it is a method of identifying PRF. This instrument consists of 44 questions and assesses 9 psychosocial factors, namely: work journey length, autonomy, workload, psychological requirements, variety/content of labor, participation/supervision, concern about worker/compensation, performance and relationships, and social support (Cuixart & Bilbao, 2012). The questionnaire was in paper form, filled in by the studied persons. The descriptive and inferential statistical analysis of the responses was performed with SPPS 16.0 tool. The descriptive results are shown in Likert scales through a novel and clear distinction of answers allowed by the R language (R Core Team, 2014).

On the other hand, the qualitative focus of this study consists of semi-structured interviews with 11 randomly selected workers with more years of service, since these were longer exposed to working conditions. This approach enabled a more detailed analysis of the attitudes of the individuals under the PRF, and also allowed to know the professional and personal impact felt by them. After being transcribed to paper, the interviews were analyzed using NVivo 8.0 tool.

3 RESULTS

The descriptive results of the identification of PRF questionnaire and semi-structured interviews are as follows.

In socio-demographic terms, most respondents: are women (n = 143); are between 45 and 54 years

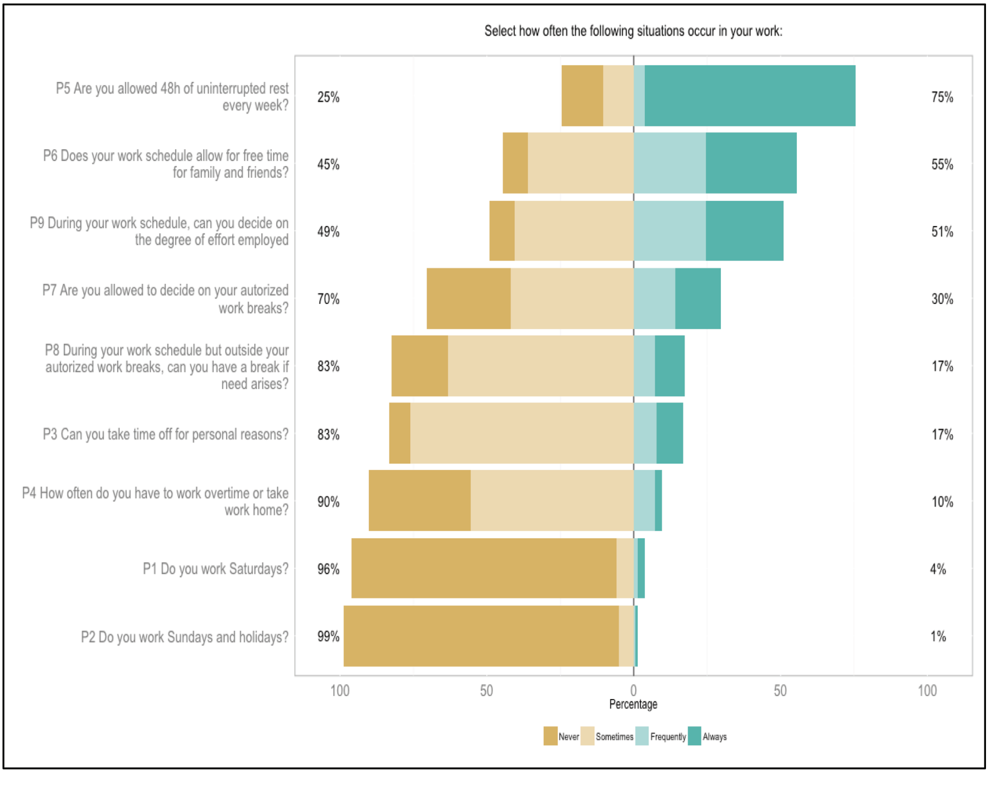

Figure 1. Relative frequency (%) of factors “time at work” and “(time) autonomy”.

old (n = 65); completed high school (n = 75) or the entire basic education (n = 45). The vast majority of individuals (n = 105) lives 5 kilometers far from their workplace. Most respondents belong to the permanent staff of the Organization (n = 86) or have an individual employment contract (n = 48). The overwhelming majority of the sample works in a complete schedule regime (n = 150). With regard to the functions performed, these are: Educational Support Operational Assistant (n = 93), Educational Support Technical Assistant (n = 25) and School Administration Technical Assistant (n = 23). The respondents have an average tenure of 16.6 years.

Among the nine PRF assessed in the questionnaire, in the factor "time at work", the individuals did not work on Saturdays, Sundays and holidays and they have 48 consecutive hours of rest during a work week. About the factor "(time) autonomy", these individuals are unable to deal with personal matters, or to decide on the regulatory and non-regulatory pauses (Fig. 1).

Regarding the factor "autonomy (in decision making)", these individuals are allowed to take decisions regarding the organization of their space, the quality and the way they do their work, but cannot decide on most aspects of their work (Fig. 2).

About the "workload" factor, the respondents are subjected to time pressure, namely on time allocated to the task, and compelled to work quickly and to accelerate the work pace (Fig. 3).

In the factor "psychological (cognitive) requirements", respondents report that, mostly, their work requires good memory and being creative (Fig. 4).

Some relevant findings whose figures are not shown, are: About emotional demands, most respondents report being "sometimes" exposed to situations with emotional impact (61.3%) and required to provide emotional responses (56.1%) (in this aspect, the interviewee A11 refers concern for *«the human environment experienced with co-workers»*, while the person A3 says that, emotionally, is affect by *«human relations»*); About "participation/supervision" factor, most individuals can only participate in decisions to change the way they work; In "concern by the employee/compensation" factor, they consider professional development as being insufficient (23.9%), or non-existent (43.2%); In factor "relationships and social support", the interviewee A3 refers to *«The interaction between people leaves much to be desired»* and that *«I think we are terrible for each other»*, while the person A8 mentions *«some worse, others better and this is a problem»* and that *«there is no team spirit»*.

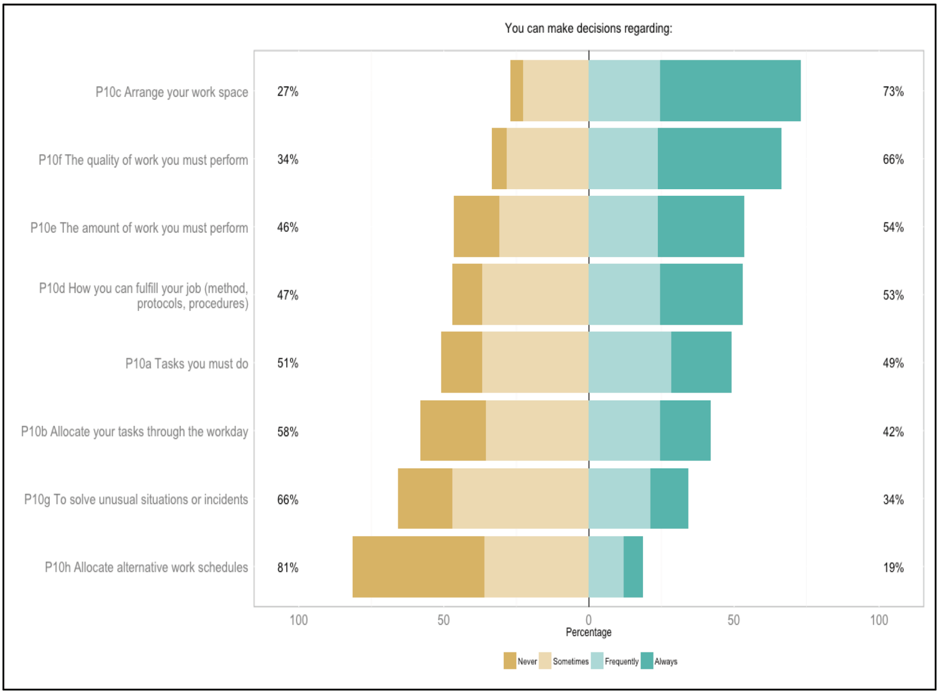

Figure 2. Relative frequency (%) of the factor "autonomy (in decision making)".

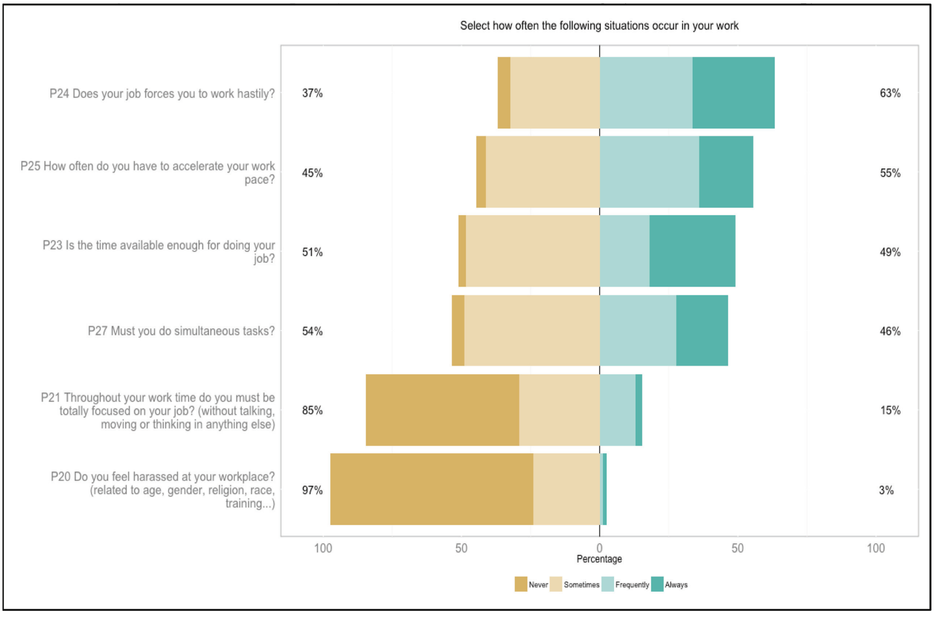

Figure 3. Relative frequency (%) of factor "workload (time pressure)".

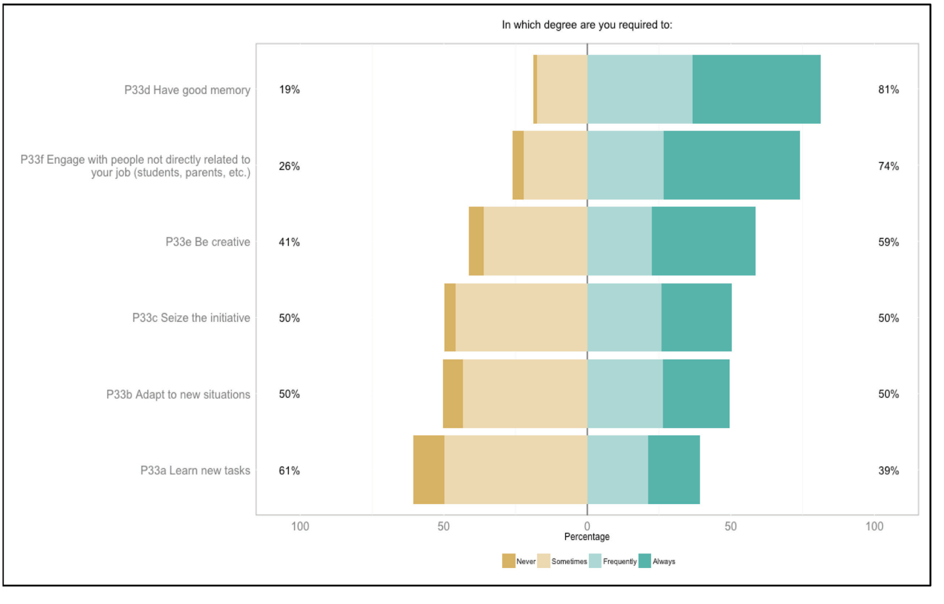

Figure 4. Relative frequency (%) of factor "psychological (cognitive) requirements".

4 DISCUSSION AND CONCLUDING REMARKS

The results suggest that non-teaching staff has the need to hide emotions and feelings and that some situations that affect psychologically relate to relationships with coworkers. This is consistent with the study of Remesal et al. (2007), in which numerous and varied psychosocial factors at work included the quality of human relationships. In terms of workload, a significant portion of individuals state that is interrupted in his work and performs multiple tasks simultaneously, dealing with a *«breakneck pace»*, *«intense»* and *«very full»* journey. About these aspects, Moncada et al. (2006) reported that the effects of work organization are manifested through various emotional, cognitive, behavioral and physiological mechanisms. PRF identified as affecting performance of non-teaching staff are: psychological requirements; (time) autonomy; workload; relationships; and social support. The results support that psychological demands are PRF that play an important role in professional performance, and are consistent with García-Herrero et al. (2012), which concluded that job requirements almost double the psychological symptoms (stress) and identified high interdependence between physical and psychological symptoms, as well as the relationship between these symptoms and work-related accidents.

Given the findings, the following measures are proposed to control the PRF identified: Development of informal communication between professionals; Adjustment of the total workload; Clear definition of roles and responsibilities of staff; Implementation of social activities; Access to support of psychology, social work and occupational medicine.

The inferential statistical findings of the present study will be the subject of a future paper.

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Changes in face and hands skin temperatures during exposure to moderate cold thermal environment

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ABSTRACT: Exposure to cold thermal environment was found to be a significant risk factor in industrial activities. The aim of this study was to simulate a repetitive cheese packing movement in a laboratory environment and investigate the influence of moderate cold on changes in hand and face skin temperature. Thermographic images were taken after ten and thirty-five minutes of exposure, in order to evaluate the influence cold on volunteers. Five volunteers were exposed to moderate cold and seven to thermoneutral temperature. All volunteers were female and in the first phase of the menstrual cycle. The findings of this investigation show that there is a big difference in skin temperatures between the left and right hand. Further investigation should be conducted in different cold thermal environment conditions, considering moderate and severe cold, considering both genders, but always considering the follicular phase when dealing with female volunteers.

Keywords: face and hands temperature changes; moderate cold exposure; thermography

1 INTRODUCTION

Exposure to cold thermal environment is a significant risk factor in industrial activities, present in outdoor during the winter season and indoor present in all seasons (Tochihara, 2005). Indoor exposure is mostly related to working activities in the fresh food industry with temperatures from 0 to 10ºC and frozen goods at temperatures below –20ºC, while cold exposure in outdoor activities is present in occupations such as marine, army, agriculture, forestry, mining, factory work, construction work and related occupations (Mäkinen et al., 2006). Outdoor exposure to cold is of particular interest for regions in high latitude environments where winter seasons last for several months (for example Finland with winter lasting for 3–7 months (Mäkinen, 2007). The degree of exposure to cold is dependent on several factors such as occupation, gender, age, health, exercise activity, and education (Mäkinen, 2007). Acclimatization to cold benefits on some aspects such as: norepinephrine response, hemoconcentration, and, in lesser amounts, skin temperature and systolic blood pressure (Leppäluoto et al., 2014). Decreasing of the body temperature resulted in increasing of the muscular strain which led to musculoskeletal disorders (Oksa, Ducharme, & Rintamäki, 2002), cooling of the tissues led to discomfort, deterioration of performance, work accidents (Mäkinen & Hassi, 2009) and increased likelihood of reporting low back symptoms (Dovrat & Katz-Leurer, 2007).

When exposed to cold temperatures, the body attempts to preserve the normal temperatures of vital internal organs. The first reaction is the blood flow diminution in the extremities. Therefore, hands should be measured in subjects' exposure to cold. To compare, face temperature changes should also be measured.

The infrared thermal imaging is often used to investigate changes in skin surface temperature distribution and to monitor the physiology (Autonomous nervous and microvascular systems) in real time for clinical assessment purposes (Ring & Ammer, 2012). Therefore, thermography was used in this experiment.

The cheese industry is a food industry where regulations imply that the air temperature should be below 10°C. Equipment and resources influenced the decision to conduct the experiment with the simulation of a cheese packing process, with moderate cold air temperature.

The aim of this study was to simulate and evaluate a working activity in a cheese industry and investigate the influence of moderate cold on changes in hand and face skin temperature.

The objective is to investigate face and hands temperature changes between.

- 10 min of exposure to cold (after a ten minutes habituation, before conducting the cheese packing task)
- 35 min of exposure to cold (after a ten minutes habituation, fifteen minutes cheese packing activity and ten minutes rest while being exposed to cold)

2 METHODS

2.1 *Subjects*

Five right handed female volunteers participated in this study. Their (mean ± SD) age was 23 ± 3.85 years old, mean body height was 165 ± 3.67 cm, mean weight was 58.5 ± 5.38 kg, mean body mass was 21.40 ± 1.81. All the volunteers were in a first phase (follicular phase) of the menstrual cycle, as it was found to be an important factor especially for the level of the body temperature (Janse de Jonge, 2003). The subjects were fully informed of the nature and purpose of the experiment, as well as the possible discomforts and risks involved discomforts. A written consent to participate in the experiment was read and signed by all subjects. Before the experiment started, nine questions were asked to the volunteers in order to evaluate possible bias factors. The questions related to medicine taking were regarding to any type of medicine, even if it was a headache pill. Furthermore, physical exertion was evaluated as –1 is the person conducted physical exertion less than usual in the last 12 hours, 0 for physical exertion as usual and +1 if the physical exertion was higher than usual. The menstrual cycle phase was checked by a telephone call prior to the volunteer's arrival.

2.2 *General experimental design*

When the volunteers arrived to the laboratory, their weight and height were measured; they answered questions related to their consuming, sleeping and physical exertion. After spending 20 minutes in the laboratory room with an air temperature from 25.6 to 25.9°C and relative Humidity (Hr) of 42–43%, they entered the climatic chamber. In the climatic chamber, air temperature was 10°C and relative humidity 30% during the cold temperature exposure, and 20°C and 30% Hr (control test) during the comfort temperature exposure. Each volunteer was once exposed to each thermal condition, once at a time. All volunteers were dressed in the same way. After entering the climatic chamber, the volunteers were asked to sit and perform a coin dexterity test for three times. The volunteers were considered to be stabilized after ten minutes, so the thermographic images were taken. Afterward, the volunteers were asked to sit once again, and put their hands on a carton box (used as a table) from which hands were photographed with a thermography camera. Volunteers' faces were photographed too. Fifteen minutes after the volunteers entered the climatic chamber, they were instructed how to perform a simulation of a repetitive work normally used in a cheese packing industry, performing it for the next fifteen minutes in a standing posture. The work was based on packing 1 kg of sand bag (simulating cheese packing process). The sand bag was located on the front-left side of the volunteers. The bag was taken by the volunteers with the left hand and put on a newspaper located in front of the volunteers and packed by using two hands into the newspaper, afterward to be taped by using the right hand. When the bag was packed, it was put on the front-right side of the volunteers by using both hands. At the end, 35 minutes after being exposed to the environmental air temperature, the second thermographic recording and dexterity tests took place again. The volunteers left the climatic chamber in total approximately 40 minutes after entering.

2.3 *Thermography*

Thermographic images were taken with the infrared camera FLIR A325 (resolution of 320 × 240 pixels, accuracy of ±2% of the overall reading and sensitivity of 0.05°C) and by using the ThermaCAM Researcher Professional 2.10 program. Thermographic images were processed by using the program ThermaCAM Researcher Professional 2.10. Temperature range was set from 15°C to 34°C. The thermography camera was turned on at least 30 minutes prior to taking images. Images were taken for two times: 10 minutes and 35 minutes after the volunteer entered the climatic chamber as it is illustrated on Figure 1.

Two images were taken each time: of both hands placed on the carton box (table) and the front part of the face from a distance of ~ 0.5 m.

On the figure 2, examined sections of the hands and face are illustrated.

2.4 *Control test*

For the control test eight volunteers were assembled (of which five were the same as in moderate cold tests). They were exposed to air temperature 20ºC and 30% Hr in a controlled environment (climatic chamber), conducting same tasks and by the same timetable as for the moderate cold test.

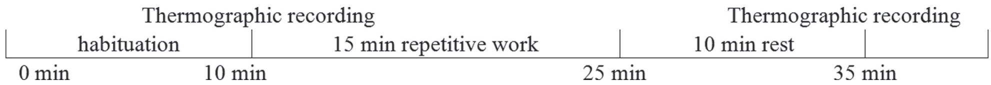

Figure 1. Diagram showing how the experiment was organized.

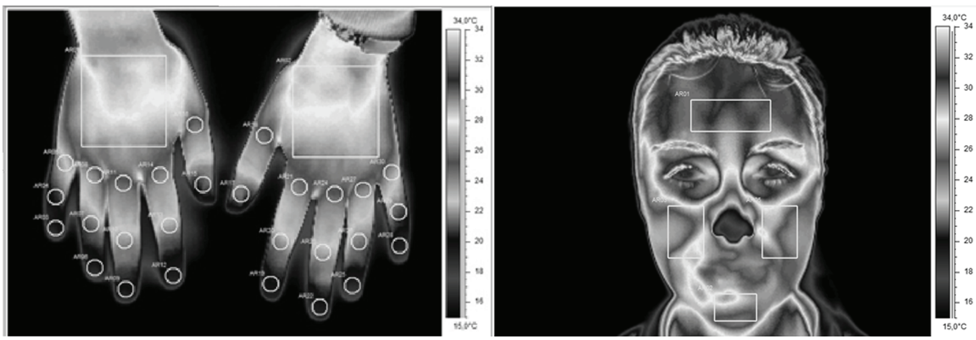

Figure 2. Examined sections of the hands and face.

2.5 *Biases*

There are several potential bias factors to consider. One bias factor was related to the volunteers evaluated, there were 5 volunteers for moderate cold test, which is a low number. When conducting an experiment in moderate cold, one volunteer consumed alcohol in the last 12 hours, prior to the test, which might have influenced the results.

3 RESULTS

3.1 *Thermography test*

One volunteer's results from the control test were not included in this paper as there were many bias factors (smoker, drink alcohol in the last 12 hours and sleeping for 2 hours during the night). When conducting an experiment on comfort temperature, one volunteer consumed alcohol and coffee in the last 12 hours, one more consumed coffee, and one consumed coffee and smoke cigarettes. The results of the volunteer V8 were not included in this study for reasons mentioned in the section 2.4. In the table 2, results of the thermography test are shown for hands, forehead, right and left zygomat region (cheek) and chin when exposed to air temperature 10ºC and relative humidity 30%. As it is illustrated, skin temperature of all measured parts declined from 1.4ºC (forehead) to 3.3ºC (right hand). From all measured volunteers skin temperatures were analyzed, and an average was calculated with a standard deviation. The difference from the skin temperature of body parts taken after 10 minutes of being exposed to moderate cold air temperature and the temperature taken 35 minutes after is illustrated in °C in the last column. In the table 1, thermography results of volunteers exposed to air temperature 20°C and relative humidity 30% are shown.

On figure 3, thermographic images of hands taken after 10 and after 35 minutes of exposure to air temperature 10ºC and 30% of relative humidity are illustrated, and on figure 4, thermographic images of the front part of the face taken after 10 and 35 minutes of exposure to air temperature 10°C and 30% Hr are illustrated.

4 DISCUSSION

While at the start point (10 minutes after being exposed) there were no significant differences in skin temperature of the left and the right hand, there is an almost 1.5°C difference in hand skin temperatures after 35 minutes of exposure. As all the volunteers were right handed, it was not possible to investigate if there was an effect on handiness. Potential bias might be laying in the working activity, which needs to be explored better. Using more one hand than the other (more left than the right) as it was described in the section "General experimental design".

Touching the cold product might have influenced the results as it might have cooled one hand more than the other, which was not found in the experimental results. In the table 3, differences in skin temperatures of different body parts considering the air temperature and exposure time are illustrated. Skin temperatures varied by 2.6°C (hands) and by 2.8°C (forehead) after 10 minutes

Table 1. Thermographic results from the experiments.

Air temperature and relative humidity	10°C and 30%				20°C and 30%			
	Exposure (min)	Average t (°C)	s.d.	Difference (°C)	Exposure (min)	Average t (°C)	s.d.	Difference (°C)
Right hand	10	28.16	± 0.97	3.30	10	30.80	± 1.22	0.31
	35	24.86	± 1.30		35	30.49	± 1.24	
Left hand	10	28.14	± 0.96	1.76	10	30.74	± 1.41	0.09
	35	26.38	± 0.76		35	30.83	± 1.27	
Forehead	10	30.78	± 0.65	1.40	10	33.58	± 0.46	0.00
	35	29.38	± 0.78		35	33.58	± 0.63	
Right zygomat region	10	28.58	± 0.99	3.08	10	32.45	± 0.67	0.89
	35	25.50	± 0.70		35	31.56	± 1.01	
Left zygomat region	10	28.42	± 1.00	3.14	10	32.35	± 0.65	0.84
	35	25.28	± 0.95		35	31.51	± 1.07	
Chin	10	29.26	± 0.92	3.12	10	32.79	± 0.73	0.48
	35	26.14	± 0.99		35	32.31	± 1.05	

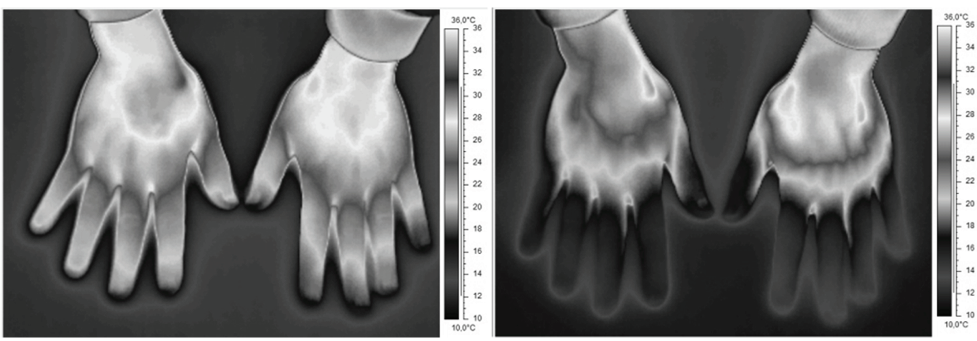

Figure 3. Thermographic images of hands after 10 minutes and 35 minutes of exposure to air temperature 10°C and relative humidity 30%.

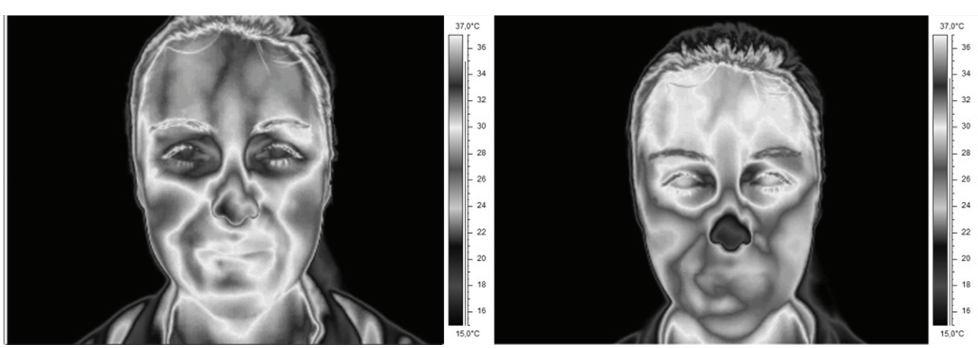

Figure 4. Thermographic images of the front part of the face after 10 minutes and 35 minutes of exposure to air temperature 10°C and relative humidity 30%.

of exposure, in between exposure to air temperature 10°C and 20°C. In the same way, skin temperature of the right and left zygomat region and chin varied from 3.5 to 4°C.

After exposure of 35 minutes, the difference become bigger, for the right hand 5.6°C, left hand 4.5°C, forehead 4.2°C and right zygomat region, left zygomat region more than 6ºC. Further investigation should be conducted on longer period exposure to 10°C, as for example for air temperature 4°C and relative humidity 80%, which is regulated for the similar food industries, as it is for example the meat industry (ISO, 2002). Thermography tests should be conducted in different cold thermal environment conditions, considering moderate and severe cold, considering both genders, but always considering the follicular phase when dealing with female volunteers. For statistically significant and consistent results, a larger group, with both handiness volunteers should be included in further experiments of this type.

5 CONCLUSIONS

The findings of this investigation show that there is a big difference in skin temperatures between the left and right hand when exposure to cold, when conducting a repetitive cheese simulation. While at the start point (10 minutes after being exposed) there were no significant differences in skin temperature of the left and the right hand, there is an almost 1.5ºC difference in hand skin temperatures after 35 minutes of exposure. The right hand was found to get colder after exposure to environmental conditions and while conducting a cheese packing process. In between exposure to air temperature 10ºC and 20ºC, skin temperatures varied by 2.6ºC (hands) and by 2.8ºC (forehead) after 10 minutes of exposure. After exposure of 35 minutes, the difference become bigger, for the right hand 5.6ºC, left hand 4.5ºC, forehead 4.2ºC and right zygomat region, left zygomat region more than 6ºC. Thermography tests should be conducted in different cold thermal environment conditions, considering moderate and severe cold, considering both genders, but always considering the follicular phase when dealing with female volunteers. A larger group of volunteers should be included in further experiments of this type. Further investigations should be conducted regarding volunteer's subjective analysis, points of view and sensations during the simulation.

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Thermographic assessment of a physiotherapy related upper limb task: Preliminary study

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ABSTRACT: The burden of work-related musculoskeletal disorders is increasing. The prevalence of these disorders among health care providers is very high. Physiotherapists are at risk of developing acute or cumulative injuries and little research has been done on the occupational demands of this profession. The aim of the research is to analyze the effect of a passive mobilization technique in the skin temperature of the upper trapezius muscle. Four final year students of a physiotherapy graduation course were recruited and a passive mobilization task was simulated and assessed with thermal imaging. The mobilization task increased skin temperature of the dominant side and affected thermal symmetry in all participants.

1 INTRODUCTION

The term "Work-Related Musculoskeletal Disorders" (WRMD) represent a group of conditions affecting the musculoskeletal system derived and intensified from the exposure to occupational demands (Luttmann et al., 2003). Regardless of the number of research studies on the subject, the burden of WRMD to individuals and the society is unquestionable and increasing. According to the American Federation of Labor and congress of Industrial Organizations (2014) these disorders were responsible for 34.7% of all serious workplace injuries in 2012. The number of days away from work due to WRMD increased 1 day to a median of 12 days in 2012 (Bureau of Labor Statistics, 2013).

The functional capacity of the musculoskeletal system is mostly assessed using questionnaires, functional tests and observational methods. This evaluation is important to indentify the risk of musculoskeletal disorders, to assess the results of occupational interventions and for research. The pros and cons of each method have been discussed previously (Barrero et al., 2009, Wind et al., 2005, Takala et al., 2010) and the need for research in new technologies to assess risk factors and task demands has been identified (Govindu and Babski–Reeves, 2012).

Forceful static or repetitive muscle contractions lead to the compression of the vascular microstructures, changing the blood supply of the involved tissues (Kumar, 2001). Several studies have related the presence of WRMD and disturbances in blood flow (Pritchard et al., 1999, Brunnekreef et al., 2006, Gold et al., 2010).

Skin temperature is influenced by complex heat exchange processes between the skin, deep tissues, blood vessels and metabolism (Merla and Romani, 2005). Thermal imaging provides information regarding the vasomotor function related to skin temperature regulation (Jiang et al., 2005). Thermal symmetry reflects normal physiology and is defined as the degree of similarity between two regions of interest mirrored across the human body longitudinal axis (Vardasca et al., 2012). The validity and reliability of thermography to measure skin temperature has been documented (Burnham et al., 2006) and skin temperature may be used as a complementary diagnostic tool or as an objective outcome measure (Ring and Ammer, 2012).

Health care professionals are highly affected by musculoskeletal system complaints. Physiotherapists perform several tasks that increase the risk of acute or cumulative WRMD such as transfer and lifting patients, assisting patients in gait and manual therapy techniques (Bork et al., 1996, Nordin et al., 2011), such as passive mobilization. The knowledge and training of these professionals about musculoskeletal health does not confer immunity to their own disorders (Bork et al., 1996). Lifetime prevalence, 12-month prevalence and one-week prevalence have been used to acesss the magnitude of WRMD among physiotherapists. Regardless the methodology adopted, the prevalence reported in the literature is very high and the most reported body regions are the lower back, the shoulders and the neck (e.g. Chung et al., 2013, Alperovitch-Najenson et al., 2013, Nordin et al., 2011), affecting the functional capacity of the musculoskeletal system of these professionals. Current evidence lacks research regarding the occupational demands imposed to physiotherapists using objective outcome measures. Therefore, the aim of this study is to analyze the effect of a passive mobilization technique in the skin temperature of the neck and shoulder of the subject performing the mobilization.

2 METHODOLOGY

2.1 *Subjects*

Four final year male students of a physiotherapy graduation course were recruited. Participant age (25.25 ± 2.06 years), weight and height were collected and body mass index was calculated (22.13 ± 1.43 kg/m^2). The volunteers were healthy and were screened to exclude history of pathology. No cardiovascular, neurological, metabolic or musculoskeletal diseases and no medication affecting these systems were self-reported. The study was approved by the ethics committee of the Fernando Pessoa University and all participants gave their written consent to participate in the study after the procedures and any risk or discomfort associated with the experiment were explained. Subjects were asked to avoid coffee, alcohol, smoking and any intense physical activity at least 12 hours prior to the study.

Each participant was evaluated a single day in which three skin temperature measurements were performed, before, immediately after and five minutes after the mobilization task.

2.2 *Equipment*

A thermal camera (FLIR A325, FLIR Systems, Wilsonville, USA), properly calibrated, with a resolution of 320 × 240, sensitivity of 70 mK and accuracy of ±2% was used to measure skin temperature. The software ThermaCam Researcher Pro 2.10™ was used for image capture and analysis. An electronic metronome was used to pace the passive mobilization technique.

2.3 *Procedures*

2.3.1 *Thermographic capture protocol*

The recommendations of previously published literature to capture thermal images were followed (Schwartz, 2006, Ammer, 2008). To achieve stable thermal readings the camera was switched on 40 minutes prior to the beginning of the experiment. The emissivity was set to 0.98 and the temperature scale set from 25 to 35ºC. Participants were asked to undress and remain still during a 15 minute acclimatization period. Room temperature was controlled in all measurements (21.78 ± 0.25ºC), humidity was less than 50% and no air flow was present. Thermograms of the upper back were obtained before, immediately after and 5 minutes post-mobilization task. The region of interest selected for analysis was located in the area of both upper trapezius muscles (Fig. 1) due to its role in the analyzed occupational task. The number of pixels in both regions of interest

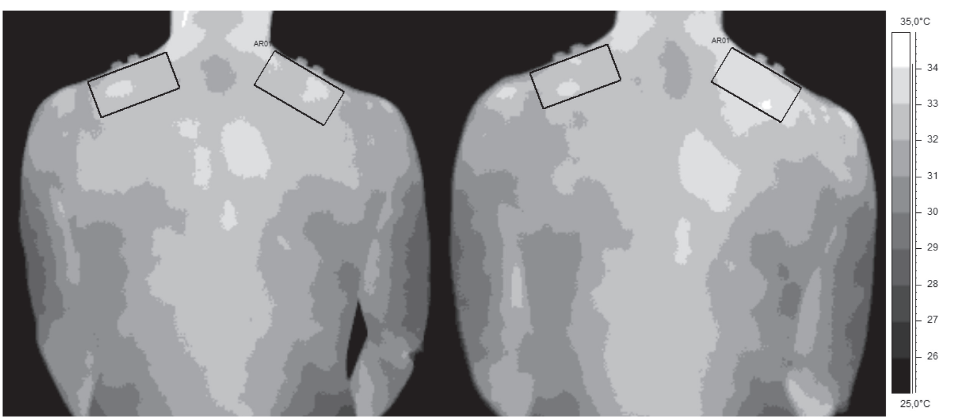

Figure 1. Example thermograms from baseline and five minutes after mobilization.

was the same for each subject. Mean temperature values of selected regions of interest were computed for analysis. Thermal symmetry was calculated as the absolute value of the difference between the temperatures of the right and left side.

2.3.2 *Passive mobilization protocol*

The mobilization task demanded to the participants consisted in passive hip mobilization to hyperextension, with the dominant upper limb, during a 4 minute period. The task was paced by an electronic metronome at a rate of 20 mobilizations per minute. The subject being mobilized was the same for all volunteers and remained in prone position during the experiment.

3 RESULTS

Our findings will be presented concerning the evolution of skin temperature and thermal symmetry before (M1), immediately after (M2) and 5 minutes post-mobilization (M3) task.

3.1 *Skin temperature evolution*

Immediately after the mobilization task, skin temperature in the dominant upper trapezius muscle area decreased in two subjects, remained the same in one subject and increased in one subject. Five minutes after the mobilization task, skin temperature had increased in all subjects for at least 0.6ºC (Table 1).

In the non dominant upper trapezius muscle area, skin temperature decreased in all subjects immediately after the mobilization task. Five minutes after, skin temperature was lower than baseline in three subjects and 0.3ºC higher in one subject only (Table 2).

Figure 1 illustrates example thermograms from baseline and five minute after the mobilization task with clear changes in temperature distribution.

3.2 *Thermal symmetry*

Thermal symmetry was affected by the mobilization task, increasing immediately after mobilization and even more 5 minutes after the task (Table 3).

Table 1. Skin temperature values (ºC) in the dominant upper trapezius.

	M1	M2	M3
Subject 1	32.80	32.30	33.50
Subject 2	33.60	33.20	34.20
Subject 3	33.40	33.40	34.20
Subject 4	32.20	32.50	33.30

Table 2. Skin temperature values (ºC) in the non dominant upper trapezius.

	M1	M2	M3
Subject 1	32,70	31,50	32,70
Subject 2	33,40	32,60	33,20
Subject 3	32,90	32,30	32,80
Subject 4	32,10	31,80	32,40

Table 3. Thermal symmetry values (ºC).

	M1	M2	M3
Subject 1	0.10	0.80	0.80
Subject 2	0.20	0.60	1.00
Subject 3	0.50	1.10	1.40
Subject 4	0.10	0.70	0.90

The difference between the skin temperature of the right and left side increased as a result of the temperature changes in the mobilizing side.

4 DISCUSSION AND CONCLUSION

To date this was the first attempt to assess skin temperature during a passive mobilization task. Thermal imaging has been used to assess risk factors and task demands in computer use (Gold et al., 2010), pipetting (Govindu and Babski–Reeves, 2012), textile industry (Camargo et al., 2012) and overhead activities (Barker et al., 2006, Bertmaring et al., 2008).

The main findings of this study were that skin temperature varied differently in the dominant and non dominant side and affected thermal symmetry. The dominant side, that performed the mobilization task, evidenced an increase in skin temperature in all subjects after five minutes but these findings were not observed in the non dominant side. Gold et al. (2004) obtained similar results during a typing task, whereas skin temperature increased until 3–5 minutes after typing and decreased after 8–10 minutes.

Thermal symmetry values reflected the increase in skin temperature observed in the dominant side as a result of the mobilization task. Reference data from previous studies indicates that thermal symmetry in the selected region of interest was 0.31 ± 0.23ºC (Uematsu et al., 1988) and 0.40 ± 0.30ºC (Niu et al., 2001). In our study thermal symmetry values before the mobilization were 0.23 ± 0.19ºC but the value increased 0.80 ± 0.22ºC and 1.03 ± 0.26ºC immediately and 5 minutes after the task, respectively. According to Vardasca et al. (2012), values of thermal symmetry above the maximum found in reference samples can be used to assess musculoskeletal injuries that manifest unilaterally, affecting skin thermal patterns. Our results suggest that regular assessments with thermal imaging may detect changes in thermal symmetry that could be related with overload in the musculoskeletal system.

Despite the limitations in the study the methodology proposed to evaluate the mobilization task allowed to monitor skin temperature without interfere with the subject and provided objective physiologic measurements associated with microcirculation. The use of false colour thermograms provided fast and easy subjective analysis of the temperature distribution. The passive mobilization technique increased the skin temperature in the upper trapezius and increased the temperature differences between the dominant and non dominant side.

A larger study is required to strengthen our results and further research is required to understand the relationship between working experience and temperature changes and to compare the effect of task duration in skin temperature changes.

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Quantification of ATP in surfaces, health and hygiene standards, assessment of knowledge level, attitudes and practice from food handlers in industrial establishments of Ovos Moles in Aveiro district

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ABSTRACT: The quality and food safety is a public health issue that exists and has evolved under the most diverse perspectives. In order to ensure the safety of consumers, is of the utmost importance assess the quantification of Adenosine Triphosphate (ATP) in surfaces and hands of handlers, as also check the health and hygiene standards of each establishment, knowledge and good practice. Checklists were applied in the three industrial establishments of Ovos Moles in Aveiro district, as well as questionnaires and quantification of ATP in the handler's hands and surfaces. According to the obtained results, it was concluded that the age, level of education and training of food handlers didn't influence the knowledge, attitudes and practice on the manufacturing process of Ovos Moles and Hóstias, as well as their own personal hygiene. The ATP method bioluminescence has detected organic matter in all samples collected, where it was found a higher ATP level was in handler´s hands. These results indicate a need for awareness raising and training of handlers before the cleanness process and good hygiene.

1 INTRODUCTION

Food Safety is one of the most important and major problems of public health, since it is related with the hazards presence associated the food at the time of its consumption. This is defined as a set of standards for the production, transport and food storage, taking into account the dangers physical, chemical and microbiological, which can occur at any step of the food chain. (ISO 22000, 2005). During the food handling there is a contamination chance, which is defined as the presence of any material unusual in a food, whether it be chemical, physical or biological. This process is defined as cross contamination, which is a substances transfer or microorganisms harmful to human health, a source contaminated for a food that isn´t contaminated or ready for consumption. Thus, the operators in the food sector are the main responsible for the safety of food-stuffs, which should ensure that all stages of production, processing and distribution that are under your control, satisfying the relevant requirements of hygiene (European Parliament, 2004). Compliance with the hygiene rules and safety is essential to a good food quality and the consumers health. The inadequate handler´s hygiene, equipment and installations where are preparing foodstuffs are a frequent contamination cause that can lead to disease in consumers. The Adenosine Triphosphate (ATP), an important intracellular energy source, is present in the cells of all living beings, being used in various cellular functions, and plays an important role in the exchange of energy in biological systems, serving as a donor of energy. The Waste of food products contain high ATP quantity, as well as the microbial cells. After equipment sanitization and surfaces in contact with food products, the amount of ATP should be reduced (Ferreira, 2009). With the sampling devices of ATP by bioluminescence, extremely low levels of contamination can be detected in seconds, allowing a fast determination of the efficiency of cleaning and hygiene status of surfaces, validating the control programs, increasing the safety of food, improving the quality of the products and by reducing the costs (Cabral & Pottker, 2003). Ovos Moles of Aveiro were the first traditional sweet Portuguese to be certified and the first sweet conventional to achieve the same status in the European Union. In such a way as to ensure their quality, the producers created the APOMA—Association of Producers of Ovos Moles of Aveiro, imposing the fulfillment of certain conditions in the manufacturing process, as described in the Specifications of the Ovos Moles of Aveiro, so that they will be able to distinguish the real Ovos Moles or falsifications (Ovos Moles de Aveiro, 2013).Ovos Moles of Aveiro is the product obtained by the egg yolk junction in a sugar syrup, following the traditional mode. These may be in wooden barrels, porcelain or involved in hóstias. That hóstia is made from wheat flour, vegetable oil and water. The process flowchart of Ovos Moles and Hóstias manufacture, from the maneuvering because of materials processing, should be organized in such a way as to prevent the contamination of raw materials, packaging materials, semi-finished products and finished products. Relevant measures must be taken in order to minimize the risk of cross-contamination (APOMA, 2004).

This research aims to evaluate the health and hygiene standards of industries under study, assess the level of knowledge, attitudes and practice of food handlers in relation to the manufacturing process and personal hygiene, but also quantify ATP levels present on surfaces and food handlers hands.

2 MATERIAL AND METHODS

The development of this study was based on a set of three industrial establishments for the production of Ovos Moles in district of Aveiro, being one of them specializes in the manufacture of unique Hóstias for Ovos Moles. In the first phase data collection, was drawn up an adaptation by researcher, a check-list, which was applied to each industrial establishments, taking into account the legislation in force, which evaluated the health and hygiene standards and finally handlers and service. Even in this field has been applied a questionnaire prepared by researcher at all handlers, which was divided into two parts. The first dealt with the data socio-biographical and training in hygiene and food safety. The second evaluated the knowledge, attitudes and handler´s practice, which included the manufacturing conditions process of Ovos Moles and Hóstias, as well as personal hygiene. In the second phase took place smears sampling of ATP quantification on flat surfaces, having always pay attention to the total area and the hands of handlers. For the collection of the sample we resorted to a correct hand hygiene and use of personal protective equipment, in particular, sterile gloves, cap, gown and disposable protection to shine. The equipment used for harvesting was the system of monitoring of hygiene 3M Clean-Trace™ Surface ATP (3M Cleantrace NG3 Luminometer. The values obtained by the equipment are given in RLU (Relative Light Units). The limit value, was considered the value of 500 RLU, on the basis of the indications of the manufacturer, as well as earlier work used (Ferreira, Rigotti, Andrade, Watanabe, & Guerra). The statistical treatment of the data was performed with the software IBM® SPSS® Statistics version 21.0 for Windows. The interpretation of statistical tests were based on a significance level p-value≤0.05 with confidence interval (C.I.) of 95%.

3 RESULTS

Taking into account the checklists applied to each industrial establishment, it was observed that in the section "***General conditions of Installation***" has completed in 97.9% the conditions. The section "***Area of Manufacture***" has approximately 94.4% of the conditions necessary for the proper functioning of the industrial establishment. In relation to *"**Storage Area",*** this section fulfilled the conditions in 92.2%. In general, the "***Section Storage***" has 91.6% of compliance. The sections **"*Area to the Public/ Selling Area***" and *"**Premises for service personnel***" were fulfilled in all operating conditions (100%). The section "***Operating Conditions***", in the industrial establishments complied with 97.6% of conditions. The section of "***Units of Distribution***" was as quote end 66.6%. Finally, the section "***Personal Handler***" has fulfilled all of the operating conditions (100%). Given the questionnaire applied to handlers of Ovos Moles and Hóstias, according to their biographic data, we observed initially that the majority of handlers were female (95.8%) and the mean age was 38.12 ± 9.70 years. The majority of respondents completed the High school (50%) and only one has the Higher Education (4.2%). In relation to the years that have handlers Service, the average was 12.40 ± 7.51 years and years working in industrial establishment were 10.45 ± 8.09 years. Analyzing the Training in Hygiene and Food Safety (HFS), it was found that 87.5% of respondents indicated that training in HFS. The handlers that have training in HFS, 10 (41, 7%) had less than 30 hours of total training, two (8.3%) had between 31 to 60 hours, one (4.2%) had between 61 and 90 hours, two (8.3%) had more than 120 hours and nine (37.5) not answered. In relation to the total number of training hours that respondents had in the last year, seven (29.2%) had less than 10 hours, one (4.2%) had between 15 to 20 hours, three (12.5%) had between 21 and 30 hours, two (8.3%) had more than 30 hours, and 11 (45.8%) did not answer. Taking into account the last action of training, six of the respondents (25%) were less than 6 months ago, seven (29.2%) had between 6 months to 1 year, six (25%) had between 1 to 3 years and five (20.8%) did not answer. With respect to knowledge about the HACCP system, 22 of the 23 handlers who responded had knowledge (91.7%) and also know that this is implemented in its industrial establishment. Of the 24 respondents in total, 21 (87.5%) answered that they had knowledge about the Specification of Ovos Moles of Aveiro, but only six (25%) is that the consulted in any way.

According to Table 1, it was observed that there was no significant correlation between the number of service years with the attitudes and between the years working in industrial establishment with the knowledge and attitudes ($p > 0.05$). However there were significant correlations between the number of service years with the knowledge and good practices, as well as between the years working in industrial establishment and the good practices and we conclude that these correlations makes the handlers, who working in this area a few years ago has more knowledge about good practices for handling existing in this industrial establishment and handlers who work in this industrial establishment for some years they had good handling practices.

In order to quantify ATP on surfaces and hands of food handlers was performed sampling for this purpose. The places where he held the smear were on benches, box/tray, press, nozzle, bag and hands, in total were collected 24 samples.

Table 1. Correlation between the variables Years of service, Years working in industrial establishment, Knowledge, Best Practices and Attitudes of handlers.

	Knowledge	Good practises	Attitudes
Years of service			
r	0.603	0.688	0.327
p-value	0.008	0.002	0.186
n	18	18	18
Years of work in industrial establishment			
r	0.409	0.449	0.324
p-value	0.066	0.041	0.152
n	21	21	21

Test: Coefficient of Pearson's Linear Correlation Legend: r—coefficient; p-value—Significance Level; n—Sample Number.

Table 2. Table on the average of the Quantification of ATP in each type of surface.

	n	Mean (RLU)	Standart variance	X^2; gl; p-value
Benche	5	164.20	71.440	12.555
Box/tray	3	400.33	528.112	3
Press	2	129.00	164.049	0.006
Hands	12	1023.75	669.007	
Total	22	662.05	658.692	

Legend: n—Sample Number; X2—Test Chi-square; GL—Degrees of Freedom; p-value—significance Level.

Table 2 presents the descriptive frequencies on the Quantification of ATP on surfaces and hands. The significance level of 0.006 (< 0.05), which concluded that there are significant differences for the associated groups, respectively, type of surface and quantification of ATP. There are mentioned the types of surface nozzle and bag, since its sample was collected once and were not statistically significant. The differences detected in Table 2, are located between the surfaces Bench—Hands. We sought to compare the average obtained in each industrial establishment and the types of surface with the limit value established, values that are compared in Table 3.

Table 3 represents the average and difference in the mean of each industrial plant and type of surface in comparison with the threshold value set—500 RLU. In relation to industrial establishments, it can be observed that with the largest mean difference is the industrial plant B, with value of –224.60. On the types of surface, it can be seen that where there is the greatest difference, with the value of 523. 80 is in the hands, which means that the hands have a higher indicator of contamination, since it has higher values of ATP.

4 DISCUSSION

After the analysis of the results obtained, it can be stated that in general the conditions existing in the "Area to the Public/Area of Sale", "Facilities for the service personnel", as also "Personal handler" are completely appropriate since in all industrial establishments were not checked unsatisfactory situations. However, were identified some shortcomings, in particular, the absence of independent access and exclusive for

Table 3. Comparison between the media and respective difference with the limit value (500 RLU).

		N	Mean	Difference of mean	Standart variance	T; GL; Sig.
Industrial establishment Limit value = 500 RLU	A	8	907.0	407.0	849.32	1.36; 7; 0.217
	B	8	275.4	–224.60	213.36	–2.98; 7; 0.021
	C	8	670.5	170.50	614.76	0.78; 7; 0.458
Type of surfaces Limit value = 500 RLU	Benche	5	164.2	–355.80	71.44	–10.510; 4; 0.000
	Box/tray	3	400.3	–99.70	528.11	–0.327; 2; 0.775
	Press	2	129.00	–371.0	164.05	–3.198; 1; 0.193
	Hands	12	1023.75	523.80	669.00	2.712; 11; 0.020

Legend: N—Sample Number; Statistical Test—t-student ; GL—Degrees of Freedom; Sig—Significance Level.

the personnel, raw materials and fuels, absence of non-slip floor, food waste are not deposited in proper containers, sealed and kept in good conditions, one of industrial establishments shows distribution absence units and were detected some luminaires without protection and cabinets congested. Is important improve the functioning of these industrial establishments, it is proposed to replace it with a non-slip floor, regular washing windows, proper containers for food waste, luminaire's protection and relieving some spaces deemed necessary (Parlamento Europeu, 2004). Taking into account the results of the questionnaire, it can be concluded that the training at HSF handlers is adequate, since in 24 handlers, only two do not have this training. All food handlers must be aware of the importance of the conditions imposed by this book, because the Ovos Moles of Aveiro are a traditional product and as such has Protected Geographical Indication. (Ovos Moles of Aveiro, 2013). In accordance with the results obtained on the Knowledge, Attitudes and Practice of food handlers in the production conditions of Ovos Moles and Hóstias and personal Hygiene you can confirm that over the years that the manipulators have worked both in the area food safety and industrial establishment makes that have more awareness and knowledge about the manufactures conditions of ovos moles and hóstias. In this way, controlling the health of food handlers, establish operational procedures standardized specifications and define good manufacturing practices, will certainly contribute to improving the quality, hygiene and food safety (Souza, 2005). In this study also emphasizes the importance of ATP quantification, because sometimes the sanitization is inadequate on surfaces and hands, having as objective detection of the organic quantity matter in each of the areas chosen and manipulator's hands. This choice also had as a basis all surfaces that are in contact with the product in this case is the area of packaging, because the product is exposed to the ambient temperature. According to the analysis of the results, it is concluded that most of the samples, which correspond to the hands of food handlers, is above the threshold value (500 RLU), with an average of 1023,75 ± 669.00 RLU. In support of this analysis, it is considered that a surface is classified as clean when the value of ATP is smaller than 500 RLU (Ferreira, Rigotti, Andrade, Watanabe, & Guerra). These results should be very possibly due to the characteristics and the skin´s micro topography. To better control these results, all handlers must keep a high personal hygiene, make healthful your hands frequently with soap liquid disinfectant and hot water, in order to avoid cross-contamination. To improve the existing good practice in these industrial establishments should avoid the food contamination and the environment they are in contact with contaminants (C. M Porto, 2009).

5 CONCLUSION

After the completion of this research work it was possible to conclude it was found that the sections that showed an overall compliance greater was the "Public Area/Area of Sale", "Facilities for the service personnel" and "Personal Handler", and the smaller, the "Units of distribution". It is crucial maintain and improve the good practices and the pre-requisites in order to ensure the proper functioning of these establishments. In the study carried out in the Knowledge, Attitudes and handlers Practice of Ovos Moles and Hóstias it is concluded that the age, level of education and training Food Hygiene and Safety did not influence the levels of knowledge, attitudes and practice. The years in which the handlers were working in industrial establishments, influenced the Knowledge about the process of manufacturing of Ovos Moles and Hóstias and personal hygiene as well as the Good handling practices. The use of the method of ATP bioluminescence allowed rapid results and immediate to the interpretation of the results was easy and effective. This showed the presence of organic matter in all samples collected, however, it is concluded that the surfaces cleaning of each industrial establishment is favorable because most of the levels of ATP were below the limit (≤ 500 RLU). Highlights are the high levels of ATP found in the hands of food handlers. There is a need to revise the hygiene habits of handlers of establishments in study, particularly regarding the correct sanitization of hands, as well as the training handler´s food. A limitation of this study was the lack of a search for the identification of microorganisms, since the ATP method doesn´t qualify the contamination type. In order to make this work more expected, suggests the implementation of microorganisms identification present in each establishment, because this way the suggestions given will have a better effect in both owners and handlers and the information provided will be much greater. So this research become more complete should cover more industrial establishments as also pastries, which produce Ovos Moles and Hóstias, with certification of Association APOMA. The education and training for issues such as cleaning and disinfecting plays a crucial role, being, however, necessary that the food handlers demonstrate a responsible attitude, cooperative and, above all, a high level of professionalism.

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Occupational health and work safety at a car wash in Campina Grande, Brazil

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ABSTRACT: This paper was based on a study in a car wash in Campina Grande, Brazil. Its purpose was to assess the environmental conditions and the specifics worker's health risks in the workplace. The methodology consisted of literature and risk assessment, by applying checklists and questionnaires to investigate the usability of personal protective equipment. Measurements of thermal and acoustic variables were taken, as well as aspects of severity, urgency and trend of the workers risks in the workplace were considered. The results showed that the agents of chemical and physical risks are the potential cause of discomforts and complaints of workers and should be implemented primarily measures of control. The non-use of suitable gloves and masks exposes the workers to agents that can bring skin diseases, lung diseases, and even cancer. The environment was considered uncomfortable because it presents values of noise and temperature greater than the required by Brazilian law.

1 INTRODUCTION

The Federal Constitution says that the worker has the right of healthy protection, physical and moral integrity and security on the execution of his activities. The technological and organizational innovations have caused major changes in the workplace, leading to a new relationship between the workers and the jobs exposing workers to new risks to their health. The work has occupied an important space in people's lives, as they spend a significant portion of time inside of organizations. Thus, the work environment must be a safe, motivating, enjoyable and also satisfying to meet the desires of each individual. The work represents an important value to society, since it is something that defines personal identity, elevates the status and boosts the growth of the human being (Aquino et al., 2012).

Historically, safety and health are issues that concern humanity. One of the expressions of capital conflict and work with greater impact over health is, undoubtedly, the wear produced by the poor conditions of the work environment and by the work processes that involve great risk.

Thus, the main objective of this study was to evaluate the environmental conditions and the specific risks to the worker health in the workplace, emphasizing the physical, chemical, ergonomic risks and accidents of a company car wash in Campina Grande—PB, Brazil.

1.1 *Theoretical foundation*

The work safety refers to the measures that sees prevention and elimination of all and any kind of accidents risks, occupational diseases, always seeking the well-being of employees.

According to estimates of the International Labour Organization (ILO), 321000 deaths occur by year caused by accidents at work and about of 2.02 million deaths caused by various types of illnesses related to work, which equates to a daily average of more than 5500 deaths.

These data reflect the importance of work safety as a management tool that will fit the work environment by eliminating and/or reducing the risks inherent to activities, the costs involved in an accident, making the environment work conductive for activities enhancing worker productivity.

1.1.1 *The work safety on car wash jobs*

According Reis et al. (2010) the car wash, establishments with a growing presence in towns, have emerged with the purpose of becoming facilitators of life of people who want their cars clean and do not have enough time to devote to their cleaning time.

According to the Brazilian Regulatory Standard #4 (NR-04), which deals about the Specialized Services in Safety Engineering and Occupational Medicine—SESMT, the car wash correspond of a repair work and maintenance of motor vehicles, whose degree risk is three (3).

Thus, this type of service requires not only a good space for machines, for operation and maneuvering and parking of vehicles, an efficient infrastructure of electrical and hydraulic installations, and care with the chemical products used but, also, a type of special care to the worker that performs services of car wash, because they will be exposed to risks such as accident, ergonomic, physical and chemical and should, in cases of lack of risks control on sources, at least make use of certain types of Personal Protection Equipment (PPE).

2 MATERIALS AND METHODS

2.1 *Identification of production unit*

The research was done on a car wash in the city of Campina Grande, Paraiba, which operates in the market for four years providing car cleaning service and has four employees directly linked to production and another one at administration, and, works of Monday to Saturday, 48 hours per week.

Because it is a micro company, it does not havea well-defined process, the employees are not effectively trained to perform their duties and there is no concern for safety. Given this scenario, there was the possibility of carrying out the proposed study.

2.2 *Methodological procedures*

The collection of qualitative data was performed by applying of check sheets and semi-structured interviews allowing the respondents to answer the questions freely, being interviewed the manager of the car wash and four employees, this step was held for five days during the month of April 2014. To measure air temperature, relative humidity and noise it was used an equipment of measurement of the type, level meter—light meter—thermometer—hygrometer digital (model 400 THDL, manufacturer Instrutherm). The measuring of black globe temperature was also performed, using a globe thermometer, located in the geometric center of the work space.

Regarding temperatures, these were obtained by measurements taken every fifteen minutes during the period of 9 h 00 min to 12 h 00 min for five days. The equipment that helped this collection were the black globe thermometer, which was properly positioned at the midpoint of the car wash, at hight of 1.5 m and the thermometer which has provided us the dry bulb temperature.

3 RESULTS AND DISCUSSION

3.1 *Usability of Personal Protective Equipment(PPE)*

It was observed that there is a requirement for use of PPE in the activities of the car wash. As foreseen in the Brazilian Regulatory Standard #6 (NR-6), which deals with Personal Protective Equipment—PPE, the company supplies: gloves, mask, goggles and boots, but not supervises their use. However the staff did not receive training regarding the specific use of these equipments, since inappropriate use or non-use can cause damage effectively dangerous to health and the integrity of the worker. It was possible to identify all employees used a type of PPE, and the others were saved because they think it is irrelevant and uncomfortable uses.

3.2 *Analysis of the thermal aspects*

In the workplace studied was identified an average ambient temperature of 31.9°C, exceeding the values established in the Brazilian Regulatory Standard #17 (NR-17), which deals with Ergonomics. Thus, it can be inferred that the work in this environment is not permitted without

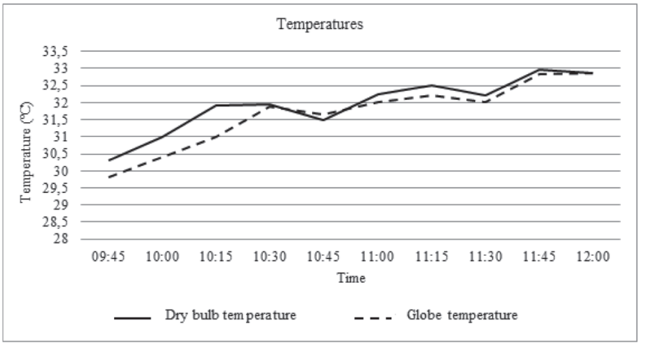

Figure 1. Temperature vs. time.

Table 1. Values of the noise level with the water pump turned on.

Values	Decibel (dB)
Minimum value	69.80
Maximum value	91.00
Average	76.86

Table 2. Values of the noise level with the vacuum cleaner operating.

Valores	Decibel (dB)
Minimum value	60.90
Maximum value	78.60
Average	70.36

taken appropriate control measures for temperature, making the environment more comfortable for the employee to carry out his work activities. Thus, by analyzing the chart, it is perceived that both temperatures (globe and dry bulb) are higher when the time is approaching noon. And can now be considered to be uncomfortable for the worker, based on the NR-17, which provides a comfortable dry bulb temperature between 20°C and 23°C.

The work environment studied, despite having a tent that has the intention to protect against the sun and heat, it can still be considered an environment with solar load. Because of this, should receive control measures, such as the use of Collective Protection Equipment (CPE) such as fans, to ensure that workers are not adversely affected by the heat that will be exposed.

3.3 *Analysis of the acoustic aspects*

Besides being exposed to ambient noise, carwash workers studied also work with the noise emitted by the water pump and the vacuum cleaner. Therefore, an analysis was performed for this risk, which happened in a simplified way due to the short time data collection and also the inability to calculate the doses of each noise. Measurements were made on two cars that were washed one by each employee and not necessarily began their washing at the same instant. The equipment used was INSTRUTHERM decibel meter and measured the noise when the pump was turned on, when the vacuum was on and when both machines were turned off.

Based on all of the detected values when the pump was on, was obtained as its minimum, maximum and average values of noise heard by the worker, the following:

In relation to the minimum, maximum and average values obtained when the vacuum was turned on, was obtained:

It is noteworthy that the value of 91 dB obtained when the pump was on was so discrepant due to ambient noise, since this moment had passed a truck and this noise was consequently enlarged. In general, it can be noticed that in both cases, most of the obtained values is above 65 dB, the maximum value allowed by the NR-17.

Another important factor to consider is the sum of noises. As stated earlier, the washing of the two cars are not necessarily initiated at the same instant, so while the car 01 may be being vacuumed, another car may be starting to be washed with the water pump, a situation that will result in the employee being subjected to two types of noise. For example, if the employee is subjected to a value of 74.2 dB when the vacuum is turned on in the first car and subjected to 80.2 dB when the second car is with the water pump on, it will actually be listening to a higher value, equivalent to 80.2 dB–74.2 dB = 6 dB. From this result, it was used the table that deals about the addition of sound levels, resulting in a value to be added to the higher noise in this case, the value of 1 dB is added to the value of 80.2 dB totaling 81.2 dB.

3.4 *Analysis of the aspects of Severity, Urgency and Tendency (SUT Matrix)*

The SUT matrix (Table 3) shows the identification, classification and prioritization of the risks found in the car wash.

Table 3. SUT Matrix—Severity, Urgency and Tendency.

SUT Matrix	G	U	T	Total	Priority
Physical risks					
Excessive noise from water pump, vacuum cleaner and surrounding area	4	4	3	48	3°
Thermal overload	4	4	3	48	3°
Chemical risks					
Direct contact with chemical products	5	5	4	100	1°
Steam from the degreaser	4	5	4	80	2°
Ergomic risks					
Improper posture	3	3	2	18	5°
Excessive physical exertion	5	4	2	40	4°
Pressure for productivity	2	3	2	12	6°
Fast and repetitive movements	3	2	2	12	6°
Risks of accidents					
Arrangement of hoses	2	1	1	2	7°

Chemical risks—Priorities 1 and 2. Not using gloves and appropriate masks positions that risk as of the 1st prioritization, to be inserted immediate actions to control, because that way the washers are fully exposed to agents that can bring skin diseases, pulmonary diseases, or even cancer.

Physical risks—Priority 3. Because it is an outdoor environment, situated in an area of great traffic activity, workers are exposed to varying levels of noise during the workday, being exacerbated by the water pump and vacuum activation. As seen, the values obtained are above the limit allowed by NR-17, which necessitates the application of control actions for noise. Excessive heat is also very present in the workplace that is above the tolerance limits of the NR-17 agent, causing fatigue and tiredness, and should be reduced to the welfare of the operators.

Ergonomic risks—Priorities 4, 5 and 6. This risk arises mainly by excessive physical exertion throughout the workday causing weariness always reported by washers. Improper posture, which can lead to back pain, the pressure for productivity, which can lead to psychological stress, and rapid and repetitive movements are risks that must be treated soon after.

Risks of accidents—Priority 7. Being a risk that can be minimized with training and operational changes, it was considered that does not bring overly serious damage to worker's health and shows no tendency to get worse, the arrangement of the hoses was ranked as the finally agent to be treated.

4 CONCLUSIONS

From the theoretical analysis, together with the data obtained and presented in the results, it can be concluded that the environment under study, the carwash is considered hazardous due to safety and risks posed to worker's health.

Regarding the use of personal protective equipment, it could be perceived that workers do not use them, simply because they are sturdy and do not want. Therefore, the company should encourage such use through awareness lectures, recommendations, and inspections so there is a cultural change going to use them in the usual way.

In relation to physical and chemical risks, the following control measures can be applied. For the primary, making wearing of hearing protection, the enclosure of the noise source, the reduction of the exposure time can be inserted to combat the noise; and the introduction of equipment such as air coolers to generate a thermally more pleasant environment. Regarding chemical risks, it is suggested the use of aprons and polyvinylchloride gloves to reduce direct contact with chemicals, besides inspecting the use of boots (only used PPE) to ensure they used them.

In terms of ergonomic risks, it is suggested that there is defined intervals for the rest of the workers and stretching in their own work environment, so that their health is not compromised. Finally, in relation to risks of accidents, it is stated that there installing handrails and a better arrangement of hoses that provides for a reduction in the risk of falling.

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ATP quantification and health professionals knowledge and performance indicators assessment regarding hand hygiene procedures in dental clinics

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ABSTRACT: The dental practice exposes patients and health professionals to several microorganisms and infections that can be transmitted in multiple ways. Hands contamination is one of them and means that is necessary to use basic precautions in order to protect professionals and patients. The study aim was to assess the levels of knowledge and calculate the performance indicators of hand washing through a questionnaire and from the process of quantification of adenosine triphosphate levels (method of bioluminescence) in the hands of health professionals (dentists and assistants dental) of Pombal's dental clinics. Through the study it was inferred that health professional's evidenced more than satisfactory levels of knowledge as well as performance indicators of hand washing. However, through the bioluminescence method there was excessive demonstrated the existence of large amounts of adenosine triphosphate in the hands of these professional, which may indicate that the hygiene may has been done incorrectly or that the products used are inadequate or there was contact with contaminated surfaces. It is of up most importance of training and raising awareness of health professionals so as to perform safe practices for hand hygiene in order to protect their own health and their patients by preventing Health Care Associated Infections. It is important the training/sensitization and training of health professionals to perform safe practices for hand hygiene in order to protect their own health and their patients for the prevention Health Care Associated Infections.

1 INTRODUCTION

The Health Care Associated Infections (HCAI) represent a serious problem and a major challenge, requiring effective preventive measures and control for health services (National Health Surveillance Agency, 2009).

It is essential that during the totality all moments the provision of patient treatment and care actions must take place simultaneously either in the area of prevention either in the area referent to cross-transmission microorganisms control. This set of actions and recommendations named Basic Precautions and Isolation constitute the basics of infection control and represent are the first "safety barrier" in health care that contributes to the prevention and cross-transmission control of HCAI implementing process for the continuous improvement of quality of care and consequently to patient safety (Pina et al., 2010).

In this context hand hygiene integrates the set of basic precautions and it represents the most important measure minimizing infection control by being one of the easiest, simple and most effective measures that fight the incidence of HCAI (General Health Direction, 2010).

In epidemiological terms, it is widely established that the transmission of microorganisms through the hands of professionals and patients is an inevitable reality that will correspond to the existence of infections outbreak considered undesirable consequences health care system. According to General Health Direction, the adhesion to hand hygiene procedures continues to be undervalued, rarely exceeding 50%. The overall Portuguese rate concerning adhesion to hand hygiene procedures can be observed in the assessment diagnostic of the phase "the National Hand Hygiene Campaign" (in 2009), represented 46.2% (General Health Direction, 2010).

Despite all evidences health professional's awareness about basic mechanisms of transmission relatively to infectious diseases and the demand for hand hygiene is still low. Studies show variations between 16% and 81% in adhesion, which eases cross-transmission of infections (National Health Surveillance Agency, 2006).

The microorganisms that cause infections are not visible to the naked eye and its existence cannot be associated to any visible sign. Due to this the industry has developed more objective and sensitive methods than visual inspection, which measure levels of organic matter and microbial contamination: measurement of Adenosine Triphosphate (ATP) or bioluminescence (Freitas, 2012).

The ATP bioluminescence method measures the ATP present in the cell whether alive or dead animals, plants, bacteria, yeasts and molds. By detecting the ATP present on surfaces and equipment it indicates the level of biofouling even though it cannot be distinguished the origin whether in live or dead microorganisms or any other organic sources like bodily fluids. High levels of ATP on surfaces may indicate an unproductive cleaning or disinfection therefore the consequent risk of contamination cannot be identified (Ferreira, 2012).

According to all of previously stated this research aimed to assess the levels of knowledge and calculate the performance indicators of hand washing through a questionnaire and from the process of quantification of adenosine triphosphate levels (method of bioluminescence) in the hands of health professionals (dentists and assistants dental) of Pombal's dental clinics.

2 MATERIAL AND METHODS

This research was developed during the academic year of 2013/2014 during the period of December 2013 to September 2014 and integrated a sample of 13 health professionals: dentists and dental assistants, divided by seven dental clinics located in the city of Pombal.

For data collection it was necessary to prepare and deliver a questionnaire developed by the research team based on existing questionnaires about the subject. The questionnaire was divided into four parts, focusing initially in the description of the socio demographic data of the participants. In a second part about professional training followed by the third part of the knowledge evaluation about hand hygiene and at last the performance indicators (structural) related to hand hygiene on the fourth part.

To assess the level of knowledge of health professionals in relation to hand hygiene a general knowledge index was created. For each question there is one correct option and was counted for each option a value of right answers. The general index of knowledge is obtained by summing all correct answers.

Regarding the ATP quantification the smears performed in the palm, the back, nails and interdigital spaces of health professionals after washing hands and before they put the gloves. To collect the sample the correct hand hygiene was used (alcohol solution). These smears were performed using swabs and the luminometer. The 3M Clean-Trace ™ Surface ATP is a device based on measuring the amount of Adenosine Triphosphate (ATP). This has a single capsule with all necessary reagents for evaluating the efficiency of the process by cleaning and the values obtained by the equipment in RLU (Relative Light Units) data. As for the limit value it was considered 500 RLU, based on the manufacturer's instructions, as well as situations previously used.

Data processing was performed using the IBM® SPSS® Statistics software version 22.0 for Windows operating system. The verification of research hypotheses it was used the statistical t-student test for independent samples, U of Mann-Whitney and Pearson correlation coefficient. The interpretation of statistical tests was carried out using a significance level of p-value ≤ 0.05 with a confidence interval of 95%.

3 RESULTS

According to these socio demographic data it was obtained that the majority of health professionals had between 31–40 years old and were female (76.9%). As for qualifications 53.8% of professionals have attended university and the remaining high school education. Of the 13 professionals, 76.9% had training in hygiene, and 50% of them reported having had training lasting between 2–5 hours. The dental assistants had an average of 16 correct answers considering the total of 24 questions and dentists averaged 14 correct answers, verifying that dentists had a level of knowledge inferior dental assistant (Table 1). However, this difference was not significant between the two types of professionals in the study ($p > 0.05$). Overall we obtained a general knowledge index of 91.6%.

Table 1. Knowledge index of professional activity sector.

Professional activity sector		N	Average	Standard deviation	p-value	Average difference
General knowledge index	Dentist	7	14,29	1,50		
	Dental assistant	6	16,33	2,58	0,112	–2,05

Test: Wilcoxon-Mann-Whitney.

We can analyze the responses of health professionals about the level of knowledge concerning hand hygiene in the following questions: "The technique of hand washing with soap and water should have a duration of at least" obtained a percentage of 76.9% correct answers; "The antiseptic friction technique should have a duration of" obtained a percentage of 53.8% correct answers; "What is the minimum time required for the antiseptic handrub reduce the microbial flora of their hands" the results were negative, with only two correct answers (18.2%); "What is the main route of cross-transmission of microorganisms between patients" just got 5 correct answers (38.5%), with 8 wrong; the same happens with the question "What is the most frequent source of microorganisms responsible for infections associated with health care" which got 11 wrong answers versus only 2 correct answers (15.4%); "Which of the following statements about the technique of hand hygiene with alcohol solution are true" divided into three topics obtained all the right answers in 2 threads, n = 10 (100%) and the other just an incorrect answer; "Which of the following situations should be avoided in the provision of health care" divided into four topics they all got the most correct answers: use of jewelry (n = 11, 84.6%), fake nails (n = 10, 76.9%), skin lesions (n = 9, 75.0%), regular application of hand cream (n = 9, 75.0%); to the question "Mark with an X where you think you should use: Technique "Hand washing with soap and water" and "Friction with antiseptic handrub", the technique for "washing hands with soap and water" also obtained the most correct answers in the 10 existing options; the "friction with antiseptic handrub'" option also obtained the most correct answers and only two options with more wrong answers than right; "Health Care Associated Infections (HCAI) affect" got all the right answers (n = 13, 100%) and the question "How do you evaluate the efforts of health professionals to wash their hands to assist patients" two options are obtained with the same number of responses at n = 5 (41.7%).

According to the indicators of performance related to hand washing, the existence of sink in the workplace/office, non-manual control taps, hand drying devices, examination gloves and even the existence of antiseptic handrub were considered indicators. Obtained all the positive responses to the existence of sink and examination gloves (100%) and 92.3% of positive responses to the existence of sinks with non-manual control taps and for the existence of antiseptic handrub for hand washing. The existence of the hands dry devices obtained a percentage of 53.8% of negative responses and only 46.2% of positive responses. To the question "In what situations uses the practice of hand washing" considered 2 right answers with a percentage of 84.6% and to the question "As an alternative to hand washing, in their activities (where there is no sink) how do you proceed" obtained all the correct option (directly related to the question "your workplace/cabinet features a sink"?).

Then we seek to compare ATP values obtained in each healthcare professional face to the reference value. We came to realize (Table 2) that the professional has showed values of quantification of ATP significantly higher (p-value < 0.05) to the reference value (> 500 URL).

In table 3 through the comparison of the ATP values obtained among occupation showed that dentists have an average value of 1136.57 RLU and dental assistants an average of 1634.83 RLU. The

Table 2. Comparison of ATP with the reference threshold value.

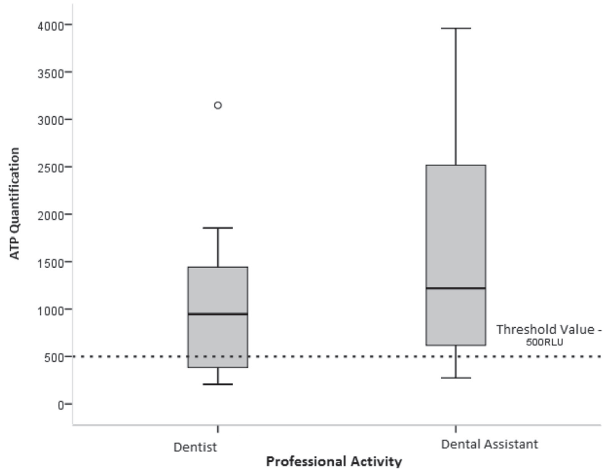
				Threshold value = 500			
	N	Average	Standard deviation	t	gl	p-value	Average difference
ATP quantification	13	1366,54	1186,87	2,63	12	0,022	866,54

Test: T-student for a sample.

Table 3. ATP comparison according to occupation.

					Threshold value = 500			
		N	Average	Standard deviation	t	gl	p-value	Average difference
Dentist	ATP quantification	7	1136,57	1053,71	1,60	6	0,161	636,57
Dental assistant		6	1634,83	1374,05	2,02	5	0,099	1134,83

Test: T-student for a sample.



Graphic 1. Comparison of ATP value by professional group with the reference threshold value.

Table 4. Correlation between the amount of ATP and the level of knowledge.

		ATP quantification
General knowledge index	Pearson correlation	1
	P-value	0,065
	N	13

different professional groups showed average ATP values above de limit reference despite those differences not being relevant (p-value >0.05).

By the graphic 1 it was found that 25% of the dentists are below the threshold value, however 75% is above the threshold value of 500 RLU. As for the dental assistants the majority exceeded the limit value, although 25% were close to it, slightly exceeding the value of 500 RLU.

It was investigated the correlation if the amount of ATP estimated in each health professional could have an inverse relationship with the knowledge index about hand hygiene (Table 4). As we can see there was no pattern of relationship between the level of knowledge and its ATP quantification (p-value >0.05). This suggests that the level of knowledge for each professional about hand hygiene does not vary in function of the amount of ATP that was presented at the time of collection analytics.

4 DISCUSSION

Through the results analysis we can notice that in general dentists and their dental assistants responded correctly to most questions about hand hygiene with a percentage of 87.9% concerning the applied questionnaire. The maximum possible score to assess the level of knowledge was 24 correct responses, yielding an average of 14 correct answers for the dentists and an average of 16 correct answers to dental assistants.

Taking into account the results obtained and depending on the number of correct responses, it was verified that the questions “Which of the following statements about the technique of hand hygiene with alcohol solution are true”, “Mark with a X where do you think you should use: Technique “Handwashing with soap and water” and “Friction with antiseptic handrub” and “Health Care Associated Infections (HCAI) affect” showed the highest number of positive responses (n ≥ 11).

Eventually these questions achieved a higher level of knowledge due to the fact that this issue is further explained in the workplace through awareness and also due to several campaigns prepared by the General Health Direction.

According to the performance indicators regarding hand hygiene it was also established from the results obtained that the majority of correct responses (76,9%), however, it would be expected that all responses were positive and this supposition did not happen. For the question regarding the existence of hand drying devices the majority of the respondents replied that there were none. It is expected that if there are sinks in every location they is provided with suitable hand drying devices.

If the sinks and dispensers of alcoholic solution are not accessible (structure fault) and hand hygiene is not performed (inadequate process), the risk of infection increases and consequently the morbidity and associated costs. A quick, simple and regular checking of the working place can be extremely useful for identifying barriers to compliance in hand hygiene, for example, checking and observing if all alcohol solution dispensers are full and operational. Conducting random audits with feedback about the practices of the current hand hygiene is essential and should be part of the multifaceted programs of behavioral change (General Health Direction, 2010).

Through the bioluminescence method it was possible to quantify ATP levels in the hands of dentists and their respective dental assistants in real time and performed quickly. 500 RLU was established as the threshold reference to the readings of ATP. From the results it was found that of the 13 measurements carried out it was obtained an average value of 1366.54 RLU with standard deviation of 1186.87 RLU which exceeds the reference value. Dentists have obtained an average of 1136.57 RLU and the dental assistants 1634.83 RLU. On average both exceed the limit of reference value, which can be consequence of several causes such as improper hand hygiene, ineffectiveness of products used for hand hygiene and contact with contaminated surfaces.

According to Freitas (2012), the health professionals hands may be contaminated during assistance therefore favoring the pathogens transmission through the hands of the team that will depend on the microorganisms present in the patient's skin or in fomites in the near by environment of the patient; the transfer of agents into the hands of the team; the survival of organisms in the hands of health professionals for at least a few minutes; of flaws in simple hygiene or hand antisepsis by the professional who may have been inadequate, was not performed or was inadequate using the contaminated hands of the caregiver product to come into direct contact with another patient or a fomite in direct contact with the patient.

The National Health Surveillance Agency (2006) states that the office routine in order to ensure patient protection means that the dental professional should wash his hands immediately before starting any treatment. If his hands are clean and dry just apply solutions that do not require rinsing. After removing gloves, washing hands is needed due to residue left by the internal coverage of the personal protective equipment, which can cause skin irritation and the possibility of skin contamination, even though a reduced one due to secretions and blood that may pass through the pores of the material (micro-holes). During the service to a patient, it may be necessary to change gloves and/or wash the hands more than once. This need derives from the work process, which provides access to various equipment and instruments, not always near the professional; eventual rupture or perforation of gloves; the interruption of service (answering the phone, preparing material, wait for reaction time of filling materials etc.); among others.

A clear, effective and appropriate guidance about measures to control the infection spread is needed. Although hand hygiene is considered the most important measure to prevent and control infections related to health care, ensure your improvement is a complex and difficult task (WHO, 2005).

Thus, in addition to training, it may be necessary to use educational and motivational programs, as it may be concerned attitudes from the culture that minimizes the associated risk alied with poor technical information (Aires & et al., 2010).

5 CONCLUSIONS

With this study it can be concluded that the majority of health professionals within dental clinics whether dentists or dental assistants both set force of the knowledge about hand hygiene. The results were obtained through the analysis of the questionnaires. As for the performance indicators related to hand hygiene, it was found that most dental clinics demonstrated having the necessary infrastructure for the realization of hand hygiene, with only a few points to improve.

Through the method of ATP quantification (bioluminescence) it was possible to obtain fast results what lead to an immediate efficient capacity of clear interpretation of the results. With this method it was found that most of the health professional's hands showed signs of the presence of organic matter whereas the values of quantization levels of ATP obtained were not the preeminent and most exceeded the Reference Limit Value (RLU 500). However, there may be several factors mentioned above to justify such results. It would be expected better results in the levels of ATP in the hands of health professionals because there were obtained good results about level of knowledge about hand hygiene by the questionnaire.

Hand hygiene is considered one of the most simple and effective measures for prevention and control infections. In almost all guidelines or regulations, hand hygiene is referred to as a measure of good practice and it is clarified the importance of this measure and the requirement of compliance. It must exist in health facilities structural conditions, equipment and products adjusted to the procedures as well as written recommendations so that all health professionals are aware of the implications of hand hygiene and motivated for this practice (George, 2005).

Infections related to healthcare are of major importance worldwide as they affect the quality care and patient safety by adding huge and unnecessary costs to health care (WHO, 2005).

You must invest in education and professional training in this area through the insistence and reinforcement good practices. Only then the professionals will be fully capable of adopting standard precautions, avoiding the risk of contact with infectious agents and thus contributing to the reduction of hospital infections (Aires & et al., 2010).

This study was limited by the fact that the method of ATP bioluminescence does not have the possibility of identifying the micro-organisms on the hands of health professionals, and only show their quantification. It is suggested a research to identify not only the quantification but also the qualification.

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Artisanal production of Serra da Estrela cheese: Evaluation of hygiene conditions and good manufacturing practice

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ABSTRACT: The Serra da Estrela cheese is a unique product legally defined that allow for the conservation of its intrinsic properties, to ensure the public health.

This study has developed, focusing the health and hygiene standards in local artisanal production of Serra da Estrela cheeses. Of 4 Traditional Cheese Dairies analyzed of Oliveira do Hospital.

Tests were performed for quantification of ATP (Adenosine Triphosphate) on the surfaces of two critical control points in places of production and in the hands of food handlers. Questionnaires were applied to handlers and an assessment by observation of the procedures for the production of cheese, using a checklist.

Even when it comes to small businesses and craft processes, it was found that the cheese dairies comply in general with good health and hygiene standards. The presence of organic matter was significantly that demonstrates the need for a review of hygiene procedures and monitoring procedures of control.

1 INTRODUCTION

Traditional portuguese products are exclusive products from a region, each being characteristic of all the surrounding area to which it pertains—from the animals and soil, to vegetation, climate and existing manufacturing technology. It is thus given a flavor and quality unique to a given product (Pereira, 2007). The Serra da Estrela cheese is legally defined by NP1922 and is a traditional Portuguese cheese which favors the development of a bacterium called Listeria monocytogenes (Noronha, Santos, Malta, Azevedo, Henriques, Madanelo, Cabral, Almeida, Oliveira, Amaral, Rodrigues, Sampaio, Branco, Melo, Guerra, 2004). The Listeria can be introduced by the food handler during the production or can be found in raw materials, contaminated through the air, water, dust or clothes (Pereira, 2007). Over the last few decades there has been a remarkable evolution of the methods of production and processing of food and the necessary controls to ensure food safety standards (Ferreira, 2008). Food toxinfections constitute one of the main concerns at the level of Public Health, and the majority arises when the microorganisms are ingested in large quantities or when there are toxins in food (Pereira, 2007). All of the establishments where food is handled, shall comply with the principles and rules laid down and concerning reception, preparation, handling, processing, storage, transport, distribution and sale to the public (Noronha, Santos, Malta, Azevedo, Henriques, Madanelo, Cabral, Almeida, Oliveira, Amaral, Rodrigues, Sampaio, Branco, Melo, Guerra, 2004). The food handlers also play a fundamental role in the quality of foodstuffs. Healthy personnel can nonetheless be carriers of microorganisms which may contaminate the food. It is thus essential that cheese dairy managers provide employees training and information concerning hygiene rules to be adopted regarding the task each handler performs (Luísa, Madanelo, Lima, 2004). On the other hand, microbial contamination and the formation of biofilms on the surfaces of equipment and utensils can also occur which result from the deposit of microorganisms on incorrectly sanitized surfaces combined with the presence of residues that favor its proliferation (Pires, Araújo, Camilloto, Ribeiro, Soares, Andrade, 2005). The implementation of these rules is possible by using the system of Hazard Analysis and Critical Control Points—HACCP, a preventive system that aims the production of safe food. The application of this concept to test methods that one will need to implement the HACCP plans, is accomplished through an internal validation of the method and is intended to demonstrate their effectiveness in working conditions peculiar to each company (Ribeiro, Cerqueira, Santos, Louzã, 2002). Thus, in such a way as to enable the safety and hygiene of the products, cheese dairies must be endowed with specific requirements and food handlers should have knowledge of good and labor hygiene practices (Morais, 2009).

2 MATERIAL AND METHODS

The present research study was developed during the months of November to June of the academic year 2013/2014 and the collection of data took place in the period of April 2014. The study is a descriptive and exploratory cohort and cross-sectional level I. From the population of 6 Traditional Cheese Dairies focusing on the production of certified Serra da Estrela cheese within the municipality of Oliveira do Hospital, 4 were selected, according to the type of non-probability sampling and regarding the technique for convenience. Tests were performed for quantification of ATP in surfaces, questionnaires were applied and a checklist was used. A checklist drawn up by the team of research on the basis of checklists already existing and the legislation in force, by Directorate General for agriculture, was used. A questionnaire was given to each handler of production, also prepared by the team of research and oriented according to the legal requirements and questionnaires from the area of food safety. The samples for quantification of ATP were collected in the hands of all the handlers and in two critical control points defined by research team. The detection of ATP was performed by test of bioluminescence using the system 3M™ Clean-Trace ™ ATP Systems, in which the result is expressed in RLU (Relative Light Unit). The researcher had to collect it by running a correct sanitization and disinfection of hands and using the appropriate personal protective equipment. It was asked that subjects clean their hands correctly before the harvest. It should be noted that the samples were carried out within the establishments, before starting work in conditions in which the cheese would be produced and the transportation of swabs was carried out in an insulated chilled bag. The measurements in order to obtain the results were performed immediately after the completion of each smear. As the threshold value, was considered the value of 500 RLU, on the basis of the indications of the manufacturer, as well as earlier work used. The statistical treatment of the data was performed using the software IBM® SPSS® Statistics version 22.0. Were used descriptive statistics simple. Was used the parametric and non-parametric statistical tests, t-Student for 1 sample and the Kruskal Wallis test, respectively. The interpretation of the statistical tests was performed on the basis of the level of significance of p-value <0.05 with a Confidence Interval (C. I.) of 95%. The results, as a unit of measure RLU were related to the questionnaires and the assessment by observation made.

3 RESULTS

The study was analyzed by descriptive tables: the "general Conditions" of installation met most of the requirements (89.3%). In "Premises of cheese", was verified compliance with the parameters in most cheese dairies analyzed (91.3% of the cases), being however that two of them were not "Allow the prevention of accumulation of dirt on the surface" (50%); three cheese dairies don't "Prevent the contact of food with toxic materials, shedding of particles and formation of molds" (75%); and did not have "natural or mechanical ventilation enough" nor "mosquito nets and electrocutors of insects". In the section "Characteristics of the components" it was found that, with respect to items "windows", "interior doors and exterior" and "ceilings", some of the establishments did not fulfill the necessary conditions. This section a fulfilment of 96.2%. In relation to the "characteristics of the equipment", the characteristic "Is prohibited equipment with exposed wood, rusty or damaged" were met in two establishments (50%), as well as the "Additives and condiments must be in container with lid and identified" (50%). It was found that compliance with the items "Tidy and clean whenever possible" in 75% of cheese and the parameter "If you use wood in cupboards, must be sealed" it was found in 100%. As regards the "Equipment of staff", it was found that the "Use of livery, gown, boots and cap" was fulfilled in 100%. The industry concerning the "Food Waste" has proved to be satisfactory in the majority (89.3%). The condition "All workers should keep work clothes clean and protected, and not the use outside the workplace" became meet in 75%, in relation to the "Personal Hygiene". It was noted that the item "all persons who handle food must be trained in food hygiene matters" if he did fulfill all the cheese dairies (100%). In relation to the issue of "raw materials and consumables", the term "handling equipment, raw materials and finished products not packaged in hygienic conditions" was not satisfied by one of the analyzed cheeses (25%). In the section "Hygiene of the staff of the farm", 100% fulfilled with the item "All the staff in the milking and handling of milk is obliged to prove that, from a medical point of view, there is no impediment to its allocation", 66.7% meets the requirements "The staff responsible for milking must wear suitable clean clothes", "milkers must wash their hands immediately before milking and must keep it clean as much as possible" and "There are appropriate arrangements for washing of hands and arms next to this place". As to the "Hygiene in milking", the items they meet in 91.7%. At the "packaging", only one of cheese has proven unsatisfactory as the item "Carried out in locations with satisfactory hygienic conditions" (25%). Results obtained through the application of the questionnaires form, through the analysis of frequencies, show that the handlers responsible for the production of cheeses are all females and the ages range between 36 and 47 years. From the

Table 1. Quantification of ATP (RLU) present on surfaces and hands.

	N	$\bar{x}$	s	$\bar{d}$	X^2; gl; p-value	Ref. Value
Quantification of ATP	15	20490,27	37414,961	19990,267	2,069 14 0,058	500

Legend: n = sample number; $\bar{x}$ = Average; s = standard deviation; d = Average difference; Test: Student t test for one sample.

Table 2. Quantification of ATP (RLU) per sampling points.

Sampling points	$\bar{x}$	s	X^2; gl; p-value
Hands (n = 7)	3618,14	4021,265	7,707
Bench (n = 4)	1569,00	1754,321	2
Curing chamber (n = 4)	68937,75	47182,914	0,021
Total (n = 15)	20490,27	37414,961	

Legend: $\bar{x}$ = Average; s = Standard deviation; Test: *Kruskal-Wallis* test.

8 respondent handlers 3 were to play roles in the establishment between 2 to 5 years and 3 others, there are more than 10 years, being in these handlers that if there were more failure in relation to the parameters questioned. The handlers, regardless of qualifications that they had and the time of service in which they are on the property, all have demonstrated knowledge (100%) in all the parameters asked that relate to conditions of hygiene, infrastructure and operation, HACCP and health. With regard to good practices, it was found the existence of gaps in relation to compliance with good practices, regardless of qualifications. However, it can be seen that the majority of the failures occurred in handlers with secondary education (12th year). With regard to the quantification of ATP in surfaces of 15 measurements carried out in the whole of the establishments and surfaces, were performed 7 measurements in the hands of food handlers, 4 in the stands for the production of cheese and 4 on the surfaces of shelves of chambers of cure. After the application of instruments for data collection, was compared the mean values estimated analytical, either in areas such as in the hands of the handler (Table 1).

As we can see, the amount of ATP estimated in different harvests, significantly exceeded the reference value stipulated by legislation (500 RLU). It was observed an increase of the amount of ATP of 19990,276 RLU face that was allowed in this type of establishments.

The aim was to compare the locations with the greatest amount of ATP, to evaluate the surfaces that need cleaning best (Table 2).

According to Table 2, we observed a statistically significant difference ($p = 0.021$) of the average number of colonies ATP according to the point of harvest. The average values are higher in the chambers of cure/shelves of maturation (x = 68937,75) and the lowest average values found in the hands of food handlers (x = 3618,14), although they are above the threshold value considered. In the "Hands of manipulators" section (n = 7), the minimum value shown was 211 RLU and the maximum value was 11437 RLU. In the section "Bench of production" (n = 4), the values recorded as minimum and maximum were, respectively, 34 RLU and 3639 RLU. As regards the "House of healing", the areas analyzed (n = 4) showed values of 4222 RLU as minimum value and 116553 RLU as maximum value.

4 DISCUSSION

In general analysis of the results obtained, it can be said that the existing conditions in cheese are satisfactory, being the minimum rate of compliance with above 70% for each section. The sector in which was revealed the highest rate of failure corresponds to the field of health care, since staff hygiene of production and exploitation of the equipment of staff. The requirements of the facilities, equipment and components, they do not meet in full by the fact that cheese artisanal and traditional. These establishments have to be appropriate as much as possible, and the majority always tries to maintain a good state of cleanliness, organization and maintenance of equipment, in order to "ensure that the health and hygiene standards are maintained over time and during the various operations" (Regulation CE, 2006). It was further noted that, regardless of qualifications that the manipulators have and the time of service in which they are the establishment, all demonstrate knowledge in all the parameters asked that relate to conditions of hygiene, infrastructure and operation, HACCP and health. As regards the evaluation of best practices, it was found that some, even known by the handlers, are not always complied with or performed. In this situation include the parameters related with work clothes, rules of conduct in the workplace and washing of hands. It was found that the majority of producers of Serra da Estrela cheese have some years of experience in the activity and in the establishments in question, however there are habits that must be eliminated. To improve this situation, establishments must ensure that all food handlers receive adequate training, continuous and applicable in safety and food hygiene, so that they will know how adopting best practices to avoid contamination of food (Regulation (EC) Nº 852/2004 and Law Nº 7/2009). It is evidenced in this study, the assessment of the conditions of hygiene. For that a surface can be considered as clean, you have to meet the physical requirements and microbiological, because a surface can be cleaned from the point of view physical and not from a microbiological point of view, or from the chemical point of view and not organic. The surface must be able to guarantee the safety and the intrinsic characteristics of food (Santos, 2010). It was intended with the quantification of ATP, to assess the effectiveness of the sanitization, either from the hands of both surfaces. The results obtained by quantification of ATP were high, with an average value of 20490,27 RLU. These results can be explained by several factors. As regards to the chambers of cure, the surfaces evaluated are networks, used to replace the old wood and cloths. The networks used in the shelves of maturation in the chambers of cure, have grooves, cracks and depressions that facilitate the accession of waste from cheese and favor the accession and training of microbial biofilms that produce ATP. As far as the hands of food handlers, the high results can be justified due to microtopography skin and due to the characteristics of the production process, the handler responsible for drawing up the cheese comes into contact with other objects and surfaces that were not hygienic and that naturally contain organic matter. All food handlers must maintain a high degree toiletries, hygiene frequently and properly the hands, in order to avoid cross-contamination (Benchmarking, 2012). The method of quantification of ATP, according to other studies, when compared to the traditional method, shows no agreement regarding classification of hygienic conditions of the areas. It is important to note that the method used is not suitable for microbiological assessment of areas of food processing, but as an indicator for the presence of biological material on the surface and alert for more efficient cleaning. In this way, the level of public health, the results obtained do not assess the presence of pathogenic micro-organisms, however significant values observed there that there is possibility of causing some negative consequences to the health of consumers.

5 CONCLUSIONS

The existence of bacteria in cheese production is fundamental to the process of fermentation, however it is important to control the microbial flora, which is required by legislation and whose limits are defined (Santos, 2010). The knowledge of microbial populations on working surfaces is critical when you want the security of a given food product. In addition to microorganisms as indicators of hygiene, it is also important to ensure the absence of potentially pathogenic micro-organisms, and the use of other tests that are more specific and even the analysis of classical microbiology should be periodically performed (Ferreira, 2008). The method used for quantification of ATP was shown to be applicable because regardless of readings in RLU provided are of microbial origin or not, are a reflection of hygienic conditions of the surface. This method proved to be very useful as regards the rapid hygiene monitoring of surfaces and from the hands of food handlers, which is reliable and easy to use, and it may be applicable in procedures of monitoring and verification, preventing bacterial proliferation, which may cause serious risks to public health. However, the realisation of counts of bacteria on surfaces with methods of traditional microbiology, cannot be replaced by luminometry ATP, continuing to be required in verification activities and audit in HACCP plans, by which it would be interesting if they were analyzed the locations under the same conditions using this other method, in order to make the study more complete. The presence of organic matter was significant, although the values obtained can be justified due to several factors, the results demonstrate the need for a review of hygiene procedures and procedures for monitoring and control, particularly with regard to correct sanitization of hands and review the methods of washing the networks of placing of cheese used in the chambers of cure. You should look to make various evaluations, covering the before and after cleaning these surfaces, so as to ascertain what are the methods of procedure more effective cleaning and sanitizing. It was found that some practices of manipulators that even known by the handlers, are not always complied with or performed. Even when it comes to small businesses and craft processes, it was found that to the cheese dairies, the food quality and safety a priority. In the study carried out in the knowledge and good practices of food handlers, it is remarkable the growing concern on the part of the handlers to comply with the rules of hygiene and good manufacturing practice, in a manner that preserved the conformity of cheese, because they know the importance of maintaining a traditional product certified as is the Serra da Estrela cheese, with protected geographical indication. The handlers are the "key people" that can keep the intrinsic characteristics of this product, and that is why it is important to use the training and awareness of same to the aspect of food safety and the importance of implementation of good practices. One of the limitations found was the size of the sample, as well as the restrictions of establishments, which compromises the comparison between establishments craft and industrial and manufacturing establishments of Serra da Estrela cheese certified and non-certified. In this way, the choice of establishments has been made on the basis of artisanal cheese production certified comprehensive county of Oliveira do Hospital, by which suggests the implementation of a sample wider.

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Risk factors for upper trapezius overload during computer work: Short review of electromyographic studies

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ABSTRACT: The aim of the present review was to identify risk factors for the development of upper trapezius muscle overload during computer work, using surface electromyography as an assessment tool. The search was performed on Pubmed, AMED, CINAHL, PsycINFO, SPORTDiscus and Business Source Premier, using key-words and boolean operators (AND, OR) in combination, with no temporal restriction. Only peer reviewed journals and English available abstracts were accepted for inclusion. As a result, 83 articles were identified, which after removing of duplicates only 70 were considered. Subsequently, the reading of the full-text and application of the exclusion criteria enabled the identification of 6 articles for the final review. Although it was possible to ascertain some of the predominant risk factors for upper trapezius overload during computer use, more studies are required to qualify the constitution of computer use guidelines.

1 INTRODUCTION

According to the European Working Conditions Observatory of the European Foundation for the Improvement of Living and Working Conditions (Eurofound, 2007, Houwink et al., 2009), work-related Musculoskeletal Disorders (MSDs) is the most widespread occupational related illness in the EU. Moreover, the European Agency for Safety and Health at Work (EU-OSHA, 2000), stated that the MSDs cover a broad range of health problems. The main group is back pain/injuries and Work Related Upper Limb Disorders, whereas lifting, poor posture and repetitive movements have been referred as linked causes.

Neck and shoulder discomfort is particularly prevalent in work tasks requiring highly repetitive finger, hand or arm movements, as well as work with high visual demands, like the computer use (Nakata et al., 1993, Madeleine, 2010, Szeto et al., 2005, Thorn et al., 2007, Levanon et al., 2012). The overload of the upper trapezius muscle has been identified as potential risk factor for musculoskeletal symptoms during computer use (Bruno Garza et al., 2014, Marcus et al., 2002) and the lowering of its activity may contribute to diminish the risk of work related musculoskeletal disorders (Madeleine et al., 2006).

According to Criswell (2011), the use of Electro-Myography (EMG) has many advantages, because it provides a safe, noninvasive and easy method for objective quantification of the energy of the muscle. The EMG traces provide information to clinicians and researchers about muscle function and dysfunction.

The aim of the present review is to analyze the effect of physical risk factors, assessed by EMG, for musculoskeletal disorders of the upper trapezius, during computer use.

2 METHODOLOGY

2.1 *Search strategy*

A systematic literature search was performed on Pubmed, AMED, CINAHL, PsycINFO, SPORTDiscus and Business Source Premier, from inception to September 2014, using the key words EMG, electromyography, ergonomics, ergonomic, muscle, upper trapezius, shoulder, shoulder pain, shoulder disability, shoulder disorder, musculoskeletal disorders, neck, neck pain, neck disorder, cervical, risk factor, computer, work and labor and boolean operators (AND, OR) were also added to search, with no temporal restriction. Filters for English language, peer-reviewed studies and human subjects were also applied.

2.2 *Screening and eligibility criteria*

A set of inclusion and exclusion criteria was established prior to searching. Studies on subjects who had history of back, neck and shoulder disorders or any other pathological condition were excluded from the analysis. Studies on joints other than the neck and shoulder, or which did not use EMG as an assessment tool were also excluded from the review. Studies that did not evaluate work related risk factors for computer use were also omitted (e.g. biofeedback studies and truck location for mobile computer).

3 RESULTS

3.1 *Study selection*

From the 83 identified studies through electronic searching, 70 records were considered after removing of the duplicates and 6 studies were chosen to be included in the qualitative synthesis. All the involved steps for identification and selection of relevant studies for inclusion were performed through the PRISMA recommendations for systematic reviews (Moher et al., 2009) (figure 1).

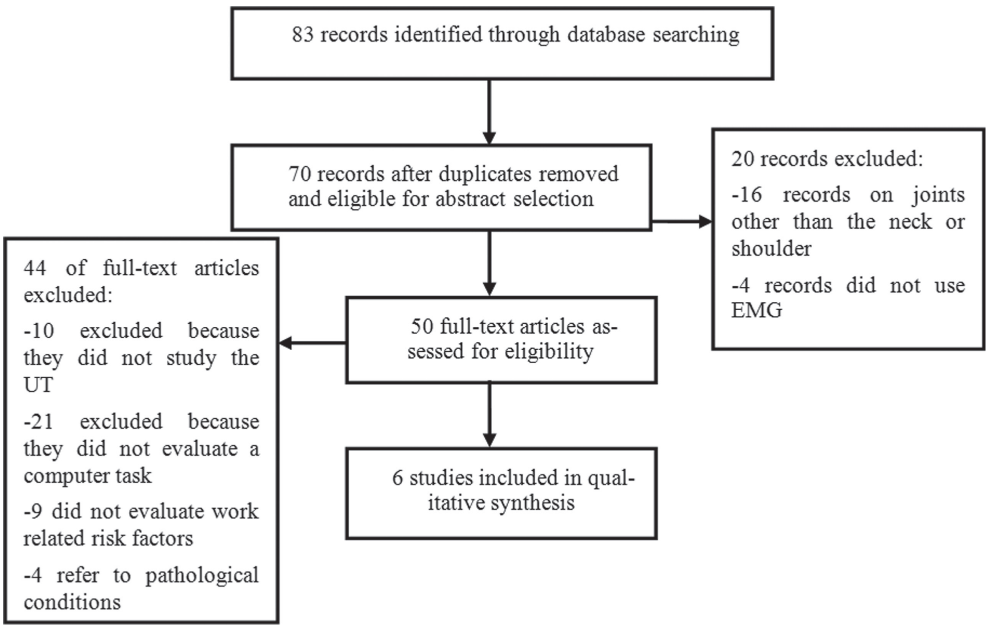

Figure 1. Flow of information through the different phases of the review.

3.2 *Included studies*

Table 1. Summary of included studies, chronologically presented.

Author	Aims	Methods	Conclusions
(Turville et al., 1998)	To investigate the effects of two Video Display Terminals (VDT) on muscular activity	VDT was positioned at a standard workplace design (15° below horizontal) and at 40° below horizontal.	The results of the normalized EMG analysis showed significantly higher muscle activity in the 40° monitor condition
(Moffet et al., 2002)	To evaluate the impact of two laptop designs (with or without palm rest) and two work situations (on desk or lap) on muscular activity	Standardized typing task of 15 min duration with two different laptops, with and without palm rest, in two situations (desk versus lap). The sequence was systematically alternated	Small differences in physical exposures in a typing task between the two laptop designs. The workstation set up had great influence on the physical exposures with higher muscle load found in the desk situation.

(*Continue*)

Table 1. (Continue)

Author	Aims	Methods	Conclusions
(Dennerlein and Johnson, 2006a)	To evaluate differences in biomechanical risk factors across different mouse positions within computer workstations	Experiment 1—Standard Mouse position (right—SM), versus Central Mouse (CM) and High Mouse position (HM). Experiment 2—SM vs CM position using a keyboard without keypad.	The muscle activity was the highest for the HM position and the lowest for the SM position. No differences were found between SM e CM positions using a keyboard without keypad.
(Dennerlein and Johnson, 2006b)	To evaluate differences in biomechanical risk factors across computer tasks	The participants completed five different computer tasks: typing text (Type), completing an html-based form with txt fields (Form), Editing Text (EDIT), sorting and resizing graphical objects (Graph) and navigating web pages (Web).	FORM and EDIT seems to be the most strenuous activity for the Upper trapezius muscle.
(Shin and Zhu, 2011)	To evaluate physical risk factors associated with the use of touchscreen in a desktop Personal Computer (PC) setting	A standardized computer use task with a standard keyboard and a mouse (traditional setting), with a touchscreen and the standard keyboard (mixed-use condition) and with the touchscreen only, was compared.	The use of a touchscreen in a desktop PC setting was associated with a greater muscle activity and greater subjective discomfort on the neck.
(Ciccarelli et al., 2013)	To determine differences in muscle activity amplitudes and variation of amplitudes when using different Information and Communication Technologies (ICT)	Muscle activity of 24 office workers (performing their usual tasks requiring different ICT at work and away from work) were measured continuously over 10 to 12 hours. Muscle activity variation was quantified using two indices, amplitude probability distribution function and exposure variation analysis.	New ICT tasks involved less electromyography variation than paper-based Old ICT tasks. Performing Combined ICT tasks (i.e., using paper—and electronics-based ICT simultaneously) resulted in the highest muscle activity levels and least variation.

4 DISCUSSION/CONCLUSIONS

There is no evidence to indicate that switching from a 15° below horizontal monitor placement, to a 40° monitor position would improve the health and safety of the operator (Turville et al., 1998).

More stress (muscle load) was imposed on the shoulder regions in the desk situation, when compared to lap positioning of the computer, whereas complaints in the shoulder-neck regions and EMG levels in the trapezius muscles increased as the vertical distance of the keyboard from the floor increases (Moffet et al., 2002).

Differences in exposure to biomechanical risk factors of the shoulder do exist across different computer tasks that require different amounts of mouse and keyboard usage. As a result, field studies of computer workers should take into account such differences in input device usage to develop a better understanding between exposure and outcomes and the development of interventions (Dennerlein and Johnson, 2006b).

The high EMG amplitudes and low variation observed when using Combined ICT may present the greatest risk for musculoskeletal complaints, and use of Combined ICT by workers should be kept low in office work (Ciccarelli et al., 2013).

The use of a touchscreen was also associated with a significant increase of subjective discomfort and myoelectric activity on the shoulder and neck region. Subjects seem to place the touchscreen closer and lower when using touch interfaces compared with the traditional setting, suggesting that users would need more frequent breaks and proper armrests to reduce physical risks associated with the use of a touchscreen in desktop PC settings.

On the choice of positioning the mouse, the standard right position, on the side of the keyboard (with or without keypad), seems to be the best option (Dennerlein and Johnson, 2006a).

There are some limitations to the present review, namely the lake of qualitative assessment of included studies and the language restriction to English only.

Although some evidence exists on the choice of the computer setting and characteristics, few studies were found to enable the identification of guidelines for computer use and more studies are needed to confirm these findings.

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ATP quantification and evaluation of hygiene good practices in dental clinics surfaces of Pombal city

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ABSTRACT: During daily routines in a dental clinic, health professionals use various equipment and materials that when contaminated should be sterilized to prevent crossed infection. Due to the fact cleaning processes are one way to control contamination, it was performed this study to evaluate the good hygiene practices and quantification of adenosine triphosphate on surfaces of dental clinics. A survey was applied and Adenosine triphosphate measurements were performed at six surfaces of seven dental clinics in the city of Pombal. It is concluded that health professionals revealed according to the questionnaire, good hygiene practices. However, through Adenosine triphosphate method there was inferred a poor hygiene surfaces, that is, surfaces are not cleaned properly after each service and others are sanitized but improperly, thus representing a risk of cross-transmission of infection. Therefore, it is crucial the need for raising stronger awareness in this area in order to enhance good practice.

1 INTRODUCTION

Modern health care provided unprecedented gains to the new generations of patients and their families. Cures were found; therefore we experienced an increase in the average lifetime and improving life quality. But all these achievements entail risks, being one of the most important Associated Infection to Healthcare (AIH). According to the World Health Organization today AIH are a silent epidemic (Pina et al, 2010). Thus, AIH are a major public health problem because they are a significant cause of morbidity and mortality and the referent burden they pose to patients, professionals and health systems. The situation is compounded by the fact that the emergence and spread of antimicrobial-resistant microorganisms hinder the control of these infections (Ferreira, 2012). The oral cavity may have between 400–1000 microbial species, saliva contains between 43 million and 5.5 billion bacteria per milliliter, presenting itself as an authentic microbial reservoir. The dental professionals use in their clinical practice various materials (tools and equipment) that when contaminated with blood and/or saliva should be compulsorily sterilized to prevent cross infection cycles (Jorge 2001 quoted by Correia, 2009). All patients should be treated as if they were carriers of contagious and infectious disease and with the same care in preventing infection, which includes the use of personal protective equipment by proper surface disinfection and cleaning, disinfection and sterilization of instruments (Kohn et al, 2003, cited by Correia, 2009). During the appointment of Dental Medicine surfaces can become contaminated, especially those that are touched frequently (light handle, appliances, switches, knobs), serving as a reservoir of microbial contamination, although not directly associated with the transmission of infection. When these surfaces are touched, the microorganisms can be transferred to instruments, and other environmental surfaces, or to catch up nasal, buccal or ocular mucosa of the doctor or patient. (Correia, 2009). All living cells contain molecules of ATP (adenosine triphosphate), including cells-from skin, blood, plants and microorganisms such as bacteria, yeasts and molds. ATP is a nucleotide that is present in all living cells and is used by them as an energy source. The use of ATP to measure the bacteriological quality is based on the fact that all living cells contain ATP which does not occur with non-viable cells (Costa, 2001). Detecting the ATP presence on surfaces and equipment, it indicates their level of biofouling, although not distinguishing if one has its origin in living organisms or other organic sources such as body fluids. Therefore, high levels of ATP on surfaces may indicate an ineffective cleaning and disinfection, and the consequent risk of contamination (Ferreira, 201 2). The study allowed us to determine if good hygiene practices are applied on surfaces through the use of questionnaires of good-practices to health auxiliaries, the quantitative evaluation of ATP on surfaces of dental clinics in the city of Pombal.

2 MATERIAL AND METHODS

This study was developed during the period of December 2013 to August 2014. Data collection was undertaken during the months of June 2014 and July 2014, based on a set of seven dental clinics in the city of Pombal. Firstly, a questionnaire (Appendix I) was elaborated by the research team, based on existing questionnaires on this topic. This was applied to nine health aids, since these perform the operations of sanitizing surfaces, between queries. The purpose of the questionnaire was to evaluate the good practices of sanitizing surfaces in dental clinics. In order to obtain standards for the evaluation of the questionnaires results it was considered the correct answer with a one mark and an incorrect answer as a zero. In the second step the ATP measurement was performed on cleaned surfaces. The execution of this step was carried out between one patient and another, where the hygiene should be done with alcohol 70% v/v rubbing for 10 minutes. The collections were performed aseptically, taking special care not to touch the swab elsewhere than analysis (Biosafety Commission, 2013). Samples were collected in an area of 100 cm^2, a square of 10 cm × 10 cm, turning the swab over the entire surface in every direction. The areas were sampled areas of the work surface where the probability of contamination was higher (Ferreira, 2012). To make these measurements the luminometer 3M Clean-Trace ™ Surface ATP was used. The serial number is TMJ118. For the test, the indications given by the manufacturer were followed. There is a capsule containing the luciferin-luciferase complex, which utilizes the chemical energy of ATP molecule, which causes light emission. Thus is obtained an association between the amount of ATP in the surface and the amount of light emitted (Santos, 2010). It was considered as the reference value, 500 RLU, lower values indicate a cleaning and disinfection of acceptable surfaces and higher values indicate the cleaning and disinfection of surfaces unacceptable. Through the IBM® SPSS® Statistics software version 19.0 for Windows was possible statistical treatment of data. To perform the statistical treatment were used simple descriptive statistics, as measures of location (mean and median) and dispersion (variance and standard deviation) and also statistical tests. The interpretation of statistical tests was based on a significance level of p-value ≤0.05 with Confidence Interval (C.I.) of 95%.

3 RESULTS

According to the questionnaire (Appendix II) results and considering the demographic data it was verified that health aides were on the entire female gender. The age was between 31 and 40 years (88.9%). According to formation on the area of activity performed, 66.7% reported having training. Observing the last part of the questionnaire, all auxiliary proceeded to cleaning and disinfection of surfaces and exclude all means of cleaning that make raised dust, the question "How about Cleaning (L) and Disinfecting (D) surfaces", only two of respondents answered "'Alcohol 70%" as the product used to disinfect surfaces. All auxiliary indicated that "the solutions used are identified as to type" and are identified as the expiration date. According to the question "Materials used for cleaning/disinfecting", 50% of respondents admit to using a cloth instead of paper or gases and after use, all respondents say that they "are sent for reprocessing or disposed of and waste containers in the unit.75% said there is "protocol for cleaning and disinfecting of these surfaces" in their clinics and all wore the datasheet of the product to determine the amount of solution used. 66.7% of the respondents fulfill the "Cleaning the floor is taken by the double bucket method" and "The water used in the buckets is hot water." "After use, it is conserved as cleaning utensils", 57.1% of respondents "Removes excess water and keep within the cleaning closet" instead of "Washed and disinfectant bath during the periods in which are not used." 88.9% admitted that "The cleaning materials are exclusive to each area" and 66.7% rinsed the cloth in the transfer from one device to another. Finally, 62.3% acknowledged that during cleaning and disinfecting "performs more tasks in addition to cleaning." Regarding the assessment of good practices of sanitizing surfaces 71.4% of health aides reveals that executes good practices and concluded that 77.8% of respondents practice proper personal hygiene. ATP quantification was performed on surfaces. A total of 42 samples were obtained at 6 locations (handlbar light, control knobs of the chair, bench, instruments, computer mouse and the professional's bench regulator) in seven clinics. This table shows the averages of ATP quantification in the evaluated surfaces. Given the results the significance level was 0.24 (>0.05), which is concluded that there are no significant differences between the different surfaces and quantification of ATP.

Let us now analyze the average quantification of ATP per clinic. At each clinic samples were made on 6 different surfaces in a total of 42 samples.

Thus, the table above represents the quantification of ATP per clinic. The significance level is 0.26 (>0.05), which is concluded that there are significant differences between different clinical and quantification of ATP. The comparison among the average values obtained in different clinics, types

Table 1. Average of ATP quantification in the various surface types.

	n	Average	Standard deviation
Handlbar light	7	3224,43	3211,978
Control knobs of the chair	7	1236,29	1369,101
Bench	7	461,14	554,876
Instruments	7	2714,57	1982,190
Computer mouse	7	2072,29	3022,827
Professional's bench regulator	7	2089,43	1833,258
Total	42	1966,36	2254,169

F:1,443; gl:5; p-value: 0,247.

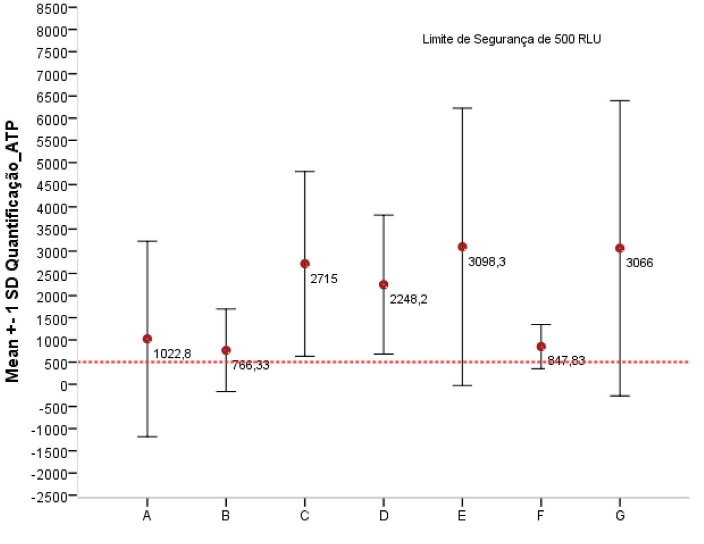
Table 2. Average quantification of ATP per clinic.

Clinic	N	Average	Standard deviation
A	6	1022,83	2204,098
B	6	766,33	929,831
C	6	2715,00	2082,178
D	6	2248,17	1565,926
E	6	3098,33	3127,422
F	6	847,83	497,604
G	6	3066,00	3327,709
Total	42	1966,36	2254,169

F:1,398; gl:6; p-value: 0,261.

Table 3. Comparison between the average and their difference with the value of security (500RLU).

	Average	Average difference	Standard deviation	t, gl, p-value
A	1022,83	522,833	2204,098	0,581; 6; 0,586
B	766,33	266,333	929,831	0,702; 6; 0,514
C	2715,00	2215,000	2082,178	2,606; 6; 0,048
D	2248,17	1748,167	1565,926	2,735; 6; 0,041
E	3098,33	2598,333	3127,422	2,035; 6; 0,097
F	847,83	347,833	497,604	1,712; 6; 0,148
G	3066,00	2566,000	3327,709	1,889; 6; 0,118
Handlbar light	3224,43	2724,429	3211,978	2,244; 5; 0,066
Control knobs of the chair	1236,29	736,286	1369,101	1,423; 5; 0,205
Bench	461,14	–38,857	554,876	–,185; 5; 0,859
Instruments	2714,57	2214,571	1982,190	2,956; 5; 0,25
Computer mouse	2072,29	1572,286	3022,827	1,376; 5; 0,218
Professional's bench regulator	2089,43	1589,429	1833,258	2,294; 5; 0,062



Graphic 1. Average and the standard deviation of the values obtained by dental clinic in relation to the safety limit of 500 RLU.

of surface and the safety limit will be analyzed in the following steps:

The table above represents the average and the average difference in each clinic and type of surface, compared to the limit of 500RLU. It ensures that the handle of light is the surface with the highest level of contamination, due to a higher average difference of 2724.4. Regarding dental clinics, clinic E has the highest average difference with 2598.33 and it also owns the highest values of ATP. In comparison with all clinics, the average value of ATP and the safety limit, with their respective confidence intervals. Some surfaces of different clinics presented values below the safety limit except clinic C and D. All surfaces of these clinics were above the safety threshold levels, as can be seen in Graphic 1.

4 DISCUSSION

In order to improve good practices, all clinics should keep health professionals informed through continuous and appropriate formation. From the questionnaires analyzed it is inferred that the professional assistant is the one that books appointments', aid the doctor during them as well as cleaning and sterilization tasks. They also collect the payment of each patient and in the end of the day they disinfect equipments and the office itself. It is in this environment that chains and routes of contamination of infectious diseases may be originated (Vasconcelos, Pereira, Veloso, & Vasconcelos, sd). During the development of this study this method showed to be feasible, by providing immediate and measurable results in Relative Light Units (RLU).During the ATP sample collection it was verified that, among patients, not all clinics proceed to surfaces hygiene. However in some clinics, the surfaces were cleaned and the professional thoroughly washed his hands and put gloves. But at one point the light needs to be positioned, the chair needs to be lowered, new instrument needs to be removed from the drawer, then, are also handled (Vasconcelos, Pereira, Veloso, & Vasconcelos, sd). The surface with the highest average of ATP was the light handle unlike the bench which is the only surface that the average was below the safety limit. This result is direct consequence of these surfaces being made of different materials therefore the light handle shows an irregular shape that hardens hygiene. The method determines the presence of ATP on surfaces, whether is from bacterial origin or not, it turns out that the values found were higher than considered safe for the classification of a surface under hygienic conditions. Therefore, five of the six areas evaluated showed an average higher than the values of 500 RLU. Thus, the surfaces were in unsatisfactory hygienic conditions. In the cleaning process it is expected that there is a removal of microorganisms from the surface, so it is expected that the process can also be capable of reducing organic matter at low levels. However, these situations may be due to various factors such as the surfaces not being cleaned and disinfected after use, the cleaning protocol not being properly applied; ineffectiveness of the procedures; use of material or cleaning contaminated equipment. During analysis of the means within ATP quantification by clinics, all have higher values than expected.The ATP method measures organic waste, which may or may not include microorganisms.

5 CONCLUSION

Environmental contamination can contribute to the transmission of pathogens when health professionals contaminate their hands or gloves by touching contaminated surfaces, or when patients come into direct contact with these surfaces (Ferreira de Andrade, Rigotti, & Ferreira, 2011). It was concluded the deficiency in cleaning and disinfection of the clinics studied. Thus, the surfaces and dental equipment are not sanitized properly after each service, representing transmission risks of cross infection. It is emphasized the importance of hand washing. Hand washing is one of the most important procedures to prevent disease transmission. Before and after attending patients, the hands of health professionals, should be washed with an appropriate antimicrobial solution. Latex gloves should be worn during the entire dental procedure and should be removed after and the hands are washed before touching surfaces. An investigation is suggested in order to identify the microorganisms present in the surface analyzed, since the limitation of this study was the fact that the ATP method only quantifies the microorganisms, not being possible to identify the type of contamination. It is essential the awareness of the clinics owners so that they can ensure a safe and effective dental care to all patients attended. They should establish rules and routines that minimize occupational hazards that the patients and the staff are exposed to, establishing preventive measures. Thus preventive awareness among health professionals transform into attitudes of bio security. It is essential to establish protocols for monitoring accidents involving exposure to biological materials and processes to ensure efficient disinfection and sterilization (Biosafety, C. d. 2009). However, the primary role is to invest in academic and professional training in this area, emphasizing and reinforcing good practices. Only then can the professionals fully adopt standard precautions, avoiding the risk of contact with infectious agents and thus contributing to the reduction of infections (Aires et al., 2010).

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Ergonomic assessment of electrical and electronic equipment's dismantling

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ABSTRACT: Work-Related Musculoskeletal Disorders (WRMSD) are a common health problem in many countries, and repetitive movements, extreme postures and force application are the core risk factors associated with the appearance and development of these disorders. This study aimed to perform the ergonomic assessment of two important tasks, related to Electrical and Electronic Equipment's Dismantling (EEED): (1) unloading trucks containing EEED and (2) dismantling washing machines. Quick Exposure Check (QEC), Rapid Entire Body Assessment (REBA) and Ovako Working Posture Analysing System (OWAS) were used. The study results show that, while performing both tasks, workers are often required to adopt extreme postures, high force exertion, and repetitive movements. Since a high risk level was found for both tasks, an ergonomic intervention is required in order to prevent the development of WRMSD.

1 INTRODUCTION

Work-Related Musculoskeletal Disorders (WRMSD) are an individual, organizational and social problem with high costs (Putz-Anderson et al., 1997). They are a common health problem and a leading cause of disability in the European Union (David et al, 2008, Schneider & Irastorza, 2010), as well as in many industrialized countries (Westgaard & Winkel, 1997). The adoption of extreme postures, the repetition of movements, the force exerted, and the exposure to vibration and extreme temperatures are often pointed out as the main risk factors for the development of WRMSD (Putz-Anderson et al, 1997, Punnett & Wegman, 2004, Larsson et al, 2007).

According to the data from the European Survey on Working Conditions 2005, the most common complaints reported by the European workers are back pain (24.7%) and muscle pain (22.8%), while working in critical positions (45.5%) and handling heavy loads (35%) were pointed out as the most important underlying causes. In Portugal, workers most reported problems were back pain (30.7%) and muscle pain (28.8%) (cited by Schneider & Irastorza, 2010).

Moreover, beyond workers disability, huge costs for organizations due to loss of production, absenteeism and compensation paid are among WRMSD most important outcomes (Putz-Anderson et al, 1997; Schneider & Irastorza, 2010).

Numerous risk assessment methods have been developed, most of which are centred on the upper body region. These methods range from workers self-reports to observational methods and direct measurements using monitoring tools (David, 2005).

This study aimed to assess the risk associated to the performance of two workplaces related to the dismantling of Electrical and Electronic Equipment (EEE) as well as to compare the results obtained by the three different assessment methods used in order to better understand the risk for the development of WRMSD and the importance of the investigated risk factors.

2 MATERIALS AND METHODS

The tasks to be assessed were selected based on the following criteria: (1) repetitiveness (short cycle tasks) and (2) handling of heavy loads. The tasks risk assessment was based on both photographic and video records, collected by a digital Sony Cyber-shot 16.1 Mega Pixels camera, while a stopwatch was used to measure the duration of some tasks. Later, the video records were carefully analyzed and two tasks (unloading trucks containing EEED, and dismantling washing machines) were selected, based on the following selection criteria: (1) task identified by workers as the hardest of their jobs, and (2) task performed during the most part of their working day.

Taking into account that in both workplaces workers are required to handle heavy objects (drag, rotate, for example) but none of them involves lifting of loads, after defining the tasks and selecting the target postures, QEC (David et al, 2008), REBA (Hignett & McAtamney, 2000) and OWAS (Mattila & Vilkki, 1999) were found as the most appropriate WRMSD risk assessment methodologies to be used. The repetition frequency and the extreme positions supported the selection of postures to be used for the risk assessment. The data collection for the application of QEC was supported by the questionnaire prepared by their authors. The remaining methodologies were applied by using the tables and schemas constructed and made available by their respective authors. For data processing Microsoft Excel 2010 was used.

The two workers performing the analyzed jobs freely agreed to participate in the study and they were observed in the workplaces during about two weeks.

3 RESULTS AND DISCUSSION

Both workers (male) are 47 years old and similar in stature. The workplaces are characterized by the performance of most tasks in the standing position, by repetitive movements and the use of high force levels. Unloading trucks containing EEE and dismantling washing machines are the two tasks selected for the current study. In Task 1, five postures were selected (Figure 1) and, in Task 2, seven postures were chosen (Figure 2).

The task of unloading trucks containing EEE (Task 1) is performed by using a stacker. While this is operated by one of the workers, the other one is positioning the EEE inside the truck in order to facilitate the grip by the stacker. There are two different types of trucks: one with side opening, which facilitates the unloading, and the other one with back opening, which requires a higher effort from workers to position the EEE in an accessible location of the truck. Task 1 was identified by both workers as the heaviest task of the workplace, since a high force exertion (the weight of the handled EEE ranges between 40 kg and 80 kg) is required, and it lasts on average one hour (in trucks with side opening) or two hours (in trucks with back opening). About two-thirds of all unloaded trucks are side opening and the workers can unload one or two trucks per day. After unloading the EEE, these are placed in the reception area, and then are dismantled. Most (about 70%) of all dismantled EEE are washing machines. In dismantling of washing machines, some of the components are removed (electric engine and the plastic components, for example). On average, workers take 2 minutes and 15 seconds to dismantle a washing machine. This task takes most of the working day (about 65% of the time).

The application of QEC provided us with scores for different body areas of both workers, which are indicators of the risk level and allowed to identify priorities for intervention for Task 1 and Task 2 (Table 1).

The analysis of QEC scores shows that, in Task 1 (Table 1), the risk level for the different body regions is at least moderate, and indicates the need for immediate implementation of preventive measures in the case of the back, while actions must be taken in the short term concerning the shoulder/arm and wrist/hand regions and in the medium term concerning the remaining body regions. In Task 2 (Table 1) the risk is at least high and, therefore, actions must be immediately implemented for the shoulder/arm, back and neck regions, short term measures must be implemented for wrist/hand and, in the other cases, medium term actions are required.

The methodology REBA identified the levels of risk associated with the analyzed positions and the possible need for implementation of corrective measures aiming at minimizing the risk of WRMSD (Table 2). In Task 1, although the scores are slightly higher for the worker B (except for posture 1), they are very close. The total scores indicate risk levels, which are the same for both workers in each of the analyzed positions, ranging from high (posture 1) and very high (other positions), pointing to the need for, respectively, short term or immediate interventions. Also in Task 2, the REBA scores are quite close and the total scores indicate the same risk levels for both workers in each of the analyzed positions and ranging from medium to very high, pointing to the need for interventions in the medium term, short term or immediate, as appropriate.

In turn, applying OWAS led to action categories (Table 3) which are the same for both workers in the analyzed two tasks, which mostly require the implementation of corrective actions as soon as possible or in the near future. Table 4 shows the values of actions categories for back, arms and legs.

Taking into account the residence time in the postures, it was found that 80% of the duration of the Task 1, both workers have remained tilted or inclined and twisted the column and the two arms below the level of the shoulders and of 60% of time remained standing with his weight on one of the legs straight (Table 5). In Task 2, the workers kept leaning column for 85.7% (worker A) and 71.4% (worker B) of the time, remained with both arms below shoulder level (71.4%) and remained standing with his weight on one of the legs straight (57.1%) (Table 5).

Figure 1. Unloading trucks containing EEE (Task 1) (up: worker A; below: worker B).

Figure 2. Dismantling washing machines (Task 2) (up: worker A; below: worker B).

Table 1. QEC: Scores and exposure level (Tasks 1 and 2).

	Task 1				Task 2			
	Worker A		Worker B		Worker A		Worker B	
Exposure factor	QEC	Exposure	QEC	Exposure	QEC	Exposure	QEC	Exposure
Back (moving)	50	****	50	****	44	****	44	****
Shoulder/arm	38	***	38	***	48	****	48	****
Wrist/hand	36	***	30	**	32	***	38	***
Neck	10	**	10	**	16	****	16	****
Driving	1	*	4	**	4	**	4	**
Vibration	1	*	1	*	4	**	1	*
Work place	4	**	4	**	1	*	1	*
Stress	1	*	1	*	1	*	1	*

* Low. ** Moderate. *** High. **** Very high.

Table 2. REBA: Scores and risk levels.

	Worker A		Worker B			Worker A		Worker B	
Posture	REBA	Risk	REBA	Risk	Posture	REBA	Risk	REBA	Risk
1	10	***	9	***	7	9	***	10	***
2	11	****	11	****	8	9	***	9	***
3	12	****	13	****	9	13	****	12	****
4	12	****	13	****	10	5	**	4	**
5	11	****	11	****	11	4	**	5	**
6	13	****	14	****	12	9	***	9	***

* Low. ** Moderate. *** High. **** Very high.

Table 3. OWAS: Scores and action categories for prevention.

	Worker A		Worker B			Worker A		Worker B	
Posture	OWAS	Actions	OWAS	Actions	Posture	OWAS	Actions	OWAS	Actions
1	1	*	1	*	7	2	**	2	**
2	3	***	3	***	8	2	**	2	**
3	3	***	3	***	9	3	***	3	***
4	3	***	3	***	10	2	**	2	**
5	3	***	3	***	11	2	**	2	**
6	3	***	3	***	12	2	**	2	**

* No actions required. ** Corrective actions required in the near future. *** Corrective actions should be done as soon as possible.

Table 4. OWAS: Action categories taking into account the residence time (back, arms and legs).

	Back			Arms			Legs		
		Workers			Workers			Workers	
Posture	Time (%)	A	B	Time (%)	A	B	Time (%)	A	B
1	0–20	1	1	81–100	3	3	0–20	1	1
2	81–100	3	3	0–20	1	1	0–20	1	1
3	0–20	2	2	0–20	1	1	81–100	3	3
4	81–100	4	3	0–20	1	1	0–20	1	1
5	81–100	3	4	0–20	1	1	0–20	1	1
6	81–100	3	4	0–20	1	1	0–20	1	1
7	41–60	2	2	81–100	3	3	41–60	2	2
8	81–100	3	3	0–20	1	1	81–100	3	3
9	81–100	4	3	0–20	1	1	0–20	1	1
10	41–60	2	3	81–100	1	1	41–60	1	1
11	41–60	2	3	81–100	1	1	41–60	1	1
12	41–60	2	2	0–20	1	1	81–100	2	2

Table 5. OWAS: Frequency and relative proportion (%) postures of back, arms and legs (Tasks 1 and 2).

		Task 1		Task 2			
		Workers A and B		Worker A		Worker B	
Body	Position	Frequency	%	Frequency	%	Frequency	%
Back	Straight	1	20.0	–	–	–	–
	Bent forward	2	40.0	6	85.7	5	71.4
	Bent and twisted	2	40.0	1	14.3	2	28.6
Arms	Both below shoulder level	1	20.0	5	71.4	5	71.4
	One at or above shoulder level	4	80.0	2	28.6	2	28.6
Legs	Standing with both straight	2	40.0	3	42.9	3	42.9
	Standing with one straight	2	60.0	4	57.1	4	57.1

4 CONCLUSIONS

The current study shows that, while performing their jobs, workers often adopt extreme postures, and are required to exert high force levels as well as repetitive movements. Even though OWAS seems to underestimate the risk, all the three risk assessment methods used mostly indicate high to very high risk levels, meaning that short term or even immediate actions are required so that the risk of WMSD can be minimized. The implementation of measures such as to provide workers with training, information and sensitization seem to be an important step for the adoption of more neutral postures during the performance of their professional activity. On the other hand, a rotating and lifting platform could be used to help workers to minimize the adoption of extreme positions as well as to reduce the level of force required to handle (e.g. rotate) the washing machines during the dismantling procedure.

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Testing a human thermal software using field investigation from an industrial plant

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ABSTRACT: The analysis of a thermal comfort or to a thermal stress situation can be achieved using diverse techniques, models and numerical simulations. The main purpose of this paper is to use a human thermal software to analyze the human response to different thermal environmental conditions. The human thermal model is based on equations of heat and mass transfer and, based on the parameters of thermal environment that influence comfort, it can predict the temperatures and humidity at the human body and clothing. A simulation was done using the experimental data obtained from a field investigation at an industrial plant. Results indicate that the software can differentiate body parts concerning its thermal behavior according to their adaptability and in all cases, the temperature values tend to stabilization. A verification of the coefficients of heat transfer between the cloth and the environment is required being pointed as future work.

1 INTRODUCTION

Humans are homeotherms, which mean that their internal body temperature (core) should remain constant and near to 37ºC, despite the exterior temperature (Parsons, 2000). According to Miguel (2012), homoeothermic is assured by the equality between the heat flow produced by the body and the heat loss to the environment. This loss of heat is made through conduction, convection, radiation and evaporation processes.

The occupational environment can be neutral, cold or hot. A combined action between the four environmental parameters (temperature, relative humidity, velocity and radiant heat) and the two individual parameters (clothing worn by the occupants and their activity) can lead to a thermal comfort, discomfort, or to a thermal stress situation (Parsons, 2013). The integration of these parameters can be done in a thermal index in a way that will provide a single value that is related to the effects on the occupants. Three types of indices can be identified: empirical, rational and derived. According to Parsons (2000), rational indices are derived from mathematical models that describe the behavior of the human body in thermal environments. The analysis of these situations can be achieved using diverse techniques and comfort models, such as Computation Fluid Dynamics (CFD) and other numerical simulations (Murakami et al., 2000). The human thermal software (Teixeira et al., 2010) is based on differential equations of heat and mass transfer and it can predict the temperature and humidity at the human body and its clothes along the time. The human body is simulated as 16 different parts: (1) heart-lungs, (2) trunk, (3) abdomen, (4) left arm, (5) right arm, (6) left forearm, (7) right forearm, (8) left hand, (9) right hand, (10) left thigh, (11) right thigh, (12) left leg, (13) right leg, (14) left foot, (15) right foot and (16) head (Fig. 1). Part (1) is a single blood-vessel system and the other parts are divided into three layers: core, shell and skin. The body can be considered naked or covered with clothes. When naked, the heat exchange with the air is made through convection, radiation and evaporation.

According to Teixeira et al. (2010), when the body is dressed, two layers are simulated: one along the skin which is assumed to be air, and an exterior layer of clothing. The model also includes the moisture diffusion through the cloth fabrics. The heat and humidity fluxes are divided into 2 parts: the exterior layer exchanges with ambient through convection, radiation and evaporation and the interior layer takes the properties of the air, exchanging with the skin and the clothes (Teixeira et al., 2010). This paper aims to analyze the human response to different thermal environmental conditions, using this thermal human software. To achieve this goal, a simulation was made using as input parameters, the experimental data obtained from a field investigation conducted in an industrial plant (Guise et al., 2014).

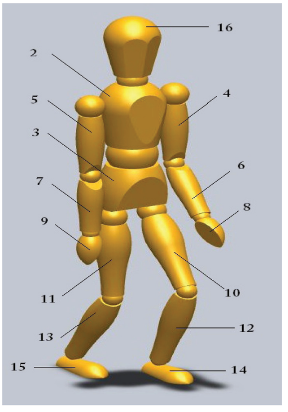

Figure 1. Simulated parts of the human body.

2 METHODOLOGY

This study presents an investigation concerning the simulation of the human response to pre-established conditions, including the environmental and individual parameters. It should be referred that for this study, data obtained from field investigation in an industrial plant were used. The assessment of the thermal environment was carried out in a plant of a textile industry for automotive components, located in Vila Nova de Famalicão, Portugal. The company belongs to a Corporation that produces tires and other automotive systems. Thermal environment parameters including the air temperature, the relative humidity, the radiant temperature and the air velocity, were measured. For this purpose, the plant was divided into 29 measurement points and, in each point, three levels were defined: head, abdomen and ankles. Each one contained one temperature and humidity sensors for testing vertical temperature differences (Data Logger model EL-USB 2 from Lascar), one black globe temperature sensor, and one air velocity meter for measuring the air velocity (model 8330 from TSI VelociCheck). The air velocity, air temperature and relative humidity were automatically recorded and radiant temperature was manually measured. It is important to point out that the Data Logger was scheduled to take measurements every 2 minutes. A stand was used to suspend the equipment so that they do not restrict free air flow around the bulbs and the wet-bulb and globe thermometer were not shade (ISO 7726:1998). To achieve accurate values for the radiant temperature, a stabilization time of 10 minutes between each measure, was defined.

Workers clothing level was also evaluated. Workers pointed out the clothes they were wearing from a list in the Thermal Sensation Questionnaire (TSQ) (Guise et al., 2014) allowing the latter calculation of the overall clothing insulation. Workers were also asked to evaluate the airflow level around them, the level of acclimatization and their thermal sensation. The metabolic rate was also calculated. For this purpose, work process was defined through activities direct observations, as well as, workers and supervisors interviews.

The field investigation was important for the subsequent selection of the points that should be included in the simulation test. From the 29 measurement points, two were selected (points 6 and 24). The selection had the assumption of equal values of metabolism (independent of the type of tasks) and different environmental parameters with a focus on air temperature. The thermal environmental conditions used in the simulation are presented in Table 1. As it is possible to observe, the air temperature is substantially higher in point 24.

The mathematical model implemented is based on differential equations of heat and mass transfer along the time and they are numerically solved using the Runge-Kutta-Merson method. The final program is implemented in Fortran. Different time steps (*delta t* = 0.001 s and 0.0001s) were used for the numerical integration and the same results were obtained. The objective of the software is to estimate temperatures and humidity in the different parts of the body, as function of time (Teixeira et al., 2010).

Assuming that in the present study, only the head (part 16) and forearms and hands (parts 6 to 9) are naked, a system of 86 differential equations is solved, including 20 equations to calculate the water vapor density variation along the time, in the cloth layers.

Only the results for the head and abdomen parts are presented here as the output values, for simplicity. It was considered that these parts have higher significance in terms of occupational comfort. Although the measurements were made at three levels: head, abdomen and ankles, the abdomen was selected to be the covered part in this study, as in terms of numerical equations no distinctions were considered between the abdomen and ankles concerning the insulation. To test the effect of the cloth insulation, the results of the head were also presented as a naked part.

Table 1. Simulated conditions.

	Ta	HR	Trad.	Met.
Points	ºC	%	ºC	W
6	24.7	41.7	24.2	394
24	30.3	35.7	30.7	394

3 RESULTS AND DISCUSSION

The results from the simulation, regarding the behavior of the skin temperature in the head are presented in Figure 2. This part was considered to be uncovered. It is possible to observe that in point 6, temperature ranges over and it is higher in the first 1800 seconds. After this period of time, the temperature in the two points starts to converge to similar values. This behavior can be explained by a likely destabilization in the human body caused by the significantly higher air temperature in point 6 (see Table 1). When the body is presented at a higher temperature, at the beginning the head will warm up more, but after some time, when the thermoregulation process takes effect, the temperature converges for a similar state.

The skin temperature of the abdomen for the two points is presented in Figure 3. The temperature evolves in a similar way but it is always higher in point 6. From the start point at the simulation, from 0 to 1000 seconds, the temperature in point 24 goes approximately from 33.5ºC to 34ºC, and in point 6 from 33.5ºC to 35ºC (approximately). These results can be explained, as well as for the head, as the time required for temperature stabilization. However, it is possible to observe that the two body parts react differently. It seems that the adaptation capacity is greater in the head than in the abdomen. This is in agreement with the theoretical models where the head is a privileged body part in the thermoregulation process.

Also, these differences can be explained by the presence of clothing. In Figure 4, the temperature of the cloth covering the abdomen part is presented for the two different locations. A higher temperature in point 6 is obtained when compared to point 24.

Although in both cases, the initial cloth temperature is set at 27ºC, in the first 1000 seconds, stabilization is achieved but it occurs at around 33ºC in point 24, and near 35ºC in point 6. Taking into account the ambient temperature and the skin temperature at the abdomen part at point 6, the warmer location, it seems that the cloth temperature is not adjusting so well along the time. A first approach to this subject will be to verify the coefficients of heat transfer between the cloth and the environment, and testing if the heat transfer at this point is being correctly implemented.

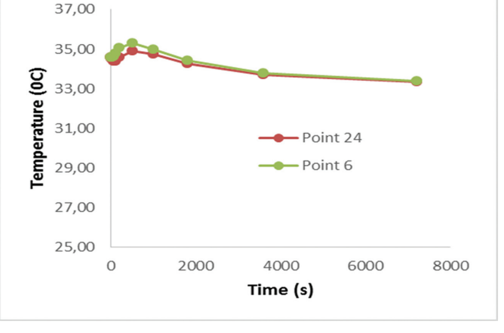

Figure 2. Skin temperature in the head along the time, for points 6 and 24.

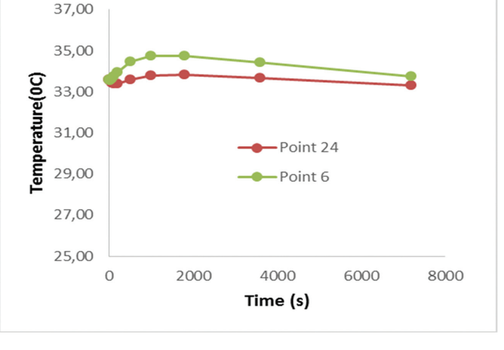

Figure 3. Skin temperature in the abdomen along the time, for points 6 and 24.

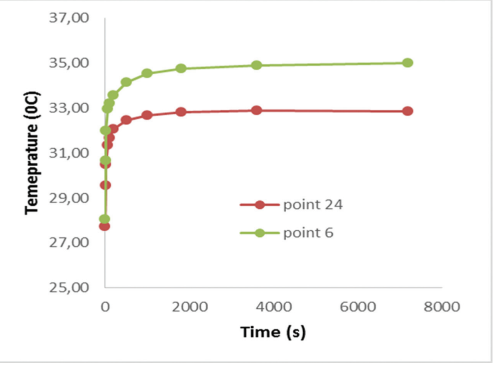

Figure 4. Cloth temperature in the abdomen part along the time, for points 6 and 24.

4 FINAL CONSIDERATIONS

The software can differentiate body parts concerning its thermal properties and geometry. It was also shown that the body, in these cases, tended to temperature stabilization regarding the different environmental conditions.

As future work, the software will be tested for different environmental conditions as well as different metabolism and clothing parameters values, in order to study how it tends to different equilibrium temperatures. Another point to be worked on is the heat transfer of the clothing with the environment.

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Exposure of urban bus drivers to Whole-Body Vibration

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ABSTRACT: Urban bus drivers are exposed to mechanical vibrations which are transmitted to the whole-body and have effects on health of the workers. The aim of this study is to evaluate Whole-Body Vibrations (WBV) among urban bus drivers, relating vibration magnitude with the road characteristics. A study of seat's transmissibility is also presented. Were used the methodological recommendations of ISO 2631-1 (1997) and ISO 2631-5 (2004). Three routes, with three different drivers to collection data were defined. All drivers were exposed to values lower than exposure and action limits. So according the standards, the probability of health effects is low. The seats have also a positive effect reducing the transmission of the WBV to the driver in all cases. The workers are not exposed to highest values than exposure limits, but some preventive strategies were recommended. Despite the improvement of urban pavements is not an enterprises responsibility, its evaluation and improvement is suggested.

1 INTRODUCTION

It is world-wide accepted that discomfort, reduced work efficiency and health impairments are problems found among professionals repeatedly exposed to Whole-Body Vibrations (WBV) (Melo & Miguel, 2000; Bernardo, *et al.*, 2014). The risk depends on its intensity and duration. Several standards define procedures for measurement and evaluation of Whole-Body Vibration (WBV), providing "*limit values*" and "*action levels*". However, there are no studies demonstrating what is the dose of WBV that can cause any specific disorder related to the magnitude, frequency, direction and duration of vibration exposure (Griffin, 2004).

Nevertheless, previous research indicates a causal relationship between WBV exposure and the large number of low back disorders among public bus drivers (Blood & Johnson, 2012). Several studies have identified road conditions as a major contributor to WBV exposure's levels (Lewis & Johnson, 2012). In addition, the factors that seem to determine the vibration magnitude are also the design of the vehicle and the skills and behavior of the driver (Tiemessen, Hulshof & Frings-Dresen, 2007).

The International Organization for Standardization (ISO) standard 2631-1, '*Mechanical Vibration and Shock—Evaluation of Human Exposure to Whole-Body Vibration—Part 1: General Requirements*', specify how to measure and analyze WBV. Action limits and exposure limits values are presented in Table 1 (Lewis & Johnson, 2012). To further evaluate transient shock vibration exposures in relation to human health, the International Organization for Standardization (ISO) published a new WBV standard, ISO 2631-5, in 2004. Long-term

Table 1. Daily (8-h) action and exposure limits for whole-body vibration.

	ISO 2631-1	ISO 2631-5	
	A(8) ($m.s^{-2}$)	S_{ed} (MPa)	Probability of an adverse health effect
Action limit	0.5	0.5	Moderate
Exposure limit	1.15	0.8	High

(Thamsuwan, et al., 2013).

exposure to vibration containing multiple shocks is considered to be a health risk, by the adverse effects they can have to the lumbar spine. The ISO 2631-5 standard uses raw data, continuously collected from tri-axial equipment, to calculate a daily equivalent static compressive dose (S_{ed}) on the lumbar spine. The threshold values for adverse health effects over a lifetime exposure, based on an average 8-hour daily equivalent exposure, are shown on the right side of Table 1 (Thamsuwan, Blood, Ching, Boyle, & Johnson, 2013).

The aim of this study was to develop a pilot study for the assessment of Whole-Body Vibrations (WBV), among urban bus drivers, relating vibration magnitude with the road characteristics. To analyze workplaces' quality, seat's transmissibility was also studied.

2 METHODOLOGY

2.1 *Data collection*

2.1.1 *Equipment*

Data collection was performed using two devices on seat and floor of the vehicle, simultaneously. Accelerometers SVANTEK (model SV 106 e model SV 948, Poland) were used to measurements. The continuous data were downloaded using *software* SVAN PC ++, version 2.2.8 of SVANTEK and then data were analyzed and calculated using Microsoft Office Excel.

2.1.2 *Roads type, drivers and vehicles*

A standardization test route was done in order to select three routes (numbered 1, 2 and 3) with different characteristics in terms of pavement (asphalt and brick). Routes characterization is present in Table 2.

The group study was defined from a group of three professional drivers of the Transports' Company (A, B and C). Table 3 shows drivers' characterization.

Were used bus MAN (models NL 233 CNG and NL 310 CNG) and were tested two bus seats (ESTEBAN FA 416 E2 and ISRY 6860/875 EASY9).

Table 2. Characteristics of roads included in the study.

Route	Pavement type	% of pavement for road	Mean time of journey (minutes)
1	Asphalt and brick	63.1% asphalt and 36.9% brick	50
2		62.8% asphalt and 37.2% brick	48
3		48.2% asphalt and 51.8% brick	28

Table 3. Characteristics of subjects included in the study.

	Bus drivers		
	A	B	C
Gender	Male	Male	Male
Age	36	35	40
Weight (kg)	111	84	90
Height (cm)	178	184	180
Bus driving experience (years)	12	13	14
Daily time exposure to WBV (h)	6.40	6.40	6.40

2.1.3 *Experimental procedure*

The measurements of exposure to WBV was in accordance with methodological recommendation of ISO 2631-1 (1997) and ISO 2631-5 (2004) standards. Data were collected from the seat pan and the floor of the bus. Data obtained on the floor allow quantifying the parameter SEAT (Seat Effective Amplitude Transmissibility). In both cases, data collection was performed according x, y and z-axis. Monitoring consisted in measurements in all route defined, in each driver performed four complete journeys. The routes were completed in the usual daily transport service.

2.2 *Data analysis*

2.2.1 *Exposure to Whole-Body Vibration*

The analysis of exposure to WBV was performed using the ISO 2631-1 (1997) and ISO 2631-5 (2004) standards. After calculating weighted Root Mean Square (RMS) values for each orthogonal axis, the highest value was chosen. This parameter was normalized to reflect A(8) (eight hour daily exposure), in meters per second squared (Bernardo, *et al.*, 2014b). In order to evaluate whole-body vibration exposure containing multiple shocks in relation to human health, the average daily dose related to the drivers' exposure at whole-body vibrations was estimated. This parameter was also normalized to the daily equivalent static compression dose, S_{ed}, in mega Pascal.

2.2.2 *Seat effective amplitude transmissibility*

Seat Effective Amplitude Transmissibility (SEAT) value was calculated as the ratio between WBV exposures in the vertical direction, measured at the seat and the WBV exposures in the vertical direction measured at the floor of the bus. SEAT values represent the attenuation of the vibration transmission through the seat.

3 RESULTS AND DISCUSSION

3.1 *Effects of pavement types*

The z-axis values were identified as higher in all pavements, for all drivers. Highest exposures were found in brick surface when compared with asphalt-paved road.

3.2 *Whole-Body Vibration exposure*

As can be seen in Table 4, exposure values, RMS and A(8), were lowest than action values (0.5 $m.s^{-2}$) in all cases analysed. Comparing between routes, values were located in 0.26 $m.s^{-2}$ for route 3 with the driver C and 0.34 $m.s^{-2}$ for road 1 also with the driver C. The acceleration levels in the route 3 are substantially lower than in the route 1, because its surface conditions are better.

Table 5 presents the values which categorize the probability of adverse health effects from cumulative impulsive exposure.

The S_{ed} values were similar in all cases. Long-term whole-body multiple-shocks exposure includes an increased risk to pathological disturbances to the spine, ISO (2004). According ISO 2631-5, S_{ed} values are above limits (0.5 MPa for action limit) and there is a moderate probability to adverse health effects.

Table 4. Values of RMS and A(8) obtained on seat, comparing different routes and drivers.

Route	Bus driver	RMS ($m.s^{-2}$)	A(8) ($m.s^{-2}$)
1	A	0.341	0.312
	B	0.312	0.284
	C	0.369	0.337
2	A	0.352	0.322
	B	0.330	0.299
	C	0.349	0.319
3	A	0.286	0.261
	B	0.301	0.275
	C	0.281	0.256

Table 5. Values of S_{ed} obtained on the seat, comparing different roads and drivers.

Route	Bus driver	S_{ed} (MPa)
1	A	0.214
	B	0.240
	C	0.295
2	A	
	B	0.256
	C	0.211
3	A	0.447
	B	0.246
	C	0.258

3.3 *Floor vibration and SEAT values*

Table 6 shows the results obtained to SEAT parameter. Owing to technical problems, it was not possible to assess the transmissibility in all days of monitoring. Thus, there are not results for this parameter in route 1, and in route 2, with the driver B.

As SEAT parameter represents the ratio between the RMS values on the seat and on the floor that means that as lower the value better is the seat ability to attenuate vibrations. The minimum value (47.3%) of SEAT was found to road 1, with driver A and the maximum value (60.6%) was found also to road 1, with driver C.

Although the workers are not exposed to values higher than exposure limits, preventive strategies are suggested. On the one hand, the continuous training on health and safety is recommended. On the other hand, according previous research, engineering, administrative, and organizational strategies must continue.

An adjusted selection of seats, its regular maintenance, the existence of lumbar support and suspension mechanisms are very important. In organizational terms, either the redefinition of routes based on the road type or the establishment of regular rest breaks can also help to reduce the effects of vibration exposure. By drivers, speed adjustment according to driving conditions, physical exercise and healthy eating habits can reduce the effects caused by exposure to WBV.

Road surface improvement is not a Bus Companies' responsibility, but the evaluation and improvement of pavements is suggested, because they are the main source of vibration and have a big influence on the comfort not only for bus drivers but also to passengers.

Table 6. Values obtained to evaluate Seat Effective Amplitude Transmissibility (SEAT).

Road	Bus driver	RMS_{seat} ($m.s^{-2}$)	RMS_{floor} ($m.s^{-2}$)	SEAT (%)
1	A	0.341	0.723	47.3
	B	–	–	–
	C	0.369	0.609	60.6
2	A	0.352	0.620	56.8
	B	–	–	–
	C	0.349	0.650	53.7
3	A	0.286	0.545	52.4
	B	0.301	0.550	54.7
	C	0.281	0.560	50.1

4 CONCLUSION

This work allowed to expand the knowledge in this topic and is expected to have made a useful contribution to other similar situations. Evaluating WBV in urban bus drivers with both ISO standards, allowed a more complete assessment of working conditions. It was clear that the WBV exposures in this sample of urban bus drivers, do not exceed the recommended limit values. The seats are also doing its role reducing the transmission of the WBV to the drivers in all the cases. The constant adoption of preventive measurements is recommended, as well as the preoccupation about pavements improvement. In the future, this research may be consolidated starting from the limitations identified.

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Whole-Body Vibration in urban bus drivers—a short review

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ABSTRACT: The aim of this study is review systematically relevant literature in order to explore Whole-Body Vibration (WBV) in professional bus drivers. The search was performed using the methodology of PRISMA statement. Using key words and defining selection criteria, 22 studies are included. These studies are analyzed into different categories: sources and background of WBV, methodologies applied to the measurement, effects and control. The literature uses the methodology present in ISO standards (ISO 2631-1 and ISO 2631-5) and some authors consider the ability of seat as a factor used to attenuate vibration exposure. It was found that a relationship exists between the road type and the magnitude vibration. Low back pain is the more evident symptom among professional drivers. In some cases, workers are exposed to highest values than exposure limits and action values and the risks can be reduced using preventive strategies.

1 INTRODUCTION

Numerous studies have shown an association between exposure to WBV in professional driving occupations and low back pain (Blood & Johnson, 2012; Schwarze, et al., 1998). The International Organization for Standardization (ISO) standard 2631-1, '*Mechanical Vibration and Shock—Evaluation of Human Exposure to Whole-Body Vibration—Part 1: General Requirements*', specify how to measure and analyze WBV. The Exposure Action Value (EAV) is a daily amount of vibration exposure above which employers are required to take action to control exposure, and the Exposure Limit Value (ELV) is the maximum amount of vibration an employee may be exposed to, on any single day. For an 8 h exposure, the A_w action and exposure limits are 0.5 $m.s^{-2}$ and 1.15 $m.s^{-2}$, respectively. To address the limited guidance available regarding impulsive WBV exposures under ISO 2631-1, ISO recently adopted a new standard, ISO 2631-5: '*Evaluation of Human Exposure to Whole-body Vibration—Part 5: Method for Evaluation of Vibration Containing Multiple Shocks*'. It provides guidance on the calculation of cumulative acceleration dose (D_k), which takes into account multiple shock/peak exposures and recommendations for computing a daily equivalent static compression dose (S_{ed}) to the spine. S_{ed} less than 0.5 MPa are expected to have a low probability of adverse health effects after a lifetime of exposure, while those over 0.8 MPa are expected to have a high probability of adverse health effects (Lewis & Johnson, 2012). The aim of this study is review systematically relevant literature in order to explore whole-body vibration (WBV) in professional bus drivers.

2 METHODOLOGY

The literature search was based on PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). The resources used for researching scientific articles were essentially databases of reference (Web of Knowledge and Scopus) and scientific journals (Science Direct, among others). In addition, were also included articles referenced in the bibliography of reviewed ones. The keywords were: occupational vibration, whole-body vibration, pavements, vehicles, bus, driver, road type and seat effective amplitude transmissibility.

These were combined with each other, searching on tittle. For select articles, exclusion criteria were: 1) Access: were excluded articles not available in full text; 2) Language: were excluded articles not published in Portuguese or English; 3) Publication Date: were excluded articles published before 1990; 4) Relevance: were excluded articles not addressing occupational vibration among public bus drivers. Were also excluded very specific items of medical nature, the diseases caused by vibrations and that were not directly related to occupational exposure in urban bus drivers.

3 RESULTS AND DISCUSSION

3.1 *Search results*

A total of 152 articles were retrieved from literature search. Forty two duplicates were identified and others 88 were refused by different reasons. Thus, 22 studies were included in this review. After applying the methodology on literature search, it was possible to systematize the relevant information that contributes to the purpose of this literature review.

3.2 *Whole-Body Vibration in urban bus drivers*

Various land-based vehicles are the most common source of seated WBV exposure and occupational operators of these vehicles often report musculoskeletal symptoms (Rehn, Lundström, Nilsson, Liljelind & Järvholm, 2005). Previous research indicates a causal relationship between WBV exposure and the large number of low back disorders among public transit drivers (Blood & Johnson, 2012). Mass transit operators represent one of the largest working populations in the transportation sectors in the USA and have substantial occupational exposures to WBV. An exponential dose–response relationship between hours of weekly driving and injury risk has been found. Currently, there is limited data available on WBV levels experienced by workers on transit systems, but much of the data that have been published suggests that these workers' exposures e exceed recommended standards. Studies have identified road conditions as a major contributor to levels of WBV exposure (Lewis & Johnson, 2012). In addition, the factors that seem to determine the magnitude vibration are also the design considerations of vehicle and the skills and behavior of the driver (Rehn, et al., 2005; Tiemessen, et al., 2007).

3.3 *Methodologies applied to the measurement and assessment of Whole-Body Vibration*

The methods for measuring WBV exposures and multiple shock exposure used are according the ISO standard documents ISO 2631-1:1997 (Blood & Johnson, 2012; Bovenzi, 2009; Lewis & Johnson, 2012; Marjanen, 2005; Melo & Miguel, 2000; Paddan & Griffin, 2002a, 2002b; Picu, et al., 2010; Pinto & Stacchini, 2006; Rehn, et al., 2005; Thamsuwan, et al., 2013) and ISO 2631-5:2004 (Lewis & Johnson, 2012; Marjanen, 2005; Thamsuwan, et al., 2013), respectively, and provide guidance on the assessment of health effects. Both ISO 2631-1 and ISO 2631-5 standards should be used for better understanding of the exposure.

In general, data collection was performed using tri-axial accelerometer (model 356B40; PCB Piezometrics, Depew, NY, USA) (Blood & Johnson, 2012; Bovenzi, 2009; Lewis & Johnson, 2012; Thamsuwan, et al., 2013), although others equipment are refered in literature. The measurements were collected from the seat pan (Blood & Johnson, 2012; Bovenzi, 2009; Lewis & Johnson, 2012; Melo & Miguel, 2000; Okunribido, et al., 2008; Rehn, et al., 2005; Thamsuwan, et al., 2013) and also from the seat backrest (Melo & Miguel, 2000; Paddan & Griffin, 2002b) and the floor of the bus (Lewis & Johnson, 2012; Paddan & Griffin, 2002a, 2002b; Thamsuwan, et al., 2013). In most cases, the evaluation on the backrest is justified by considering that this rout have a most significant on vibration transmission, while measurements obtained to the floor allow quantify the parameter SEAT (Seat Effective Amplitude Transmissibility). In addition, (Blood & Johnson, 2012; Thamsuwan, et al., 2013) use the Global Positioning System (GPS) to collect data in order to record the location and velocity of the bus, and type of road associated with the WBV exposures. Z-axis exposures were consensually the highest (Blood & Johnson, 2012; Bovenzi, 2009; Lewis & Johnson, 2012; Rehn, et al., 2005; Thamsuwan, et al., 2013). According some authors, in addition to z, y-axis is also relevant and these axis exposures tend to be slightly higher than x-axis (Blood & Johnson, 2012; Melo & Miguel, 2000). The standardized tests routs of the studies were defined to include different road types. These include city streets, new freeway, old freeway, and circular route containing speed humps (Blood & Johnson, 2012; Lewis & Johnson, 2012; Thamsuwan, et al., 2013).

According (Melo & Miguel, 2000), the itinerary chosen included asphalt and brick-paved roads. For this, data was always collected according to the following sequence: 1st measurement—bus stopped, with the engine running; 2nd measurement—bus riding on brick-paved road; 3rd measurement—bus riding on asphalt-paved road. The study was conducted in actual working conditions and so the bus was transporting passengers and would stop whenever needed for boarding or alighting, traffic lights and pedestrian crossings were part of the itinerary and traffic jumps happened on some occasions (Melo & Miguel, 2000). The Table 1 shows the compilation of the values obtained in some studies of evaluating WBV exposure.

Exposures of seated persons to whole-body vibration are influenced by seating dynamics. In some environments the dynamic response of seat can be a factor most easily used to control human exposure to whole-body vibration (Paddan & Griffin, 2002a). Seats can perform differently in their ability to attenuate vibration exposure for the driver. In some cases the seat can amplify the exposure and the understanding of seat performance is not well quantified (Blood &

Table 1. Compilation of studies evaluating WBV exposure in urban bus drivers.

Authors	Road type	Axis	RMS ($m.s^{-2}$)	A(8) ($m.s^{-2}$)	S_{ed} (MPa)
(Blood & Johnson, 2012)	City streets	x	-	0,14 (±0,01)	-
		y	-	0,11 (±0,01)	-
		z	-	0,36 (±0,01)	0,45 (±0,03)
	Speed humps	x	-	0,17 (±0,01)	-
		y	-	0,15 (±0,01)	-
		z	-	0,36 (±0,01)	0,42 (±0,03)
	New freeway	x	-	0,11 (±0,01)	-
		y	-	0,11 (±0,01)	-
		z	-	0,43 (±0,01)	0,29 (±0,03)
	Old freeway	x	-	0,13 (±0,01)	-
		y	-	0,12 (±0,01)	-
		z	-	0,51 (±0,01)	0,30 (±0,03)
(Bovenzi, 2009)	-	x	-	0,07 (±0,02)	-
		y	-	0,09 (±0,04)	-
		z	-	0,30 (±0,09)	-
(Lewis & Johnson, 2012)	Freeway	x	-	0,16 (±0,06)	0,42 (±0,05)
		y	-	0,17 (±0,02)	
		z	-	0,51 (±0,04)	
	City street	x	-	0,20 (±0,05)	0,71 (±0,21)
		y	-	0,21 (±0,02)	
		z	-	0,47 (±0,04)	
	Speed humps	x	-	0,25 (±0,06)	0,58 (±0,2)
		y	-	0,28 (±0,02)	
		z	-	0,46 (±0,08)	
(Melo & Miguel, 2000)	Bus stopped	x	0,010	-	-
		y	0,019	-	-
		z	0,041	-	-
	Brick surface	x	0,213	-	-
		y	0,267	-	-
		z	0,343	-	-
	Asphalt surface	x	0,113	-	-
		y	0,180	-	-
		z	0,524	-	-
(Thamsuwan, et al., 2013)	Smooth freeway	x	-	0,16 (±0,01)	0,09 (±0,01)
		y	-	0,18 (±0,01)	0,17 (±0,01)
		z	-	0,42 (±0,02)	0,24 (±0,01)
	Rough freeway	x	-	0,19 (±0,01)	0,11 (±0,01)
		y	-	0,21 (±0,01)	0,18 (±0,02)
		z	-	0,53 (±0,02)	0,32 (±0,01)
	City street	x	-	0,20 (±0,01)	0,12 (±0,02)
		y	-	0,19 (±0,01)	0,22 (±0,05)
		z	-	0,39 (±0,01)	0,32 (±0,02)
	Speed humps	x	-	0,24 (±0,01)	0,12 (±0,01)
		y	-	0,26 (±0,01)	0,20 (±0,01)
		z	-	0,39 (±0,02)	0,41 (±0,05)

Johnson, 2012). SEAT value was calculated as the ratio between WBV exposures in the vertical direction measured at the seat divided by the WBV exposures in the vertical direction measured at the floor of the vehicle. Its values indicate how the seat attenuates vibration (Lewis & Johnson, 2012; Nawayseh & Griffin, 2005; Paddan & Griffin, 2002a; Thamsuwan, et al., 2013). Studies summary is presented in Table 2.

3.4 *Prevention and control of WBV*

A possible administrative control to reduce a bus driver's exposure to WBV could involve assigning routes based on road type, with the goal of limiting or distributing WBV exposures based on road type (Blood & Johnson, 2012). As the road surface's improvement is not the Bus Companies' responsibility, the most reasonable actions capable of reducing the effects of vibration transmission to these bus drivers are: 1) use of a seat equipped with vertical suspension and lumbar support; 2) driving speed adjustment to the driving conditions (namely, ground roughness, traffic flow and distance from pedestrian crossings and bus stops); 3) choice of proper types and maintenance of correct pressure and routine maintenance of both the seating and the engine mounts (Melo & Miguel, 2000). From (Thamsuwan, et al., 2013) control of vibration-related exposures and risks can be reduced using engineering, administrative, and work organizational strategies. From an engineering design aspect, improving the seat or vehicle suspension system could help reduce the vibration exposures as well as the transmission of vibration to the drivers. Active suspension systems have been shown to reduce vibration-related discomfort under several driving conditions developed an optimization procedure that included all the vehicle suspension components and the interaction between road and tire to minimize vibration in order to improve the ride and handling behavior. In addition, seat selection plays important role in reducing WBV exposures. As well, long term effectiveness and health outcomes of such ergonomic risk reduction programs need to be further assessed (Johanning, 1998).

Table 2. Summary of studies characterizing seat effective amplitude transmissibility in urban bus drivers.

Author	Road type	SEAT (%)
(Lewis & Johnson, 2012)	Freeway	101,7 (±1,30)
	City street	106,9 (±1,68)
	Speed humps	122,8 (±3,04)
(Paddan & Griffin, 2002a)	–	95,9 (70,5–119,6)
(Thamsuwan, et al., 2013)	Smooth freeway	90 (±2,5)
	Rough freeway	86 (±2,6)
	City street	88 (±2,6)
	Speed humps	106 (±2,6)

4 CONCLUSION

The studies indicate a causal relationship between whole-body vibration and the effects to health in urban bus driver. This depends on frequency and magnitude of vibration. The factors that seem determine the magnitudes of vibration are: design considerations of vehicle, skills and behavior of the driver, seat characteristics and road conditions, as a major contribute. All bibliography followed methodological recommendations of ISO standards (ISO 2631-1 and ISO 2631-5), which both gives a better assessment of occupational WBV vibration. The dynamic response of seat can perform differently in their ability to attenuate vibration exposure for the driver and this can be a factor used to reduce human exposure vibration. Exposure to whole-body is now recognized as associated with discomfort, reduced work efficiency and health problems. In addition, low back pain has been reported more extensively in research. In order to control WBV exposure and risks associated can be adopted engineering, administrative, and work organizational controls.

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Potential risks related to the polymer mortars production with nano ZrO_2

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ABSTRACT: Polymer binder modification of polymer mortars with inorganic nanomaterials could be a potential and efficient solution to control matrix flammability of these materials without scarifying other important properties. However, the incorporation of nanomaterials into polymer mortar materials can expose workers and final users to new risks. This research work aims to evaluate the risk in the polymer mortar production with nano-zirconia, focusing on exposure to the NP in a known research laboratory. In order to obtain exposure data control, air particle measurements were made with a Dust-Trak TM Aerosol Monitor (1 µm nozzle). Maximum concentration was observed in the cleaning task (0,195 mg $\cdot$ m^{-3}). Future challenges relative to nanomaterials exposure prevention and control should focus on the development and use of more sensitive and specific equipment, devices and measurement methods.

1 INTRODUCTION

The need for a building material with high strength and durability afforded the development of Polymer Mortars (PM). PM show, in general, high mechanical, chemical and durability properties; however, they also exhibit great sensitivity to high temperatures and creep phenomena, and mainly, deficient behaviour under fire (Ribeiro et al., 2004, 2008; Tavares et al., 2002).

The use of fire-resistant resins or the incorporation of Flame Retardant (FR) systems into the polymer binder improve, partially, fire reaction behaviour; however, these solutions generally lead to a reduction of mechanical properties of the final product. Polymer binder modification with inorganic Nano Materials (NM), could be a potential and efficient solution to control matrix flammability without scarifying other important properties of PM (Ribeiro et al., 2013).

It is expected that related industries associated to nanotechnology will have an annual turnover by 2015 over 1.5 trillion euros (Savolainen et al., 2010). The rising production and consumption of materials with Nano Particles (NP) can expose workers and final users to new risks associated to the NM. Exposure can occur by inhalation, accidental ingestion and absorption through the skin during the work (Crosera et al., 2009; Gupta, 2011). Thus, with the nanotechnology based products in rapid growth, researchers, manufacturers, regulators and consumers are increasingly concerned about potential safety impacts that these products could have (ISO, 2011). Until now there is no specific legislation in many countries for NM, but recently, it started to appear some ISO, ASTM and BSI related standards. Most of these regulations can be interpreted as the transposition of the chemical procedures to the NM (Amoabediny et al., 2009; INRS, 2011; Kaluza et al., 2009; Lövestam et al., 2010; MESD, 2006).

This research work is aimed at evaluating the risk in the PM production with nano-zirconia, focusing on exposure to the NP in a known research laboratory.

2 MATERIALS AND METHODS

In the production process of PM, a commercially available unsaturated polyester resin (Aropol® FS3992, Quimidroga Portugal-Produtos Químicos Unipessoal Lda) was applied as polymer binder. Nano-zirconia particles (ZrO_2, Innovnano), with 20 nm average size and 25.0 m^2 $\cdot$ g^{-1} specific surface, were used for polymer binder modification; and a foundry sand (Fundipor), with an average diameter of 245 µm, was applied as mineral aggregate. Manual stirring and ultrasound sonication techniques were used to promote the

Table 1. PM formulations.

Formulation	Resin (%)/(g)	Nano ZrO_2 (%)/(g)	Foundry sand (%)/(g)
Control PM	20,00/740,00	0,00/0,00	80,00/2960,00
ZrO_2 PM	19,50/721.50	0,50/18,50	80,00/2960,00

homogeneous dispersion of NP into the resin system, and afterwards, the mixture was added to the sand aggregates and thoroughly mixed in a mechanical mix device. The final mixtures were casted into standard prismatic moulds and allowed to cure at room temperatures. The different PM formulations produced in this study are specified in Table 1.

The production process only involved a single operator who used collective protection existing in the lab (ventilation/general exhaust), and personal protective equipment (two pairs of nitrile gloves, three latex gloves, a mask with $ABEK_1$ P_3 filters, protection goggles, tyvek protective cloth and disposable polypropylene shoe covers), according to the materials safety sheet indications and the several guidelines for NM safe handling (Amoabediny et al., 2009; BSI, 2007; Groso et al., 2010).

To measure the particles concentrations in the workplace air, the Dust-Trak TM Aerosol Monitor (model 8520) was used, which is the reference equipment for sampling and measuring indoor air quality under buildings' HVAC systems regulation. This equipment measures the fine and coarse particles concentration by weight ($PM_1 \leq 1,0$ µm, $PM_{2.5} \leq 2,5$ µm and $PM_{10} \leq 10,0$ µm). In this study, the 1 µm nozzle was used with the aim to detect particles with lower dimension than those of the applied sand. The established maximum concentration limit in Portugal is 0.15 mg · m^{-3} for particles smaller than 10 µm. (M.O.P.T.C., 2006).

In order to obtain control exposure data, air particle measurements were made in the laboratory at different conditions: without any production and during both, the production of plain PM (0% of NP) and NP modified PM.

3 RESULTS AND DISCUSSION

During the production process of the PM (Figure 1), it was observed that particles go through different "states": in the pre-production phase (carrying, handling and weighing), particles are at powder state; throughout production (mixing and pouring), particles are dispersed in a resin (solution); and finally, in the post-production phase (curing, thermal treatment, demoulding and cleaning), the particles are embedded in the solidified resin matrix.

The obtained measurements, carried out during 8 h, are showed in the Table 2. It was verified that the maximum values recorded in both types of PM production were reached during the cleaning task (30 min.).

There is still no adequate legislation applicable to NM; however, some standards appropriate to these materials have begun to emerge. In the traditional risk assessment, the exposure doses are compared with the Occupational Exposure Limit Values (OELs). However, there are no specific OELs for NP; so, these new standards propose a pragmatic orientation, referring that for insoluble or poorly soluble NM not included in the fibrous or carcinogenic, mutagenic and reprotoxic chemicals category, the final OEL should be reduced 15 times (Schulte et al., 2010). It was found by observation that many tasks involved in the PM production show different risk levels of exposure to NP. Considering the statutory limit values for the used material (OEL for ZrO_2 is 5 mg · m^{-3}) (Innovnano, 2013) and the proposed reduction (adjusted OEL for nano ZrO_2 is 0.33 mg · m^{-3}), it was verified that the exposure values were not exceeded or even reached. However, considering the recommended maximum limit values for air quality and taking into account that all the dust could be potentially NM, it was verified that the measured value for the cleaning task is higher than the suggested maximum limit (0.15 mg · m^{-3}). One point must however be stressed: the used equipment is standardized and it is only appropriate to detect particles lower than 1.0 µm and not specifically NP.

Studies with micro ZrO_2 showed that these particles have low carcinogenic potential under severe overload conditions, and the few research works relative to nano ZrO_2 (without or with surface modification) did not find any pulmonary adverse effects (Landsiedel et al., 2014; Klein et al., 2012). Further, the final PM with nano ZrO_2 is unlikely to present a direct risk because the NM are trapped in the solid resin. Though, the NM might still be released to the environment at the end of the product's service life (Figure 2), and this risk could not be disregarded (Roes et al., 2012). However, the present analysis is only addressed and restricted to the risk assessment during the PM production.

It must be stressed that the nano ZrO_2 is insoluble in water and there are not, until now, studies related to the environment impact of these NM. So, as a precautionary procedure, it should be considered that these NM behave in a similar manner to the other nano oxide particles. Once in the environment, the behaviour of the NP is mainly governed by agglomeration process (Som et al., 2011).

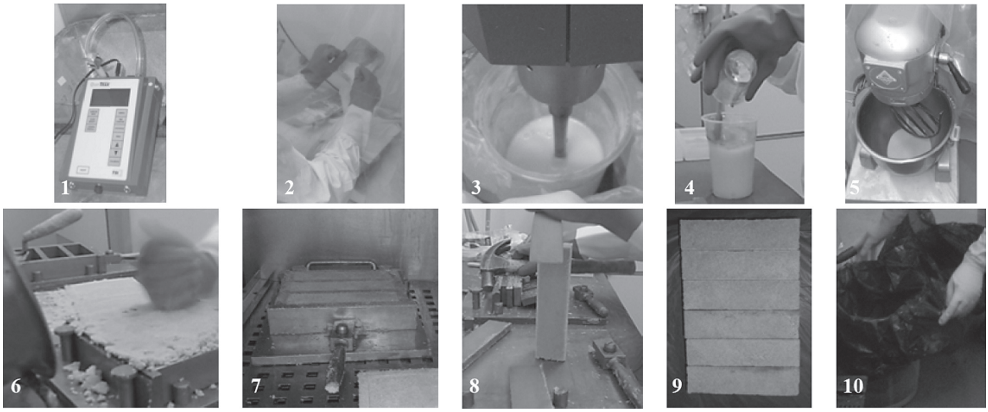

Figure 1. Dust-Trak TM Aerosol Monitor (1) and sequential tasks on PM production (2 to 10).

Table 2. Particles concentrations measurements ($mg \cdot m^{-3}$).

	Initial (t = 0 s)	Minimum	Maximum	Mean
Without production	0,011	0,009	0,045	0,015
Plain PM	0,09	0,039	0,131	0,063
ZrO_2 PM	0,08	0,026	0,195	0,049

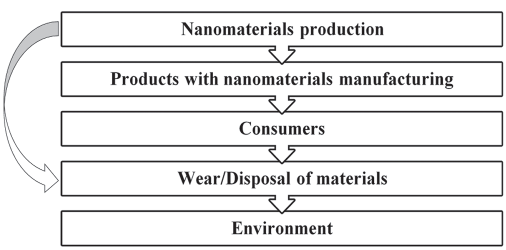

Figure 2. Nanomaterials potential exposure sources.

With the current uncertainly about the impacts of nano ZrO_2 on the human and environment safety and the consequent lack of regulation and specific toxicological data for NM, precautionary and prevention measures should always be enforced in order to reduce the potential negative effects associated to the NM use. It cannot be forgotten that the NM are normally highly reactive due to their great surface area in comparison to the same particles at macro and micro scale; therefore, the potential presence of any kind of NM in the workplace should require that workers always use collective and individual safety equipment.

4 CONCLUSIONS

The risks are a key issue to be considered especially in the initial stages of any new material development. By studying proactively emerging risks, one can prevent future negative impacts. The risks are inherent to any technology and nanotechnology is no exception.

Within this scope, in this study, the inherent risks associated to the main production stages of PM with nano ZrO_2 were evaluated. The experimental study was conducted in a laboratory environment but it provided an overview of the measures that could be applied to improve the safety levels during PM industrial production. The obtained results showed that the occupational legal exposure limits were not achieved but were higher than the recommended values for indoor air quality.

The present knowledge about the behaviour of nano ZrO_2 is very limited, and there are only few data available that describe the possible effects of nano ZrO_2 on humans and in the environment.

From the sustainability point of view, the use of NM involves both opportunities and risks. Regarding the first ones, nano ZrO_2 could be an interesting alternative to other hazardous chemicals additives, such as certain flame retardants used to improve PM fire behaviour, or could contribute to the reduction of resource consumption, and thus, promoting the environmental sustainability.

Quantitative toxicity studies on engineered NM are still relatively sparse, and the published data on nanoscale oxides support the need to carefully consider how NM are characterized when evaluating its potential biological activity. Though, until now there are no direct implications of the health effects in humans except to caution against ingestion of large concentrations of NP.

The recommendation 2011/696/EU (definition of NM) and the Commission Communication "Regulatory Aspects of Nanomaterials" indicate that the legal basis exists for NP; however, there is still a long way to go through in terms of safety in handling and use of NM and derivative products. Still, with the present and impending legislation applicable to NM, it is possible to implement prevention and protection based on generic technical, organizational, personal and cleaning management safety measures.

Future challenges relative to NM exposure prevention and control should focus on the development and use of more sensitive and specific equipment, devices and measurement methods.

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The effects of obesity on muscle activity during lifting tasks

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ABSTRACT: Obesity is an emerging public health problem affecting the industrialized countries. Besides, obesity seems to negatively affect the individuals' work performance. In occupational contexts, manual lifting tasks are common and can produce significant muscle loading. With the aim of analysing the possible effect of obesity on workers' muscle activity, surface Electromyography (EMG) data were collected from six muscles recruited during these tasks. In the present study, different tasks of manual lifting were performed by 14 participants with different obesity levels. EMG data normalization was based on the percentage of maximum contraction during each task (MCT). The muscles' Activation Times (AT) before each task were also calculated. The current study suggests that obesity can increase the MCT and the delays on muscles' AT. This investigation proposes obesity as an individual risk factor for the development of Work-related Musculoskeletal Disorders (WMSD), throughout lifting, and reinforces the need to study it more deeply.

1 INTRODUCTION

The obesity prevalence is growing in the workforce of the industrialized countries. Obesity has more than doubled since 1980 and, currently, more than 1.4 billion adults have overweight (WHO, 2012). Nevertheless, obesity is associated with psychological, social and physical problems, which can negatively affect the productivity. Subjects with overweight are absent from work due to illness for longer periods and more often than non-obese subjects, being this absenteeism frequently related to WMSD (Lier et al., 2009).

Associated with this type of disorders appearance are the stressful working postures, which can be affected by the excessive BFM (Body Fat Mass). However, the effects of obesity on posture maintenance during occupational tasks are rarely studied, and, founded on this statement, Park et al. (2009) developed a psychophysical research, verifying that obese subjects reported higher perceived overload during static box-holding tasks in different working postures. Additionally, it has been also demonstrated that obese subjects, when compared with normal weight subjects, have more problems with work-restricting musculoskeletal pain, including low back pain (Peltonen et al., 2008).

It is important to highlight that the low back pain continues to be the most common musculoskeletal problem in the workplaces. Several findings have shown that workers who perform Manual Materials Handling (MMH) are exposed to a greater risk of having back pain and/or WMSD, compared with those that their jobs do not require this type of tasks. However, these tasks, including manual lifting, are very common in a wide variety of workplaces (Arezes et al., 2011) and can have associated several occupational and individual WMSD risk factors. One of these individual risk factors is the workers body composition (Marras, 2000). In this field, Singh et al. (2009), according to a psychophysical approach, showed that the obesity does not seem to reduce the maximum acceptable weight during manual lifting. However, these authors pointed out that this area requires further studies, which should try to find other type of data, such as biomechanical data. Consequently, Xu et al. (2008) analyzed the lifting kinematics and kinetics in subjects with different body compositions. These authors verified that the obese subjects registered greater values for the kinematics trunk variables, than the normal weight subjects. The effect of excessive BFM on the function of the locomotor system is not well understood yet. Thus, ergonomic studies are required to provide a more complete understanding of obesity effects on work performance (Williams & Forde, 2009), including during manual lifting tasks.

It should be noted that from the biomechanical point of view, excessive BFM can negatively affect the spine behaviour and muscles during MMH tasks performance. Several findings have correlated obesity with impairments on muscle activity, such as decreased muscle strength (Maffiuletti et al., 2007). The alterations on muscle activity can increase the individual predisposition to WMSD (Lewek et al., 2004). Concerning the occupational contexts, one of the key elements in WMSD prevention deals with the understanding of the muscular demands related to commonly performed tasks (Butler et al., 2009), including manual lifting. With this purpose, the surface EMG has been widely used in ergonomic studies focusing on various risk factors for WMSD, aiming the optimization of lifting tasks in order to reduce the risk of such disorders (Kingma et al., 2001; Kothiyal & Kayis, 2001; McKean & Potvin, 2001).

In the current study, the EMG was also applied with the main purpose to investigate possible effects of the obesity on muscle activity during manual lifting.

2 METHODOLOGY

2.1 *Subjects and experimental design*

Ten men and four women, without musculoskeletal disorders history, volunteered to participate in this experimental study. After signing an informed consent, different anthropometric measures, such as age, weight, height and waist circumference, were collected. The mean age, BMI, waist circumference and fat mass percentage of the subjects are, respectively: 29.2 (±10.5) yr, 25.2 (±5.5) kg/m^2, 88.1 (±16.6) cm, and 24.9 (±8.9)%.

However, in the present study, the obesity levels were based on subjects' BFM, determined by Bioelectrical Impedance Analysis (BIA) using an OMRON BF306 Body Fat Monitor. Based on this technique, the subjects were categorized in the following obesity levels: "non-obese" (5 subjects), "high" (4 subjects) and "too high" (5 subjects). These levels were obtained through predictive equations adjusted to individual factors such as gender, age and height (Horie *et al.*, 2008).

The participants performed 6 trials (3 loads × 2 styles) of lifting and replacing a test box, in the sagittal plane, with loads of 5, 10 and 15 kg, in constrained and free situations. During the constrained style, the box was placed behind a 60 cm high barrier simulating an industrial bin. The participants stood in front of a height platform adjusted to each subject's standing knees height. They used both hands to lift the box vertically until their shoulders height and replaced it in its original position in a slow movement. The movement was subdivided into 4 phases, namely: standing up (rest position), reaching, lifting and replacing the box. Data analyzed in this investigation are related to the lifting phase only.

2.2 *Surface EMG data collection*

A portable EMG system, PLUX wireless bio-signals, was utilized to collect EMG data while the subjects performed the manual lifting tasks. EMG activity was collected using bipolar surface electrodes with 10 mm diameter and an inter-electrode distance of 20 mm. The electrodes were placed according to Surface Electromyography for the Non-Invasive Assessment of Muscles (SENIAM) standard placement guidelines. The areas of electrodes placement was shaved, abraded and cleaned with rubbing alcohol to lower skin's electrical impedance (Konrad, 2005). The electrodes were located at 6 muscles recruited during this type of tasks: right and left *Erector spinae* (*iliocostalis*) at L2 (RI, LI), right and left *Erector spinae* (*longissimus*) at L1 (RL, LL), right and left *Deltoideus Anterior* (RD, LD). Generally, it was observed that there was not a high fat mass accumulation in these areas of the muscles. In addition, this selection of the muscles was also based on their functionality. The muscles belonging to *Erector spinae* are spine extensors, significantly recruited during vertical handling tasks (McKean & Potvin, 2001). The *Deltoideus Anterior* muscle acts during arm abduction, assists arm flexion, extension and rotation, as well as it is responsible for shoulder joint stability. For these reasons, the *Deltoideus Anterior* is a muscle recruited during this type of tasks (Kothiyal & Kayis, 2001).

2.3 *EMG signals processing and statistical analysis*

AcqKnowledge 3.9.0 software was used to process the EMG data. The raw EMG signals were amplified, high-pass filtered at 20 Hz and low-pass filtered at 500 Hz, rectified and smoothed. The Root Mean Square (RMS) amplitude and its Standard Deviation (SD) were quantified for each muscle and for each phase of the experimental trials. EMG data were normalized to peak value during each lifting, according to the following expression: MCT percentage = (Mean amplitude/Peak value)*100. This normalization procedure has been used in another EMG studies with subjects presenting restrictions to perform maximum voluntary contractions, such us musculoskeletal pathologies or obesity (De Luca, 1997). In addition, before each lifting trial the muscles' AT were calculated. This muscle onset quantification was based on the threshold definition by multiple SD of EMG-baseline noise (Konrad, 2005).

A statistical analysis was conducted using the *IBM® SPSS® Statistics 22.0* software. For each task condition, the MCT percentages were compared across the subjects belonging to different obesity levels, to test the hypothesis: greater MCT percentages are observed in individuals with higher BFM percentages. In order to achieve this purpose, the outcomes were compared using Pearson correlation tests, because it was found a normal behaviour on variables ($p > 0.05$ in Kolmogorov-Smirnov tests). Additionally, for each muscle considered, the following null hypothesis was also tested: the distribution of AT is the same across the obesity levels. To assess the normality of the AT values, the Kolmogorov test with Lilliefors correction was made, but, for most of the variables studied, this condition is not verified. Thus, the non-parametric Wilcoxon Mann-Whitney test was applied (to reject the hypothesis, the decision rule used is to detect statistically significant evidence if $p < 0.05$).

3 RESULTS

Relatively to the mean MCT percentage, comparing the values associated with the different obesity levels, the results showed that this variable presents higher values in the group "too high" obese subjects. This difference is evident in the lifting tasks involving more load handling, in this case, 10 and 15 kg, as it can be observed in Figure 1.

In this context, many lifting tasks require workers to lift from industrial bins. These bins can constrain the knees flexion and can increase the trunk flexion during these tasks (McKean & Potvin, 2001). At the beginning of the current study, the authors had the expectation that the excessive body fat mass could negatively affect the posture adopted during these tasks, so in a constrained situation the muscle loading would be higher in this group of individuals. Nevertheless, in all obesity levels did not significantly differ in their MCT to the constraint for any lifting.

Relatively to the relations between BFM and MCT percentages, the Pearson correlation test demonstrated a significant linear statistical association, in the sense of increase fat mass percentage is related to increase of the other variable. This positive relation was established for different muscles studied, as demonstrated in the Table 1.

Relatively to the muscles' AT, the null hypothesis tested was rejected only in the following tasks conditions: 10 kg constrained lifting in LL muscle (p = 0.029) and 15 kg constrained lifting in RI muscle (p = 0.042). Therefore, these statistically significant differences in the distribution of AT were in the sense that obese individuals have higher values when compared with non-obese. These greater delays in AT registered on obese subjects suggested that the increase of BFM can decrease the ability of skeletal muscle to rapidly activate before starting a movement, as occurs in another groups with locomotor difficulties, as elderly people or with musculoskeletal disorders (Lewek *et al.*, 2004).

The obtained results obtained in this current study seem to demonstrate that an increased BFM could produce some changes in muscle activity during lifting. In general, the outcomes are in agreement with literature and emphasize the need to explore

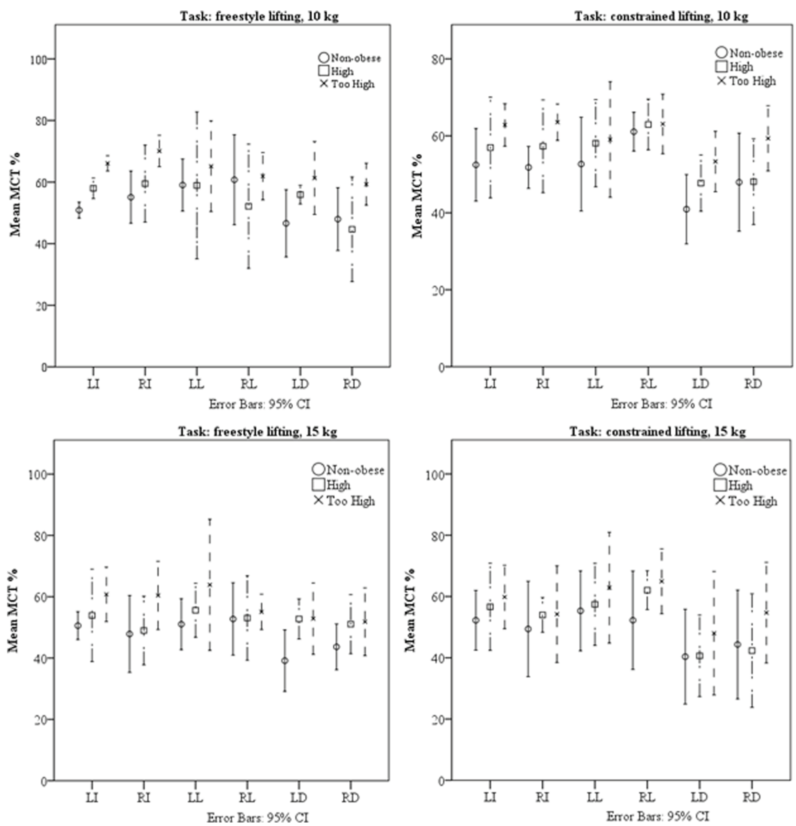

Figure 1. Representation of MCT percentages of the muscles involved across the different obesity levels and tasks conditions.

Table 1. Summary of statistical significance for the positive relation between individuals' BFM percentages and MCT percentages for the muscles analyzed.

	Muscles analyzed					
Trials conditions	LI	RI	LL	RL	LD	RD
5 kg Freestyle lifting	–	–	–	–	–	–
5 kg Constrained lifting	–	–	–	–	$r = 0.641$*	–
10 kg Freestyle lifting	$r = 0.792$**	$r = 0.611$*	–	–	$r = 0.572$*	–
10 kg Constrained lifting	–	$r = 0.584$*	–	–	$r = 0.742$**	$r = 0.761$**
15 kg Freestyle lifting	$r = 0.671$**	$r = 0.830$**	$r = 0.687$**	–	–	–
15 kg Constrained lifting	–	–	$r = 0.539$*	–	–	–

r coefficient of Pearson correlation; –non-significant; *statistical significance at $p < 0.05$; **$p < 0.01$.

this research topic. The excessive BFM can lead to an overreaction of the recruited muscles, causing increases in spine compressive loading and subsequent risk of back injury. However, in order to examine this relation other tests need to be performed.

4 CONCLUSIONS

The obesity prevalence is increasing among the workforce. This investigation suggests that obese individuals can present some changes on their muscle activity during lifting, when comparing with non-obese individuals. The obesity is an individual risk factor frequently forgotten in WRMSD risk assessment. With the aim of studying the obesity as a WRMSD risk factor during lifting further studies are needed. As the future work, a kinematics study will be developed to achieve a better understanding of the obesity effects on individual lifting capability.

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Butterfly collection cart for waste recyclables: Ergonomics and sustainability

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ABSTRACT: This paper aims to present a new sustainable cart for collecting waste recyclables in urban areas, which was conceived in favor of this category worker's needs. Such project has its main justification based on the fact that these workers need a collecting instrument that can offer ergonomics conditions and comfort during the activity, as well as contribute to the increase in the productivity on collecting and storing recyclables, seen that most of the models in use are manufactured by the waste collectors themselves through a handmade process. Methodologies of product design and participative research were used in the development of the butterfly collection cart and this paper. As a result, a new collection cart was conceived, inspired in nature elements' shapes, ergonomics and sustainable, ergonomics safety and accessible costs to the group studied. In addition, the butterfly collection cart has confirmed the importance of product design of social nature which aim to meet social lower classes, promoting not only an improvement in the practice of the activity, but also a strengthening of the professionals, more humanized and knowing best their role in building a more livable world.

1 INTRODUCTION

According to the currency stabilization, the elevation of the minimum wage and income of the poorest families, there was an increase in consumption of classes "D" and "E" in Brazil. This leads to the abundance of solid waste generated, but also to the lack of integrated management and poor management of these waste materials, generating costs to the public purse, since significant resources are reserved, daily, for urban cleaning. (IBAM Brazil 2001).

In this sense, IBGE (2008)—Brazilian Institute of Geography and Statistics, free translation—, through the National Basic Sanitation Survey (PNSB), also free translation, reported that 99.96% of the Brazilian municipalities have solid waste handling services, but only 50.75% of those dispose of their waste in dumps; 22.54% composting of organic waste; 11.56% have a unity for separation of recyclables; and 0.61% have incinerating treatment units. (IBAM Brazil 2001)

Thus, the estimative is that this is due to the increase in the purchasing power, and consumption profile in the population, which have a lack of environmental education or even necessary information about how to manage their waste, consume more and generate not only more waste, but also several environmental problems (IBAM Brazil 2001).

1.1 *Solid waste*

The definition of "waste" is presented as the remains of substances subjected to the action of several agents, such as ashes, which are the residue from combustion of firewood. According to Peltier and Sapota (2009), waste is an inevitable product of any life and consumption cycles. These authors argue that the daily habit of the humans in throwing away their waste had onset on the prehistoric era, in which they disposed of food remains at the same place they used to eat. (Eklund et al. 2010; Engkvist 2010a).

There are records of agglomerates of solid waste in Athens and ancient Rome, but it was only on the thirteenth century that regulations appeared to reduce the lack of hygiene, recommending that inhabitants should clean the front of their houses, once a week (Bari et al. 2012).

In more recent times, the amount of waste generated in the world has been astounding and its poor management has caused the flood of cities with trash, which not only causes financial costs for cleaning, but also may provoke serious damage to the environment and compromise the health and well-being of the population. So attempts were made to solve the urban and public wastes issue through public administration actions to move the collected garbage away from the urban areas, which caused the problem of creating dumps

Figure 1. Collectors performing their jobs collecting recyclables.

in absolutely inappropriate places, such as forested slopes, mangrove swamps, rivers, bays and valleys. (Chiasson, Imbeau, Aubry, & Delisle, 2012; Krook & Eklund, 2010).

Regarding the treatment of solid waste, there are some units of composting/recycling in Brazil. These unities utilize simplified technology, with manual segregation of recyclables in conveyor belts and composting in the open, with subsequent screening (IBAM Brazil 2001).

The most searched materials for resale and viable to the recycling plants are the aluminum, plastic, cardboard, glass and iron (in order of importance). In Brazil, circa 91% of aluminum utilized as raw material in the industry is obtained from the recycling of aluminum, for it can be recycled infinite times without losing its characteristics (ABAL, 2011). In the sequence of importance, PET bottles (plastic) are the second recyclable most wanted and the cardboard comes in third, meeting the demand of food packaging, etc. (I-L Engkvist et al., 2010).

1.2 *The recyclables collector's profession*

Due to the market created by the waste, a new category of workers has appeared: the collectors. Unqualified manpower, looking for financial survival, they "collect materials to sell to the recycling industry, so as to promote income to them and their relatives" (Fergutz et al. 2011; Fossá 2006).

Although their service is relevant to the society and the environment, the collectors' profession is discriminated. Many work precariously collecting recycling material in dumps and avenues, without minimal hygiene and safety conditions (Medeiros and Macêdo, 2006).

There are approximately a million of pickers in Brazil, placing the country among the ten countries that recycle more paper in the world, which means more than 3,3 tonsof recovered paper.

In order to support and subsidize legally this area, the National Congress has proclaimed the Law Nº 12.305/2010 on the policy of solid waste, that designates to regulate these professionals, specifying in the article 18 that all of the Brazilian municipalities, when implanting the environmental management program, will benefit from the incentive funding of federal funds, if they employ solid waste collectors and separators, guaranteeing means to develop a safe and satisfactory activity (Brazil, 2010).

In this context, the daily routine of the picker occurs in precarious and exhaustive conditions, for, at times, its duration can be longer than twelve uninterrupted hours of work (Maschio 2008; Magera 2005).

With small cars pulled by human traction, exceeding 200 kg of materials, usually over twenty kilometers are covered daily. The activity is considered in human by many (Lopes, Ferreira, 2009).

The carts are mostly manufactured by the users themselves, without any scientific project, generating factors that may lead to lack of safety, health and well-being to the user (Fergutz et al. 2011), besides the higher effort of the user regarding the load capacity, making more effort than the needed to conduct and transport the recyclables (Engkvist 2010b). In fact, because of the lack of training, the collectors cannot produce ergonomic work equipment eliminating the bad handling conditions of the product (Rosa, 2003; Tirado-Soto, Zamberlan, 2013).

2 MATERIALS AND METHODS

This research was featured as a case study because the intent of proposing solutions to the proposed problems, and even apply them in practice. Due to answer the assumptions mentioned above, that is, qualitatively, by performing a comparative analysis because the activity of the collector measured in two ways, with a rudimentary vehicle made by the pickers (real environment) and the car butterfly (simulated environment).

In this work if you want to get a deeper knowledge about the researched investigating it in a real context object, as mentioned earlier. Normal cart was designed and made by the collectors and the Butterfly car was designed according to the methodology of product design from the following authors: Lobach (2001), also according to

Figure 2. Normal cart.

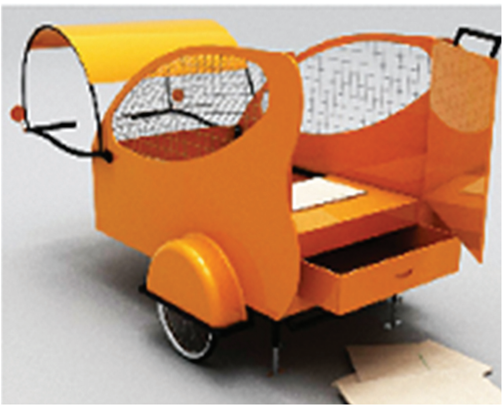

Figure 3. Butterfly cart.

criteria of the Eco design, which was attended the nine existing three (3) criteria, they are: design of components, technology for sustainability and eco advertising.

In addition, we selected a few steps projetais studied methodologies of the authors mentioned above, the research of product creation, they are: Survey and Data Analysis, Search Target; Search for similar products; Functional aspect; Structural aspect; Ergonomic and Aesthetic Appearance Appearance; Requirements and parameters; Draft and design.

Yet it was told to create the butterfly car some natural solution principles from the perspective of biomimicry, bringing the alternatives the study of shapes, colors and structures of natural elements like the butterfly is an animal that possesses beauty, lightness and idea of freedom.

For the rudimentary car the unit of analysis were 56 two pickers cooperatives: Association of garbage collectors in João Pessoa (ASCARE) and the Green Agreement, which provide material for

1 = Negligible risk
2 or 3 = low risk, change may be needed
4 to 7 = medium risk, further investigation, change soon
8 to 10 = high risk, investigate & implement change
11+ = very high risk, implement change

Figure 4. Rapid entire body assessment.

the Special Municipality of Garbage—João Pessoa (EMLUR) where are formalized approximately 230 (two hundred thirty) scavengers. Butterfly Car for a simulated environment was created in the computer and built a scale model.

As a technique for data collection document analysis was used, the technique of participant observation and an interview by the Brazilian standard questionnaire and Research Institute (IBGE) for profiling and scavengers plus some use of digital media (Camera photographic) for preparation of photographs, photogrammetry and a video of collectors making use of a car to rudimentary observation data. For ergonomic analysis was initially used to REBA. The variables were REBA:

Dimension Posture:

Static	Dynamics	Changing rapidly	Unstable

Scale transport of heavy loads:

Often	quickly

Dimension on changes at the workplace:

Equipment	Training	Worker behavior in risk taking	Monitoring pre/post

3 RESULTS AND DISCUSSIONS

The main result has become the considerations of REBA tool, with the score 11 with normal postures and cart through the variables, causing a percentage of:

Getting in the red band with the very great risk of causing illness due to working postures. And done the same analysis with the tool cart with butterfly noticed a significant difference since the score was 3 and sometimes 4. Getting a little to medium risk of promoting occupational diseases to the health of scavengers.

4 CONCLUSIONS

We note that this work is an ergonomic research that requires time and dedication. And the choice of REBA tool—Rapid Entire Body Assessment aimed to provide a complete and thorough evaluation of the activities of scavengers, ranking them from the total score if is risk or not. In this sense, ergonomics assumes increasingly the role of extreme importance within companies when interrelates product quality and processes to increase productivity and improve working conditions.

In this study it was found that the Rudimentary Car used by collectors of recycled materials in the city of João Pessoa, the Association of garbage collectors in João Pessoa (ASCARE) and Green Agreement does not provide the minimum conditions of decent work and physical security. The Butterfly Car in a simulated environment, presents a proper ergonomic setup which will provide increased productivity and consequent increase in income for the business, in addition, will provide well-being and quality of life for themselves, and consequently minimize accidents labor and environmental impact.

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Consideration of occupational risks in construction confined spaces in a brewery

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ABSTRACT: In this paper, it was conducted a study of occupational risk assessment during the construction of confined spaces in a brewery, located in the State of Pernambuco, Brazil, where confined environments have been built to meet the discharge of malt, to serve as a reuse box passage of water and wastewater. Among the methodological aspects used in this work, we highlight the use of a management tool consisting of the GUT matrix (severity, urgency, tendency) for prioritization of specific risks by activity. It has been observed that the risks have been classified as accidents, were the predominant both in transport activities and preparation of materials, as in digging activities by machines and manual excavation and containment. Thus, these agents are the risks that require prioritization of implementation of mitigation measures and correction. Therefore, a special attention should be given to: signaling work, traffic allowed by the ape-adequate access, respect to the speed limits and beeps, driving machinery and equipment only by a qualified professional, obedience to safety procedures on the construction site and others. It was observed that biological risk were those who required lesser relevance.

1 INTRODUCTION

Are considered confined spaces workplaces that have limited or restricted entry or exit and which were not designed for continuous human occupancy such as: vases, columns, fixed tanks, tanks for transportation, containers, silos, dams, storage warehouses, underground boxes and etc. The jobs that are performed in environments considered confined spaces requires a high attention due to the risks involved in these activities. There are several activities that need to be performed in confined environments. Among them, may be mentioned: cleaning, maintenance, inspection or activities in construction as: wells, ditches, excavations, ceilings, ducts, etc. Various difficulties may be encountered in executing services in a confined space: motion limitations, limited input and output lack of ventilation, the presence of noxious to humans and other contaminants. This makes them require more attention by workers qualified to perform such service.

According to Moraes Junior (2008), a major problem of areas or confined spaces is that not all the people know how to identify them, distinguishing it from other workplaces, and especially to assess the risk involved in the work performed in this environment. To the layman, working in this or that place does not make much difference, especially with regard to the risks present.

The presence of various risks in confined spaces necessitates the adoption of procedures and prevention of such risk measures thus making the entry, perform the services and the output of the safest workers. It is known that accidents in confined environments mostly cause fatal victims, and this occurs precisely for lack of advance knowledge of the risks.

It is required that all companies and individuals involved in such activity are aware of the risks and mostly know exactly how to identify and adopt control measures, as well as the responsibilities of each stakeholder. According to the Regulatory Standard 33—Safety and Health at Work in Confined Spaces (BRAZIL, 2006) Management of Health and Safety at Work in Confined Spaces should include "technical, administrative, and personal measures of job training in Confined Spaces".

In this paper an approach to confined space in construction will be presented through a case study, the construction of a well for storage of ingredients needed for the manufacture of beverages (beer), located in the state of Pernambuco. It will be focused on the assessment of the risks to which workers are exposed during the stages of construction of confined spaces, the types of services performed and mainly control the prioritization of these risks intending to protect workers involved, preventing them from accidents, occupational diseases and death.

Therefore, this work aims to study the risks which the workers are exposed in performing activities for construction of confined environments, using the management tool GUT (Severity, Urgency and Trend) to prioritize the most critical risks of the activity performed.

1.1 *Theoretical basis*

The confined environment, according to NBR 14787 (2001), is any location or device, configured in such a way that allows the employee to put the head, the chest or the whole body, which has limited means of entry/exit. Usually these spaces are not designed for continuous occupancy with the following characteristics: a) potential to contain a hazardous atmosphere (internal atmosphere contaminated with flammable or toxic vapors; atmosphere with excess or deficiency of oxygen); b) potential for serious risk to health and safety, such as electric shock, radiation, moving internal mechanical equipment; c) Has an internal configuration can trap or asphyxiate an occupant.

In Brazil the most recurrent definition Confined Space is the one that appears in NR 33—Security and Health at Work in Confined (2006) Spaces with its latest update by MTE Ordinance No. 1409, August 29, 2012: Confined Space is any area or environment not designed for human occupancy continues, having limited means of entry and exit, whose existing ventilation is insufficient to remove contaminants or where there might be a deficiency or oxygen enrichment.

In Brazil there is a lack regarding specific statistical data on accidents in confined environments, despite the Ministry of Welfare and Social Assistance (MPAS) provide the Statistical Yearbook of Social Security with some data on occupational accidents. But it is suspected that such data do not represent all because just contain only accidents recorded by Communication Workers' Compensation (CAT), and one of the accidents are not reported.

1.1.1 *Risks and accidents in confined spaces*

Are common to other activities but may also be present in the confined space hazards. According NR 33 (2006), such risks are:

Physical Risks—noise, heat, moisture and non-ionizing radiation are found frequently in confined spaces.

Chemical Risks—The presence of contaminants and oxygen deficiency (O_2) can cause intoxication, asphyxia (simple or chemical) and, eventually, death of workers. Contaminants (aerosols, gases or vapors) can be generated by the substances stored, by the decomposition of organic matter, for leaks, or the activity performed in the confined space.

Biological Risks—Confined spaces have favorable conditions for the proliferation of micro-organisms and some species of animals, because of the high humidity, poor lighting, presence of stagnant water and nutrients. Rats, bats, pigeons and other animals that have easy access to confined spaces, and use them as shelter from predators, are vectors of communicable diseases or intermediate hosts. Snakes, insects and other arthropods can cause poisoning and diseases. Dust present in confined spaces may contain biological material potentially pathogenic, the presence of excrement, urine, saliva and other body fluids from these animals.

Ergonomic Risks—The access and movement in the confined space are often difficult due to the size of the inlet and its geometry. The lighting is generally poor and some activities require excessive force and awkward postures. Measures such as relay between Illuminators and Authorized Workers, work organization to avoid unnecessary inputs and outputs and continuous renewal of air give good results.

Risks of Accidents include working at heights, inadequate wiring, contact with hot surfaces, unprotected machinery, impact tools and materials, flooding, slope, collapse, and formation of an explosive atmosphere, which can cause falls, electrical shocks, burns, entrapment and injury in limb or other body part, drowning, engulfment, suffocation, fire and explosion.

Araújo (2006) mentions two reports published by OSHAS (Ocuppational Safety and Health Administration), the first 122 were investigated accidents involving Confined between 1974 and 1982, and asphyxia and toxic atmosphere were responsible for 173 deaths, the second document analyzed accidents between 1974 and 1979, finding that 50 incidents involving fire and explosions and caused 78 deaths. This researcher also mentions a study by NIOSH (National Institute Occupational Safety and Health) containing the analysis of more than 20,000 accidents in a period of three years, where 276 accidents occurred in Confined Spaces resulting in 234 deaths and 193 wounded. In general accidents in confined spaces represent a small portion of all accidents, but account for a significant proportion of serious accidents Krzyzaniak (2010).

Ambrosio and Ferreira (2007) consider irrelevant information from MPAS, "the statistics in the country are dispersed, little comprehensive, and lacking more detailed information" (op cit.. 2007 p. 11th). Few published studies on accidents involving Confined Space in Brazil, some researchers perform a few actions for this topic. However, often serious or fatal accidents are reported in environments classified as Confined Spaces (Stadikowski, 2010).

In sum, the reasons usually accidents in confined environments are the result of lack of training and information on the part of those involved, particularly in identifying the risks of the activity.

2 MATERIALS AND METHOD

2.1 *Methodological procedures*

This research was conducted in building a beer factory, located on Highway BR 101, North, PE, 37.5 km, Itapissuma—State of Pernambuco, Northeastern Brazil. It was performed the assessment of the risks to which the workers involved were subjected in the construction of confined spaces in a brewery, so that contributes to mitigate and control these risks specific process activities. Monitoring the construction of the silos was undertaken to meet the discharge of malt, to serve as water recycling box and to the passage of effluent. The GUT method, which is a tool to help in prioritizing actions, especially when they do not have quantifiable data was used. According Klassmann (2011), this method should be used to prioritize the elimination of problems, especially if multiple and interrelated.

The method consists on building a matrix, in which the considered dimensions are: gravity, urgency and trend of each problem, by allowing risks to be assessed by class: Gravity (G), commensurate with the impacts caused in people and the effects will emerge in the long term, if the problem is not solved; Urgency (U), is evaluated according to the time that the employee is in risk exposure, according to the cycle or the working day; and Trend (T), which assesses the severity of the damage, or injury risk in people.

The Risk Prioritization: shows the attitude to be taken in the prevention, elimination or minimization of the risk, according to their priority. The scale is represented in a format which suggests that the higher the results, the higher the priority: $G \times U \times T$ = prioritization. For favorable conditions, it is recommended that efforts be undertaken to minimize the maximum indicators stated in the Priority (P). For interpreting the risks from each class represented, criteria of quantitative and qualitative levels are assigned according to Table 1.

3 RESULTS AND DISCUSSION

3.1 *Activities of transport and preparation of materials*

Risks of Accidents—Priorities 1 and 2. The risk of accident is present in practically all activities involved in the preparation and transportation of materials to the beginning of excavation, adding to the activities of energization of equipment that will be used in the steps of cutting, welding, sanding; and the activities of charging and discharging material, such as cuttings profiled steel and timber structures used in the retainers; it is worth highlighting the risks due to the possibility of trampling motivated by the proximity of operators with machinery in motion. There are serious and imminent risks related to fires and explosions due to manipulation of the gas used in the welding process cylinders as well as the presence of nearby electrical equipment. These risks are increased due to the possibility of internal insulation failures and existence of leakage current and short circuit. It must be considered inherent to the projection of sparks in the activity of cutting and sanding welding Risks and unsafe conditions inherent activities. Some unsafe acts contribute to the occurrence of accidents, such as the rush to execution and completion of the services, the improper handling of machines and tools, distraction; the effect of weather, as well as misuse of personal protective equipment—PPE and collective protective equipment—EPC are factors that further increase the risk of accident. The awareness of the worker through training as well as obedience to safety procedures for each activity must be constant so that they can carry out routine activities safely avoiding such unwanted accident.

Ergonomic Risks—Priorities 2, 3 and 4. Although the construction already has various equipments that perform several functions, there are still activities that require physical effort and pronounced so require a greater concern. Physical exertion and lifting and transporting loads are predominant and causing accidents. We highlight the risks due to: Drive productivity control, monotony, repetitiveness, excessive rhythms and long working hours.

Table 1. Matrix score GUT.

Points	Gravity	Urgency	Trend
5	Losses or difficulties are extremely serious	Immediate action is required	If nothing is done the increase will be immediate
4	Very severe	With some urgency	Will worsen in the short term
3	Serious	As fast as possible	Will worsen
2	Minor	Can wait a bit	Will worsen
1	Without gravity	No hurry	Will not get worse or may even improve

Physical Risks—Priorities 3, 4 and 5. The preparation activities are all carried out in the open so heat is constant, as well as exposure to weather type, fog, gales, etc. The noise is also present in activities with machines. Depending on the time of exposure, the worker can acquire diseases such as hearing loss and diseases of the skin. It's worth noting the risks due to the vibrations of the upper limbs and direct exposure to solar radiation.

Chemical Risks—Priorities 4 and 5. Dust is the agent most obvious chemical, but in welding processes, and considerable toxic vapors gases are also found. The absence of adequate masks or even the misuse of these PPEs may aggravate such risks.

Biological Risks—Priority 6 Although this risk is not so obvious compared to others, must pay attention to the spread of disease, because in an environment where several people from several different places, it is not difficult for contamination work by micro-organisms, viruses, bacteria, fungi, etc.

3.2 *Activities of excavation by machinery*

Risks of Accidents—Priorities 1 and 2. The risk of accident for excavation by machine activity focuses primarily on trampling or accidents due to turning the machine (excavator). This machine can perform various movements and some even out of sight of the operator. This excavation operation also observed a risk of rupture of underground electrical cables and other types of pipes such as boxes of various passages, leading to severe accidents, both the operator of the machine, and for workers in the neighborhood. Working conditions, the rush to execution and termination of services, improper handling of the machine as well as misuse of Personal protective equipment—PPE and collective protective equipment—EPC are factors that further increase the risk of accident. The risks due to overloading at the edges, such as the collapse of the excavation machine itself can not be ignored.

Ergonomic Risks—Priorities 2, 3 and 4 Although the operator is in a booth considered comfortable, there is plenty of demand from his superiors for quick execution of tasks and this can lead to accidents or illnesses to the employee. However, one can not ignore the risks due to awkward postures and monotony and repetitiveness.

Physical Risks—Priorities 4 and 5 The most present physical risk is noise, though dimly, however, the exposure time is considerable. The lack of hearing protection may exacerbate this risk and consequently produce a hearing loss. However, there are risks due to mechanical vibrations and indirect exposure to solar radiation.

Biological Risks—Priority 6. Should be taken care of in connection with the cleaning of the booth and parts in common use as controls of the machine, since the machine is operated by more than one operator, since the work is performed in two rounds. In this scene, there may be a proliferation of micro organisms in the environment.

4 CONCLUSIONS

Using the methodology GUT it was observed that the risks of injury were predominant in both transport activity and preparation of materials, as the excavating machine and for manual activities and retaining cup. Thus, these agents are risks that require prioritization of implementation of mitigation measures and correction. Therefore, special attention should be given to: respect the signage will work only for adequate transit access, respect the speed limits and beeps, driving machinery and equipment only by a qualified professional, obedience to safety procedures on the construction site. This way may avoid the accident.

Likewise, it was observed that the same activities, biological risks are demanding less relevance in the application of mitigation and control measures. Although there is still the risk of contamination by microorganisms inside the operator's cab of the excavator machine, since the space is shared, yet this risk is considered small.

The observation of constructive activities, visualization of risks, and the application of the GUT method enabled a broader view of the difficulties encountered in the construction process of the confined space. From there, made it possible to prioritize risks, to be implemented mitigation measures and control in priority order found.

Unfortunately the limited model space of this article, it was possible to put the GUT matrices obtained in this study.

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Muscle fatigue: Evaluation by electromyography at different thermal environments

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ABSTRACT: Muscle fatigue is one of the contributing factors of Musculoskeletal Injuries. Different thermal environments can have distinct consequences. The main goal of this research is to analyse fatigue evolution performing a repetitive task in two different thermal conditions using surface electromyography. It was selected a convenience sample of thirteen females (N = 13). The evaluation was done in cold and thermal neutral environment under controlled conditions in laboratory. The volunteers' perception concerning the muscle fatigue and thermal conditions was also evaluated. In cold environment, the dominate side was in fatigue at the end of the task ($p < 0.05$). There were no significant differences between the right and left trapezius ($p > 0.05$). However it was identified that the trapezius of the dominant side tends to have a lower degree of muscle fatigue than the non-dominant side muscle. Overall, in cold environment was detected more fatigue than under neutral thermal conditions.

1 INTRODUCTION

Fatigue is defined as the inability of the musculoskeletal system to generate high levels of muscle strength, or maintain those levels over time. In the occupational setting, could be caused by repetitive work, short work cycles, and even by localized muscle loads. Exposure to cold thermal environments can reduce muscle performance and cause deficiencies in the functioning muscle. In several studies, muscle fatigue has been evaluated through electromyography (Sakurai et al., 2010). Surface electromyography (sEMG) is the technique usually selected by researchers because of its non-invasive nature. It is considered a valuable tool in the ascertainment of muscle fatigue (Kilby & Prasad, 2013; Erja Sormunen et al., 2009). In assessing the perceived fatigue by workers, have been developed psychophysical scales that allow estimating the workload subjectively felt by the individual while performing an effort. The main goal of this research is to analyse fatigue evolution performing a repetitive task in two different thermal conditions using surface electromyography.

2 MATERIALS AND METHOD

The sample was constituted by 13 females (20–32 years old), with normal weight (20–22 BMI) and all right-handed. The inclusion criteria were: being not smoking and absence of rheumatoid arthritis, diabetes, Raynaud phenomena and any other kind of disturbance in the upper extremities (Sormunen, E., et al., 2009). The experiments were performed in a climatic chamber reproducing two thermal environments: thermo neutral (20ºC and 40% Hr) and cold (10ºC and 30% Hr). Each participant was exposed once to each thermal environment. The time between each exposure was two days (Erja Sormunen et al., 2009). In both exposures the participants were dressed in underwear, stockings clothing, t-shirt, sweater, pants, coat and fine shoes giving a rate of isolation of clothing, Iclo, 1.29 clo (0.20 m^2.ºC / W) (ISO 1995a).

Muscle activity was assessed by sEMG technique (TM Trigno Wireless System, DelSYS), for 15 minutes (dominant and not dominant trapezius muscle of each participant) (Kallenberg, Schulte, Disselhorst-Klug, & Hermens, 2007). The location of the muscle was determined taking into account two landmarks: acromion and C7 vertebra. The electrode was set at 50% of the imaginary line joining these two points. The skin of the participants was prepared in order to ensure a good contact with the electrode. Sandpaper was used to remove small surface residues (SENIAM, nd). The skin was cleaned with cotton with 70% ethyl alcohol by doing a slight abrasion until the skin is rosy (Hermens et al., 1999) and dried before placing the electrode. The electrode was fixed on the skin by an appropriate adhesive tape. The record of the amplified signals was achieved by the use of EMGworks Acquisition System version

4.1.7. (Delsys Incorporated, USA) at a resolution of 64 bit, operating at a sampling frequency of 2000 Hz, and a band from 20 to 500 Hz (Erja Sormunen et al., 2009).

The experimental procedure started for isometric contractions, so, it was asked the volunteers to execute a pattern lasting 30 seconds in which they remained seated in a rigid chair with arms at shoulder height level at an angle of 90º (Suurküla & Hagg, 1987). Before each task the Maximum Voluntary Contraction (MVC) was assessed during 4–5 seconds (Bosch et al., 2009). In this action, the subject was seated in a chair with knees bent at 90º and arms suspended vertically (Bosch et al., 2009). The subjects raised their shoulders performing MVC (Bosch et al., 2009) against the resistance applied by the researcher. Handgrip strength (in kgf) was measure before and after each task with a dynamometer (TKK D-Grip 5101, Takei). Each volunteer performed a MVC over 3 seconds holding the dynamometer with the dominant hand, letting the arm along the body. This procedure was repeated three times, being considered the highest value. Between each measurement the interval was 15 seconds (Mathiowetz, 1990). Finally, the volunteers performed a packing task for 15 minutes, in which the EMG signal was continuously recorded (Kallenberg et al., 2007). The work is usually performed in a standing position and is physically light and repetitive manual work. The products handled in the simulation model were sand bags, with the same weight (about 1 kg) and shape of the real products. During the simulation, test subjects picked up a leaf of paper with the right side of the body using the right hand and with the left side of the body using the left hand they picked the sand bags. They put the package bag of sand in the centre of the leaf of the paper. To complete the package, the test subjects picked the duct tape with the right hand and placed to hold the ends of the leaf paper. The product was moved back to the right hand, was placed in front of the body. All volunteers were previously trained to perform the packing tack exactly as described.

To evaluate subject's perception of physical and environmental discomfort were selected two questionnaires which were answered before and after executing the task. The methods used were the questionnaire SOFI (Ahsberg, E., Gamberale, F., & Kjellberg, A., 1997) and the questionnaire to the employee—*Analysis of Thermal Conditions in the Workplace*—according to ISO 10551: 1995.

The EMG signal was analysed in Delsys EMGworks Analysis version 4.1.7 software. (Delsys Incorporated, USA) at different times (0, 400 and 840 seconds) in which the duration of the signal at each time is 60 seconds (Hong et al., 2008). Thus, for each EMG signal evaluated during 15 minutes in the simulation of this task is obtained a set of three signals collected at the beginning, middle and end of the experiment. The acquired data were filtered digitally after the acquisition, using MATLAB 2013® (Math Works Inc, USA) to obtain the RMS and MDF. This process includes the removal of the mean signal and applying a band-pass Butterworth filter of 4th order, between 10–400 Hz (Bosch et al., 2009). Then a full-wave rectification of the filtered signal was calculated and the linear envelope was determined by using a low-pass 10 Hz filter (Kallenberg et al., 2007). To conduct an analysis in the frequency domain it was applied the Fourier Transform (FFT) (Kilby & Prasad, 2013). So, as to obtain a frequency spectrum without deviations and outliers was applied Hanning Window. At each extracted window of 500 Hz size was overlapped about 50% (Kilby & Prasad, 2013).

The statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) for Windows 22.0® of Microsoft®. Because it is a small sample ($N = 13$) in the evaluation of sEMG and dynamometry, nonparametric tests (Wilcoxon test) were used. The significance level used was 5% ($p = 0.05$).

3 RESULTS AND DISCUSSION

3.1 *Electromyography*

Muscle fatigue can be verified by the MDF decrease (Kilby & Prasad, 2013) and RMS increase (Kilby & Prasad, 2013). The RMS (μV) was evaluated to each individual. It was observed that in 11 in 13 subjects raised the RMS value, in the right trapezius, over the 460 and 900 seconds during the cold exposure. The left trapezius have shown the same tendency in 7 subjects. Individuals that shown increases in RMS values in both, neutral and cold, environments present pronounced increases during cold exposure (Fig. 1). Not only the RMS increase is higher but also the decrease in MDF occurs. So, according to Bosch, De Looze & Van Dieen (2007) can be concluded that a subject, when performing a task in cold, experienced a highest level of fatigue then when performing the same task under thermo neutral conditions.

The evaluation of muscular fatigue by MDF presented different mean values for the dominant and non-dominant trapezius muscles, at different periods in the different thermal environments. So, statistical differences were not found according to the assess muscle ($p > 0,05$) at both environments. However the mean values of MDF are higher in the dominant trapezius as shown in Figure 2. Frequently the muscle of the dominant side

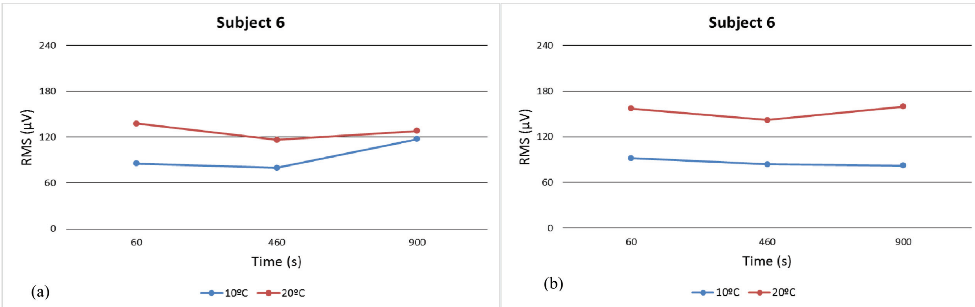

Figure 1. RMS evolution for one of the subjects. (a) Dominant (b) non-dominant trapezius.

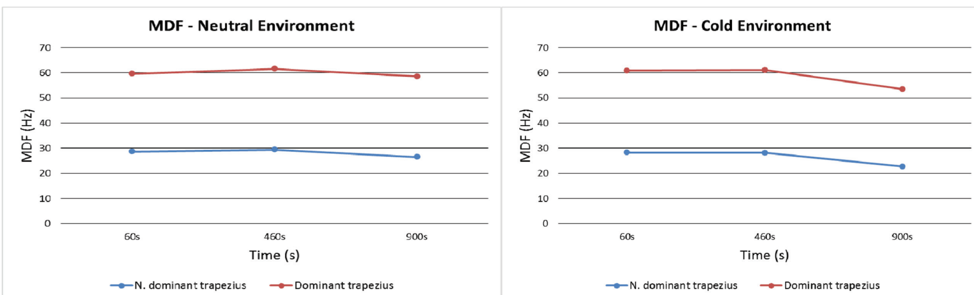

Figure 2. Mean MDF value of the dominant and non-dominant trapezius at the beginning, middle and end of the task at cold and neutral environment.

presents a lower level of fatigue compared to the non-dominant. The preferential use of a side of the body in relation to the other, leads to changes in the composition of the muscle fibre membrane unit and the motor properties (Kitahara, Läubli, Wellig, & Krueger, 2000). Although the packing movements does not allow to assure exactly the same load in both muscles, observed results show lower decrease of the MDF in the dominant trapezius in all the trials without exception.

3.2 *Dynamometry*

To evaluate the changes on CMV values, measurements of handgrip strength were made.

Taking into account the values of the female group in the study of Crosby & Wehbé (1994), was notice that mean values of strength are above of the expected. Individual physical characteristics and small size of the sample can justify it, although the differences between instruments and the procedures, in this kind of evaluation, are quite delicate. The results did not show significant differences ($p > 0,05$) of CMV before and after executing the task at neutral and cold environment. In spite of the small increase in the mean values of CMV handgrip after the cold exposure presented in Table 1, when considering the measurement error and the interval due to standard deviation, it is clear that such variation is irrelevant.

3.3 *Queries*

Queries intend to evaluate the individual perception of environmental comfort and physical fatigue. A higher number of subjects reveal discomfort when exposed to cold environment. In the query *Analysis of Thermal Environment at Workstations,* 4 in 13 subjects answered that they feel "*Very cold*" and 8 in 13 subjects "*Slightly Cold*".

The query about physical fatigue present the expression of "*pain*" and "*joint stiffness*" as the most frequent in cold environments. This shows the evident synergic impact of cold environment in development and perception of fatigue. Given this fact, the pain is one of the expressions that when mentioned, according to Aasmoe, Bang, Egeness, & Lochen (2008) is a relevant risk indicator for developing MSD specially when related to cold environment, with most common impact in the hands, arms, neck and shoulders.

Table 1. Mean values (X), Standard Deviation (SD) and p-values of Wilcoxon Test.

Variable	Exposure moment	10°C, 30% HR		20°C, 30% HR	
		p-value	X±SD	p-value	X±Dp
Strength (Kgf)	Before	0,780	27,75 ± 3,97	0,252	27,63 ± 3,18
	After		28,41 ± 4,27		27,63 ± 3,18

3.4 *Overall evaluation*

As for the results obtained from exposure to a neutral environment, participants described general feelings of exclusion, enthusiasm and drowsiness. But in the cold environment was evident that the individuals described essentially local body sensations that may result from static or isometric work, such feelings of decreased strength and some signs of metabolic exhaustion. The expected result was that the physical effort result from dynamic component, but the static component of the packing task has given an important contribution to perceived muscle fatigue.

The results of the perception fatigue reveal subjective symptoms of fatigue (such as feeling task overload, lack of preoccupation, passivity and laziness) (Hägg & Kadefors, 1996), even in those subjects that did not present evident signs of muscle fatigue.

The repetitive handwork of this study, in cold environment, caused more fatigue then performing similar tasks in neutral conditions (Erja Sormunen et al., 2009). Thus, workers performing duties in industrial environments with similar conditions to the present study, namely: repetitive movements, postures (P. Madeleine, Lundager Voigt, & Arendt-Nielsen, 1999) and cold (J. Oksa, MB Ducharme, & H. Rintamäki, 2002); may have high level of muscle fatigue that contributes to the development of MSDs. So, as observed in the present study, the occurrence of muscle fatigue associated with cold thermal environment can promote health and safety problems in occupational setting such as raise the probability of accidents, and the severity of diseases, due to a decrease in the concentration and yield at work. This is due to intense muscle fatigue proved by MDF and RMS parameter in sEMG evaluations, and described by subject's specific symptomatology that announce metabolic exhaustion.

4 CONCLUSIONS

Muscle fatigue is a common phenomenon in work places involving tasks with high energetic expenditure, repetitive movements, awkward postures and cold thermal environments, for example the food industry, which can cause in the long term MSDs.

In brief, it is clear from the sEMG evaluation that at the end of a task done in cold environment, the dominant side was in fatigue ($p < 0.05$) once there was a decrease of MDF and increase in the RMS in most participants throughout the trial. Although there were no significant differences between the two trapezius ($p > 0.05$), it was found that the trapezius of the dominant side tends to present a lower degree of muscle fatigue than the non-dominant side muscle, concerning the analysis of MDF parameter. However this trend was not identified in the individual analysis of RMS. In the present study there were no significant differences ($p > 0.05$) of handgrip strength before and after exposure to the different thermal conditions. The relation between unambiguous results and individual perception shows preferences for neutral thermal environments instead of cold ones, reinforcing these preferences by pointing physical fatigue indicators during cold exposure. Muscle fatigue is the cause of the increased likelihood of the occurrence of injuries either caused or aggravated by work. In this sense, after noting the synergistic effect of cold environment on the potentiation of fatigue, becomes apparent the need of addressing an environmental indicator when performing subjective ergonomic assessments without directly assess the physiological load on the body. One can also check behavioural changes, decline of concentration and work performance due to the discomfort created, which increases the probability of accident.

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Prevalence of skeletal muscle injuries in hairdressers in the District of Setubal

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ABSTRACT: The amount of data and research effort to indicate the MSDs among hairdressers has been limited. This study aims to investigate the risk factors of WMSDs for hairdressers by identifying the body regions associated with significant discomfort. Thirty professional hairdressers were invited to join this study in Setubal District using a hairdresser-oriented musculoskeletal questionnaire to develop the study. The results from the study show that all of hairdressers reported spine discomfort, followed by discomfort in shoulder (83%), hand and wrist (43%) and lower limbs (30%). The main causes of these symptoms are standing posture throughout the workday, repetitive movements and the maintenance of high upper limbs during prolonged time. Moreover, the study reveals that there is no relationship between the increased level of discomfort with age or with working hours.

Keywords: Work-related Musculoskeletal Disorders (MSDs); ergonomics; hairdressers

1 INTRODUCTION

The musculoskeletal system is a complex entity, composed by bones, joints, muscles, tendons, ligaments, bursa, nerves and blood vessels. All of our postures and movements are dependent on the functioning of the musculoskeletal system. Being physically active is beneficial for our musculoskeletal system, but an overload of physically strenuous tasks may pose a threat to it. Awkward postures, repetitive work or handling heavy materials may damage the system, leading to musculoskeletal fatigue, pain or other kinds of disorders.

Work-related Musculoskeletal Disorders (MSDs) are mostly cumulative disorders. They result from repeated exposure to high or low intensity loads, over a certain period of time (several months or years, in many cases). Because individuals often repeat actions or spend long periods of time carrying out work activities in awkward postures, or with intense mental stress throughout the work day, many MSDs are associated with labor.

The nomenclature MDSs was first used in the late 50 s, to designate a set of diseases, syndromes and/or musculoskeletal symptoms that particularly affect the upper limbs, relating its emergence with the process work (Browne et al., 1984, McDermott, 1986, Sommerich et al., 1993).

Upper limbs (the hand, wrist, elbow and shoulder), the neck and lower back are particularly vulnerable to MSDs.

MSDs are episodic—the pain often subsides or disappears, only to recur later. Many MSDs are transient, with symptoms disappearing with rest or change of activity. But some MSDs may become persistent or irreversible.

Higgs et al, (1993) described the age influence on the frames of MSDs, remembering the importance of this factor in the pathogenesis of some degenerative musculoskeletal pathologies (Higgs et al., 1993). The number of work-related MSD complaints increases with age. At the age of 55–64 the number of self-reported symptoms is 1.7 times higher than at the age of 25–34 years.

The risk of male workers suffering from an MSD is 1.3 times higher than the risk of female workers: 35/100.000 compared to 27/100.000. In terms of references work-related MSD complaints, the risk is only slightly higher among male workers (1.07 times higher).

Factors contributing to MSDs includes excessive use of force, repetitive work, working in awkward postures, vibration, working in cold environments, and prolonged sitting or standing. They are also affected by levels of stress, autonomy and support from colleagues, individual's prior medical history, physical capacity and age, and social factors such as leisure activities. These factors may act uniquely or in combination.

MSDs are the work-related health problem with the highest impact on sickness absenteeism in Europe; 39% of total sickness absence of 2 or more weeks is due to work-related MSD symptoms (in comparison, 19% of total sickness absence is due to stress, depression and anxiety). MSDs are also the work-related health problem with the highest impact on permanent incapacity; 61% of permanent incapacity is due to MSDs (compared to 10% due to stress, depression and anxiety and 10% due to cardiovascular disorders).

Almost 24% of workers who have suffered from a work-related MSD complaint in the past 12 months have a sick leave period between 1 and 13 days. 11% have a sick leave period between 2 weeks and 1 month, and a little more than 20% have a sick leave period of more than 1 month.

The first studies were described in "occupational cervicobrachial disorder" in cash register operators, driller's card and Japanese typists; in Australia, described "occupational overuse injury" in typists and workers of the assembly line; cases were subsequently referred to "cumulative trauma disorders" in workers exposed to cumulative trauma, including operators of video display terminals in the United States of America (McDermott, 1986, Kiesler and Finholt, 1988).

Several groups of workers have been identified at risk of developing MSDs, including: telegraphers (Ferguson, 1971, Hocking, 1987), workers of the assembly line (Luopajarvi et al., 1979), machine register operators (Maeda et al., 1982), typists, telephone operators and other administrative workers (Hocking, 1987), Americans echocardiographists (Vanderpool et al., 1993), workers in the fish-processing industry of Thailand (Chiang et al., 1993), workers in arts and illustrations (Franzblau et al., 1993), Norwegian workers of food production and administrative services (Westgaard et al., 1993), cameraman's of American journalistic enterprises (Bernard et al., 1994), workers of Sweden's electrical equipment industry (Ohlsson et al., 1995), nurses (Schlossmacher and Amaral, 2013), workers with mental disabilities (packaging cutlery, carpentry/joinery, stuffing, industrial laundry, ironing, gardening, and aid to patient transportation) (Diniz-Baptista, 2013), graduates in pathological anatomy, cytological and thanatological (Rangel et al., 2013), and workers in the Cutting and Frames area (Coelho et al., 2014). Within this context, are the hairdressers, versatile professionals who work in extremely irregular hours, and most often in uncomfortable positions. Therefore, it is necessary an alert and pay special attention to these professionals because their work involves numerous risk factors for health, mainly because they spend the entire workday in the standing position. Thus, considering that this group presents several risk factors for developing this syndrome due to the peculiarities of their work, as well as the small number of scientific publications on MSDs in professional hairdressers, there was an interest in investigating the relationship of the work of these professionals with the onset of diseases as a way to help expand scientific knowledge in this area and improve the quality of working life of the professional hairdresser.

This study aims to determine the presence of symptoms of MSDs in professional hairdressers in Setubal District, as well as observing the most affected anatomical regions and trace the socio-demographic profile of study participants.

2 METHODOLOGY

Descriptive and cross-sectional study, verifies the conditions of the present moment estimating the prevalence of an event (musculoskeletal disorders) in a specific population (hairdressers).

2.1 *Subject selection*

Thirty professional of hairdressers were invited to join this pilot in Setubal District using a hairdresser-oriented musculoskeletal questionnaire developed for this study. The predominant age was between the 20 and 64 years old; approximately 40% of hairdressers are between 10–19 years, 30% up to 9 years, 17% were 20–29 years old, and 13% more than 30 years of experience work. The mean working hours was 9 ± 2 hours per day. All subjects are right handed.

2.2 *Hairdresser's oriented musculoskeletal questionnaire*

A hairdresser-oriented musculoskeletal questionnaire was conducted. The questionnaire was divided into three sections: demographics, work history, and symptoms and injuries. To assess the presence of persistent musculoskeletal symptoms, the initial screening question was "have you experienced any recurring symptoms such as pain, aching or numbness". An affirmative response also generated a series of further questions to establish onset, quality, frequency, duration, and the intensity of the symptoms, and a history of injury to that particular body region. In this population, injuries were suspected of being a common cause of musculoskeletal symptomatology. Consequently, another set of questions was used to characterize injury to individual body regions.

The survey data were collected and analysed using SPSS version 21. Because the sample size is small, non-parameter analyses, such as the Pearson χ^2 test, was applied to these raw data. Analyses included descriptive statistics.

3 RESULTS AND DISCUSSION

3.1 *Reliability*

Reliability participants were recruited from the same beauty salon and were asked to complete the questionnaire at two different times approximately 4 weeks apart. Intra-class Correlation Coefficient (ICC) kappa and sensitivity were used as measures of validity and/or reliability.

The reliability of the questionnaire was assessed with the test-retest method. The areas addressed included questions of work-related musculoskeletal symptoms, and of work conditions items. The results shown that for these sections of the musculoskeletal symptom and work history questionnaire the observed agreements ranged from 72.5 to 95.0%, and the calculated kappa estimates ranged from 0.50 to 0.80. Injury to body regions and job specialty, had the highest kappa values of K = 0.72. The hairdresser-oriented musculoskeletal questionnaire approach has represented a very high level of reliability on a five-point scale (Cronbach's alpha = 0.95). Therefore, the results collected, based on a step-by-step confirmation approach, are reliable.

3.2 *Discomfort in body regions*

All hairdresser reported spine discomfort, followed by shoulder (83%), hand and wrist (43%), these being the most used by these professionals at work, and lower limbs (30%). This result validates a level of discomfort among body regions as being the same as in previous research by Wu et al. (2004) and Chuang (2005). Moreover, 90% reported a "moderate-to-strong" level of spine and shoulder discomfort. These dates were confirmed by other authors (Regis Filho and Lopes, 1997). Therefore, among hairdressers, the spine and shoulder regions are the most likely to suffer bodily discomfort.

3.3 *Symptoms and risk factors*

The study investigates the symptoms of discomfort reported by the hairdresser. The results shown that 77% of hairdresser reported arthritic pain in the cervical column and dorsal column (17%). The results shown a prevalence of painful symptoms between 3–4 years in 30% of hairdressers; and 5–6 years in 20% of hairdressers. But most important is that 20% of hairdressers feel pain for over than 10 years. No association between the pain in the spine and years of service was found ($p = 0.57$; $\alpha = 0.05$). Therefore, working experience may not be a risk factor which results in discomfort of body regions. Significantly 47% of hairdressers seek help from others to perform work tasks and 23% modified their stance.

The etiology of pain focuses in excess on working hours (97%); stress (83%) elevation above shoulder level objects (63%); hand as walrus in intense effort (63%); and working in posture torsion of the body constantly (53%). Also no association between the pain symptoms and the age ($p = 0.23$; $\alpha = 0.05$) and number of customers per day ($p = 0.80$; $\alpha = 0.05$). Most hairdressers (77%) perform their tasks standing, 17% work sitting with rotation of the spine and 7% sitting with the elevation of the upper limbs. 43% of hairdressers indicates that performs the movements that are unique and repeatable and 30% reported to be repetitive and dynamic movements. 60% of hairdressers elevates objects above shoulder level. Also no association between the anatomical areas affected by pain and to mode of execution tasks ($p = 0.88$; $\alpha = 0.05$), the classification of movements ($p = 0.85$; $\alpha = 0.05$) and the elevation of objects above shoulder level ($p = 0.70$; $\alpha = 0.05$).

Only in 13% of hairdressers pains disappear when they are away from work tasks. Regarding the time of disappearance of pain, the data show that 54% of hairdressers report that the pain disappears within 3–5 hours after the end of job, and 32% within 6–9 hours. The pain occurred in conditions of the job are manifested as a feeling of discomfort, localized or not, end of journey or during peak production, which sometimes improve, to rest or to decrease the rate of work (Caetano and Gonçalves, 2003).

4 CONCLUSIONS

The result indicates that most discomfort body regions were the cervical column and shoulder. The main cause of these symptoms are standing posture throughout the workday, repetitive movements and the maintenance of high upper limbs during prolonged time. Moreover, the study reveals that there is no relationship between the increased level of discomfort with age or with working hours.

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Promoting the use of Personal Protective Equipment (PPE): Illustration of critical aspects based on an intervention in the real world

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ABSTRACT: This work focuses on promoting the use of Personal Protective Equipment (PPE). Specifically, it aims to contribute to the discussion of the critical aspects in interventions in this area in a real context. The intervention presented took place in a textile company in Portugal and was designed to increase the usage rate of ear protectors. It was attended by 51 workers who were exposed to levels exceeding 85 dB. After the intervention period, the use rate of hearing protection increased from 21.6% to 86.2%. The case presented aims to illustrate and discuss the relevance of critical level aspects of the intervention in this area, where it highlights the commitment of the administration in addressing the issues of security, employee involvement and approaches based on behaviour and safety culture.

1 INTRODUCTION

Exposure to noise is one of the occupational hazards of greatest relevance in the industrial context (Arezes & Miguel, 2002a). According to the Fifth European Survey for Working Conditions (Eurofound, 2010), the percentage of workers exposed to loud noise for at least a quarter of the working time, is, on the Portuguese industrial sector, 49.4%. In this context, it is noteworthy that according to the European Agency for Safety and Health (2005) 7% of workers suffer from hearing difficulties related to work, making these the most common occupational disease in the European Union (European Commission, 2010). Furthermore, the loss of hearing resulting from exposure to noise is irreversible, and there ceases to be an effective treatment for it (El Dib, Atallah, Andriolo, Soares & Verbeek, 2007).

Hearing problems can, however, be prevented by using, for example, personal protection, such as using earplugs or earmuffs (Sbihi, Teschke, MacNab & Davies, 2010). It is commonly accepted that these practices should only be taken when those that include the elimination or reduction of risk are not possible or effective enough (Arezes, 2002). Individual prevention is, however, the one that is often most adopted, since it is relatively inexpensive and easy to deploy (Morata, Fiorini, Fischer, Krieg, Gozzoli & Colacioppo, 2001).

Effectively the provision of Personal Protective Equipment (PPE) is essential and imperative for the prevention of hearing problems. This will only be effective if the equipment is used consistently by workers (Franks, Stephen-son & Merry, 1996). Some studies have shown that when hearing protection is not used 100% of the time, its effectiveness decreases dramatically. For example, if the PPE is used only 90% of the exposure time, the efficiency decreases to less than one third (Arezes & Miguel, 2002b).

Although in recent years it has become more apparent that there is a greater concern with security issues, the reduced use of necessary protective equipment is still a problem. Indeed, this reduced use contributes to about 40% of accidents at work and occupational diseases (Zohar & Erev, 2007). Given that the use of PPE depends ultimately on the will and decision of each individual worker, from the point of view of promoting its use, it is important to understand why some workers use them and others do not (Salavessa & Uva, 2007).

More recent studies have highlighted the social, organizational and group factors as explanatory of the adoption of safety behaviours, highlighting the safety culture as a critical factor (Gonçalves Silva, Melià & Lima, 2005). Noted that the safety culture now has a central role in explaining and preventing accidents at work after the end of the 80 s. During which time it was appointed as one of the antecedents of the Chernobyl nuclear accident by the International Nuclear Safety Advisory Group (Silva, Lima & Baptista, 2003).

With that said we have seen a growing number of scientific studies on safety culture, which aimed to characterize the concept and to define the dimensions that allow the evaluation. In this context, we emphasize the study of Fernández-Muñiz, Montes-Peon and Vásquez-Ordás (2007). This study based on key publications on safety culture and an integrative perspective defined the concept as a set of values, perceptions, attitudes and behavioural patterns related to security and shared by members of an organization. In this conceptualization it is also integrated a set of policies and practices relating to the management of exposure to occupational hazards, implemented at each level of organization procedures.

The authors also tested in 455 Spanish companies from different sectors, a model on key indicators considered from the point of view of safety culture. These were the commitment of managers, employee involvement and a strong system of security management. The results highlighted the importance of the role of managers in promoting safe behaviour, both directly, through their attitudes and behaviour, as well as indirectly through investment laying on the development of a system of safety management. Thus, stressing the importance of managers that are fully committed and involved in security activities, hence conveying the importance the company attaches to these issues.

In this field Zohar and Erev (2007) also sought to demonstrate that safe behaviours depend largely on the contingencies of supervision. For that purpose, we analysed the effective and ineffective intervention programs, noting that the key to success lays in providing immediate insurance, frequent and personally meaningful rewards. This result goes against the assumption raised by Geller (2001), when analysing different studies with different approaches to reduce the number of injuries at work found that the programs or behaviours based on approaches are the most effective. Such programs "Consisted of employee training regarding particular safe and at-risk behaviours, systematic observation and recording of the target behaviours, and feedback to workers regarding the frequency or percentage of safe vs. at-risk behaviour" (p. 5). Some of these programs can also integrate the definition of objectives and/or incentives to encourage the process of observation and feedback.

The analysis of Burke et al. (2006) about the relative effectiveness of various training methods in occupational health and safety also indicated the importance of active participation by workers. Indeed, this analysis found that the most effective methods of training were those that were appealing to the involvement of employees (training in behavioural modelling, hands-on training) and less effective in terms of learning were those in which the workers had a passive role (lecture, pamphlets, videos).

The work presented below is intended to illustrate, in a real context, some of the critical issues raised by the literature to the success of an intervention that aims to increase the use of Personal Protective Equipment (PPE), including hearing protection.

2 DESCRIPTION OF THE INTERVENTION

2.1 *Context*

The intervention took place within a company in the textile sector and intends to respond to a request made by the Human Resources Department of the company. In fact, during the time the request was made, this Department was concerned about the low rate of use of hearing protection in some of the areas of production and its repercussions for the health of exposed workers. Note, however, that the request for action arose from the area of Human Resources and not from the Company Director. The company was founded about 30 years ago and had about 650 workers. 51 workers participated in the intervention because all of them were exposed to noise levels above 85 dB, which mainly affects the areas of dyeing and weaving.

2.2 *Intervention*

In a first phase we attempted to involve the labour doctor in the delineation of the intervention, and the leaders of the respective areas of production were invited to participate and be informed about the objectives of the intervention. Made the effort to "mobilize" these organizational actors, the following approach has undergone ascertain the rate of use of hearing protectors based on an observation grid. In that first record it was found that only 11 workers were using hearing protectors (22%) (See Chart 1, note 1). In the second observation, it was found that 30 workers were already using hearing protectors (utilization rate of 60%) and utilization rates until the tenth observation oscillated between these values and 70.5%. Note that in this period the observations were made day in, day out.

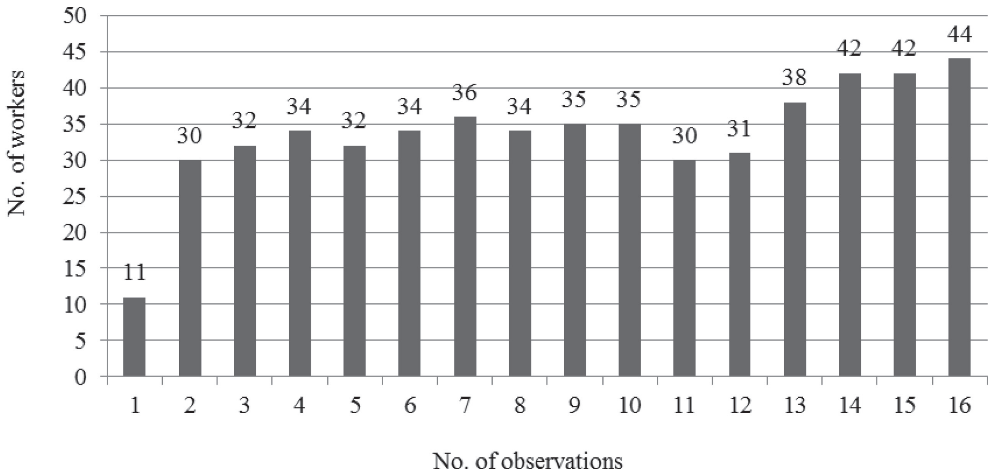

Figure 1. Changes in the rate of use of ear protectors over the observations.

It should be highlighted that the person responsible for the observation and registration procedure, adopted in each of the observations, an approach to encourage the involvement of workers, seeking to explore with them reasons for non-use, to raise awareness of the effects of noise exposure and providing information and feedback on how the protectors should be placed and on maintenance instructions. Some workers, for example, reported that the involvement of not using the hearing protectors was due to the fact that the only size available in the company wasn't the appropriate for you, and the person responsible for the action took steps to resolve internally this issue.

From the tenth observation, recording was done at weekly intervals and "intermittent" mode (i.e., the day of the week in which the observation could occur was variable), having checked the following two observations, a decrease in the rate of use (on average, the rate was 60%). Note that in the twelfth note, the person responsible for recording was accompanied in this task by the president of administration, who also spoke with workers and led earmuffs. In the next observation to this visit it was observed that the utilization rate rose to the highest value so far (i.e., 74.5% in the thirteenth observation). In the sixteenth and last observation, the utilization rate stood at 86.2%.

It was also part of the intervention strategy, preparing and providing each worker a pamphlet of sensitization to the effects of noise exposure, while at the end of these remarks it was given them another pamphlet, which were returned to the main results obtained in the intervention and enhanced information given over the comments on the hearing protectors, e.g., care in its maintenance or instructions as to their placement/use. These materials were developed in collaboration with the labour doctor.

3 DISCUSSION AND REFLECTIONS FOR PRACTICE

Although it wasn't possible to collect data from a follow-up, natural-mind aspect that constitutes a major limitation of the intervention presented, the results obtained allow to highlight and illustrate critical factors in the effectiveness of interventions that intend to improve the performance of occupational safety and health. Firstly, and as mentioned in the literature (e.g., Burke et al. 2006; Fernández-Muñiz et al. 2007; Geller, 2001), we emphasize the ability of a strategy focused on the involvement of the workforce and based on how target specific behaviours of change. Indeed, the approach of approximation of workers (e.g., through listening to the reasons for non-use of protection) as well as the emphasis on feedback on the adoption of specific behaviours (e.g., placement of hearing protectors) allowed to develop active participation by workers. Another aspect that we also believe is well illustrated in this case is the importance of management commitment. In fact, it is remarkable the change recorded in the utilization rate from the twelfth to the tenth observation after the visit of the administrator as well as in the following observations. However, to refer Fernández-Muñiz et al. (2007), the role of managers in the promotion of safe behaviours is twofold. On one hand, it is exercised through their attitudes and behaviours (that workers observe) and its effort to involve the workforce. Moreover, this influence is through investment that is pasted in the development of a safety management system (eg, available material, training provided). From the point of intervention (i.e., the promotion of improvement of working conditions in terms of safety and occupational health) it is important to understand in further detail what a strong system of security management is. According to Muñiz-Fernández et al. (2007, p. 636), an adequate safety management system incorporates six dimensions, which would be associated with a culture of positive safety. Specifically, the proposed dimensions are the following: i) safety policy (a safety policy that reflects the organization principles and values in the area of organizational / occupational safety); ii) incentives for employee participation (established incentives for the workers to become involved in safety activities); iii) training (provision of training to employees so that they carry out their work in a healthier and safer environment); iv) communication (information provided to workers about the risks to which they are exposed, and the correct way of combating them); v) planning (planned actions in order to avoid the incidence of accidents (preventive planning), as well as the quick response in case of emergency (emergency planning); and vi) control (control or feedback of actions undertaken in the organization, either through an analysis of working conditions and events that occur in the very organization (internal control), or by comparing the firm with other companies (benchmarking techniques).

Given the above, we believe that it is noticeable the complexity of the intervention in this area given the diversity of involved variables. The recent study by Hong, Chin & Ronis (2013) that sought to understand the determinants of hearing protectors use in American fire fighters reinforces the importance of integrating different levels (individual, interpersonal, and organizational) in interventions to promote the use of PPE, in this case, hearing protectors. In turn, the recent study from Hajmohammad & Vachon (2014) strengthens the important role that a strong safety culture can have not only in terms of safety performance, but also in other development indicators, including financial and environmental ones.

Ultimately, we believe that the intervention presented draws attention to the importance of developing a culture of safety and occupational health, i.e., the development of an integrated strategy at all levels of the organization and all its members, from which it highlights the management for its direct and indirect role.

In addition to the integration of follow-up in studies focused on intervention, the extension of the accomplished study to other occupational groups and respective organizational contexts naturally represent possibilities for future investigation. In this framework, it may be interesting to contrast different organizational contexts in terms of their safety culture (e.g., stronger or weaker) in what refers to the impact of such interventions and their maintenance throughout time.

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Process safety control for occupational accident prevention

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ABSTRACT: The purpose of this work is to expand the knowledge of contexts surrounding accidents in occupational situations. Particularly, a theoretical study concerning causes of accidents is conducted. It allowed to differentiate the most often considered aspects such as human and technical. In this paper a special attention was paid to assuring safety by process control in which the contributor is human and his/her response to system alarms. The study, undertaken in a simulation situation, concerned human reaction to visual and audible signals which had to reflect alarms for process control. The results of the study showed that the visual indicators were more often correctly perceived than that of auditory signal.

1 INTRODUCTION

The issue of the health, safety, and well-being is of one the greatest importance in contemporary society. In order to assure these values it is obvious that actions to ensure safe practice and accident avoidance should be undertaken (Górny & Mrugalska 2013, Mrugalska & Arezes 2013, Nazir & Manca, 2014). In industrial settings the concept of safety is realized through control of the work environment to reduce or eliminate hazards which are "source or situation with a potential harm in terms of death, ill health or injury, or a combination of these" (BS 8800:2004). Safety is not a directly measurable as it regards to materialisation of risks, for example, in the form of an accident and on the other hand, in the case of machines, it refers to a machine's ability to perform its function no causing injury or damage to health (Sławińska & Butlewski 2014). In order to assure process control and safety it is possible to implement industrial safety system.

In this paper, theories of accident causation are presented and process safety issues are highlighted. The aspects of alarms are also described as they constitute the basis for the practical investigation. The aim of the simulation study was to assess time and correctness of human reaction to visual and audible signals, which can be used for process monitoring. The final part of the paper summarizes the following discussion and provides some suggestions for future research intervention.

2 OCCUPATIONAL ACCIDENTS AND THEIR CAUSES

According to International Labour Organization every day, 6,300 people die due to occupational accidents or work-related diseases, what constitutes more than 2.3 million deaths per year. In addition, 313 million accidents happen on the job yearly what often leads to extended absences from work. The human cost of accidents is estimated at 4 per cent of global Gross Domestic Product each year (Safety at work 2013). Thus, there is a need to increase the awareness of the scope and consequences of work-related accidents, injuries and diseases, and make an attempt to find an explanation for them and their causes.

The framework of occupational accident theories has changed over the years. At the beginning of the 20th century a worker was believed to be prone to occupational accidents which meant that "certain individuals are always more likely than others to sustain accidents, even though exposed to equal risk" (Froggatt & Smiley 1964). Such a situation caused that the employer did not feel responsible for providing bad working conditions, and what is more, he just blamed his employees for causing accidents. Following this theory it was believed that there was a quite small group of workers with the endogenous tendency to be prone to accidents. In the second half of that century, for the first time the employer was perceived as a person responsible for creating unsafe working conditions. Moreover, the remark was made that a person's accident liability may vary from time to time (Heinrich 1959, Froggatt & Smiley 1964).

Nowadays, the phenomenon of accident proneness is still a subject of many discussions and has been widely criticized (Nazir et al. 2013, 2014). However, it is considered to refer to a small amount of accidents and it is revealed that an implementation of a preventative strategy based on it has only minor effects (Kjellen 2000). Furthermore, the results of the research showed that the exclusion of the workers on the basis of their accident proneness does not have to influence positively the rate of occupational accidents (Hämäläinen 2010). On the other hand, the distribution of accidents in the general population displayed that the amount of individuals with repeated accidents was higher than the expected by chance. Therefore, it can be noticed that the accident proneness exists, but the distinction in operationalisations of the concept make its study difficult (Visser et al. 2007).

The attention to the causes of occupational accidents has varied between different points of views over time, but mainly it considered human and technical aspects—where a human can be perceived as the guarantee of safety (Hale 2003). In the case of systems and accidents, which are often more complex, the human condition is treated as unchangeable, but the changeable factor is the working conditions in which people do their jobs (Mrugalska 2013a, b). The literature review allowed to differentiate a few theories of accident causes which are presented in Table 1.

As it can be seen in Table 1, the accidents triggered due to major or minor causes, and particularly in large organisations and complex technologies are not associated with a single cause. They are usually complex, interactive, and interconnected.

3 HUMAN RESPONSE TO ALARMS IN INDUSTRIAL SETTING

In the last decades the role of process operators has changed from manual control to supervision (Nazir et al. 2014). In such advanced automation Indus tries an important role in ensuring the quality and reliability plays alarm system. Its function is to signal abnormal values of the system parameters when they exceed predefined tolerance limits, or if they are approaching critical levels (for further details see Manca et al. 2014, Mrugalska 2013a, b, Mrugalska et al. 2014, Nazir et al. 2012). However, in practice it happens that contemporary alarm systems can be unreliable, what results from their complexity (Thomas et al. 2003).

Reliability of the alarm system depends on its sensitivity, setting of thresholds and defining probability of dangerous conditions (Bustamante et al. 2007, Butlewski & Tytyk, 2012). Therefore, it is important to define correctly the measurement accuracy of sensors and apply appropriate algorithms for dangerous conditions (Parasuraman et al. 1997). Unreliable system can lead to occurrence of alarm failures such as false alarms or missing alarms in a greater number than true alarms (Abe & Richardson 2007; Bustamante et al. 2007). It can cause that sensor failure or inadequate performance, data processing limitations or

Table 1. Accident causes: a review.

Author/s	Accident causes
Heinrich (1931)	Ancestry and social environment, worker fault, unsafe act together with mechanical and physical hazard, accident, damage or injury
Reason (1990)	Fallible board decisions and policy, line management problems, psychological precursors of unsafe acts, unsafe acts
Wallace (1996)	Personal factors, knowledge, training or skill, motivation, supervision, equipment/facility design or standards, maintenance, procedures
Rasmussen (1997)	Government, regulators, associations, company, management, staff, work
Raouf (1998)	Behavioural: improper attitude, lack of knowledge, lack of skills and inadequate physical and mental condition; environmental: improper guarding of other hazardous work elements and degradation of equipment through use and unsafe procedures
Hale (2003)	Accident prone, technical fix/automation, competence training, system ergonomics, safety culture, fully integrated system thinking
Leveson (2004)	Component failures, external disturbances, inappropriate interactions between system components

output failure (for example electrical problems or component malfunction, etc.) may not be detected (Abe & Richardson 2007). Such situations lead to loss of trust among operators towards alarms system which reflects in a reduction of responding and an increase in reaction time to alarm signals. Another factor which influences operator's response to alarms is the perception of urgency of alarm which depends on the knowledge of the situation in the well-known work environment (Thomas et al. 2003). In industrial environment it may also happen that the operator will be not able to recognize the signal as an alarm due to working conditions as he may fail to hear/see the signal. His lack of knowledge about process control can also reflect in failure of the proper response. It is also proven that acoustic of alarms fundamentally is connected with levels of their urgency and the level of urgency of alarms corresponds with the level of urgency of the danger which it signals (Arrabito et al. 2004). Furthermore, the perception of alarms depends on their frequency, intensity, and repetition. For instance, a low frequency alarm repeated slowly is interpreted as having low urgency, whereas a high frequency alarm repeated quickly represents a high urgency (Patterson 1982).

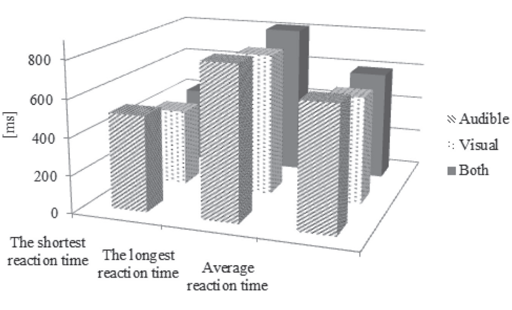
4 MATERIALS AND METHODS

Twenty three second-year students (12 men, 11 women, mean age 19 years) from industrial engineering curricula participated in the experiment during laboratory classes. They were individually tested for about 15 minutes (each person reacted to 50 signals). The task was divided into two parts: at first students were trained for 5 minutes how to operate the simulator (MCR-2001E) and then they worked with 3 visual and 1 auditory signals. Their task was to react to the signal according to the previously defined code. In order to analyse the data the mean values were calculated for the simulation situation.

5 RESULTS AND DISCUSSION

The results of the investigation are presented in Figure 1. As shown in figure, the average of reaction times was larger for audible signals when compared with visual ones. The shortest reaction time was also achieved for a visual signal. Furthermore, analysing the number of correct, delayed and wrong reactions the results showed the advantage to the usage of visual signals. However, it is worth to emphasise that it may result from the fact that it was easier for the operator to react to the same signals for a longer period to time than suddenly. As the study was carried out on a small amount of experiments, it was possible to make such a conclusion with a certain (expectable) estimation error. Further details of the experimental and statistical analysis of data will be covered in forthcoming manuscript.

It is well known that the vigilance job can be proved to be monotonous which requires lower mental workload (Kluge et al. 2014). At the same time, in case of abnormality a higher mental alertness and sharp decision making are required. Industrial operators are compulsory component of the *safety loop* of the industrial processes. The response of operators to alarms defines the consequences of any abnormal situation. If the response is quick and accurate and abnormal situation might be mitigated. On the other hand, a delayed and wrong response can lead to severe accidents and disasters (Nazir et al. 2012). Alarms are essential element of any process industry and further research is required to reach a universally accepted solution for the design, location and type of alarms. This experiment highlights the significance of diverse human responses with respect to different types of alarms. We deem it necessary to mention the limitation of this study: 1) the participants were students and not real operators, 2) a larger sample size can enable such experiment to propose a possible generalized solution. It should be also underlined that it is necessary to develop robust



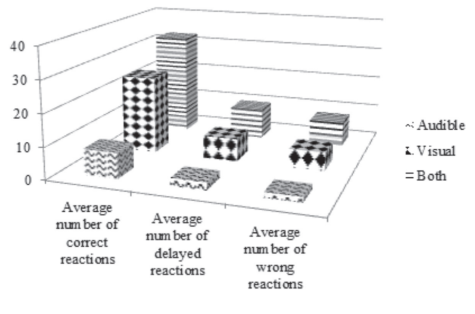


Figure 1. Reactions to alarm signals (left) and types of reactions to alarm signals (right).

methods against uncertainty in fault diagnosis systems, which provide data for the alarm signalisation systems (Mrugalska & Kawecka-Endler 2012, Mrugalska et al. 2014).

6 CONCLUSIONS

Recent industrial disasters have highlighted the need for improved safety and an increasing number of industrial quality and reliability systems. Therefore, alarms signalisation is frequently performed via display terminals where information for operators is presented in a variety of formats. In this paper a particular attention is paid to displays for alarm presentation such are visual and audible signals. The results of the present study revealed that the participants can react faster and more correctly to visual signals than audible one.

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Proposal methodology for evaluation of fire risk in urban spaces

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ABSTRACT: The fire protection and Safety in urban property is a sensitive and important topic, even more so in the context of older buildings that tend to be more vulnerable. In this case, fire risk analysis needs to be carried out, in order to ascertain safety levels, weaknesses, and hence adequate risk mitigation measures. The application of the assessment methodology of fire risk proposed, MARIEE, can be of high interest in developing a classification that can be applied to new and old buildings or those that will be targeted for rehabilitation processes.

1 INTRODUCTION

It is widely acknowledged that building rehabilitation remains a complex task involving the contribution of a multitude of experts. Their main goal—as well as that of any Fire Safety in Buildings initiative: protecting human life.

Whereas the current fire safety in buildings legislation must be implemented for any new construction, rehabilitation projects may fall under any of the following situations:

The general rule: current regulations are mandatory when refurbishing a building;

Special case for protected buildings where regulations are neither applicable nor practical: contingency protection measures are implemented;

Ad-hoc fire safety in buildings measure implementation for any building with an atypical risk profile, meaning standard regulations are wholly inadequate. These situations must be detailed in full by those responsible to enable a thorough risk-based analysis of proposed measures.

Interventions in such buildings should be made based on an assessment of fire risk in order to better assess the degree of safety and identify key shortcomings, so the most appropriate measures can be adopted in order to reduce that risk to levels considered acceptable.

2 MARIEE METHOD

2.1 *Introduction*

MARIEE, the proposed method for the evaluation of the risk of fire for a given building, serves two purposes: risk analysis for the current situation, and post-rehabilitation risk analysis (thus allowing optimal health and safety implementation).

MARIEE is a generic method and is applied regardless of the current usage of a building. Highly complex situations requiring specific analysis fall outside the scope of MARIEE. Full or partial rehabilitation of a building may be at stake, with diverse variations in scope.

This method introduces scenario-based analysis in order to determine the most effective way to handle a fire situation. Where several scenarios exist, the method is applied to the one with the highest risk. The resulting safety recommendations should then be tested against the remaining scenarios.

Two aspects set MARIEE apart from similar fire risk analysis methods: the creation of criteria for building maintenance and the analysis of fire safety devices—both from the perspective of effective building evacuation, particularly the incremental gains that each provide.

With MARIEE, we take the time required for building evacuation (partial or in full), and compare it to the time required in a fire situation for specific circumstances impairing the evacuation effectiveness to be reached. It is this delta that merits our attention.

2.2 *How MARIEE method works*

MARIEE relies on 4 global fire risk dimensions:

- POI—The probability of a fire;
- CTI—The full consequences of a fire;
- DPI—How a fire propagates;
- ESCI—The effectiveness of firefighting and assistance measures.

Note that the second dimension above includes two important concepts in risk analysis: how dangerous a fire is and one's exposure to it. The threat level depends on the chemical reactions during a fire, and the resulting fumes, gases, and heat. Exposure is measured by the time required to evacuate the premises.

Combining the 4 dimensions above enables a full view of fire risk analysis, and resulting implications for both individuals and property. The expressions for the calculation of fire risk (RI) in MARIEE are presented next. These include descriptors for the building conditions presented during the analysis.

$$RI = P \times G \tag{1}$$

where:

- RI—Fire Risk;
- P—The probability of a fire event;
- G—The seriousness of the consequences of a fire.

$$G = CTI \times (0{,}2 \times DPI + 0{,}8 \times ESCI) \tag{2}$$

where:

- CTI—The full consequences of a fire;
- DPI—How a fire propagates;
- ESCI—The effectiveness of firefighting and assistance measures.

$$CTI = \frac{CPI_{CI} + CPI_{VHE} + CPI_{VVE}}{3} \tag{3}$$

where:

- CPI_{CI}—Partial Consequences of a Fire, associated with a Fire Event Scenario;
- CPI_{VHE}—Partial Consequences of a Fire, pertaining to Horizontal Escape Rout;
- CPI_{VVE}—Partial Consequences of a Fire, pertaining to Vertical Escape Routes.

The consequences resulting from a fire depend on the danger level of the fire and the exposure, as shown in expression 4, [1]:

$$CPI = \frac{P}{E} \tag{4}$$

where:

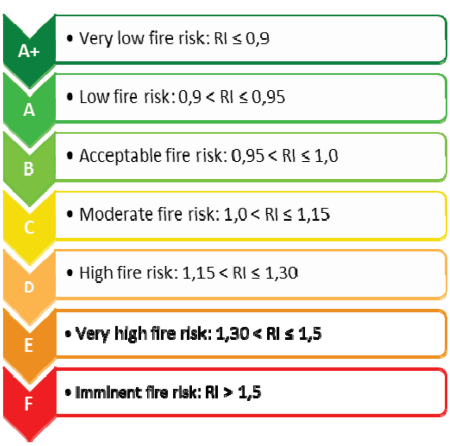
- CPI—Partial Consequences of a Fire;
- P—Potential Danger;
- E—Level of Exposure.

To sum up, fire risk in MARIEE is derived from expression 5 below, [1]:

$$RI = POI \times CTI \times (0{,}2 \times DPI + 0{,}8 \times ESCI) \tag{5}$$

3 PROPOSAL BUILDING CLASSIFICATION ACCORDING TO FIRE RISK

MARIEE can be used in different contexts, be it older or newer property, as well as any building undergoing rehabilitation. It allows for a systematic analysis of fire risk in urban spaces, thus enabling local authorities to create fire risk urban maps, identify high-risk areas and act accordingly. Figure 1 the proposed building classification according to fire risk. We consider 7 classes (A+, A, B, C, D, E and F), where the first one corresponds to a risk factor of 0.9, and the last one to a risk factor of 1.5.



Building construction year	Fire risk acceptable value
Before 1951	1,10
Between 1951 and 1967	1,08
Between 1968 and 1974	1,06
Between 1975 and 1990	1,04
Between 1991 and 2008	1,02

Figure 1. Proposal building classification according to fire risk, [1].

Figure 2. The results of the application of MARIEE to the historical centre of the city of Oporto, [2].

4 CASE STUDY

The Figure 2, shows the results of the application of MARIEE to the historical centre of the city of Oporto, [2].

5 CONCLUSION

The suggested methodology enables the evaluation of fire risk in urban spaces. Where risk levels are deemed unacceptable, mitigation measures can then be formulated. Given the casualty statistics for urban fires, this remains a relevant topic—particularly in the context of older buildings. The aim is to chart fire risk levels across an urban space and accordingly plan for the best countermeasures aiming to minimize the impact of urban fires.

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Indoor air quality in beauty establishments that use air fresheners in Guimarães

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ABSTRACT: Indoor Air Quality (IAQ) has proven to be increasingly a concern. Due to the fact that people spend too much time inside buildings, exposed to pollutants that are concentrated within the premises. The objective of this study is to evaluate the IAQ in establishments of beauty that use air fresheners, with a sample of 4 establishments, where it was necessary to assess analytically physical and chemical parameters. The study was cross-sectional cohort. Sample of non-probabilistic. The results obtained, as well as the geographical location, in rural areas there are higher values of average CH_2O, CO_2 and CO as compared to places designated as urban. The results show that the concentration has been influenced by the activities that the professionals were to be held at the time of each measurement. In relation to the two types of establishments studied, hairdressing and aesthetics, the concentrations of VOC's exceeded the reference values in the two locations.

1 INTRODUCTION

Currently it is recognized that the outdoor air pollution has serious health effects, however, is not the same awareness of the risks caused by poor air quality inside buildings. However, this lesser concern does not mean that the IAQ has less of an impact on health, as people spend most of their days in indoor environments. This is extremely dangerous, since this air is contaminated, either directly and/or indirectly by air pollution and also by all the activities carried out in its interior (Bernardes, 2009; Perera, 2012; Perera S., 2012; Thomas, 2013).

The building must ensure the well-being and preserve the health of its occupants, but often it is the generator of different types of health problems. These problems can manifest in the body immediately after the exposure, possibly after years, as in the case of carcinogenic and still, after repeated exposures, in which a person may become susceptible to particular pollutant (Sterling, 1991; Silva, 2005; Sanguessuga, 2012). In addition to the direct effects on health, there are still considering the impacts cause by the activity of occupants of buildings (Jesus, 2012). The beauty industry professionals are chronically exposed to a large number of chemicals that are in the work environment, including potential carcinogenic, such as formaldehyde, a substance present in a large proportion of products used for hair care and beauty. These chemicals through inhalation or contact with the skin, cause as already mentioned, uncomfortable sensations that many professionals are trying to hide by means of air fresheners, because the general impression that the occupants have their own environment will make you feel comfortable and accept the space, bringing positive impact on health and productivity (Lorenzini, 2010; Jesus, 2012; Sanitária; Perera S., 2012; APA, 2014).

There has been a growing concern in relation to air fresheners, candles, incense and essential oils to burn, since studies conclude that the majority of incense and essential oils emit toxic or harmful compounds to health. Studies show the usual practice of burning of three sticks of incense, twice a day, is susceptible to affect the health of an individual exposed (DECO, 2013; Ess, 2010; Perera S., 2012). The aim of the present study was to evaluate the IAQ, in particular, VOC's, CO_2, CO and CH_2O in 4 of beauty that use air fresheners.

2 MATERIAL AND METHODS

The research work was developed in the academic year 2013/2014, having been carried out the data collection in December 2013. The study was cross-sectional cohort. The type of sampling was not probabilistic, and the technique of convenience sampling. The sample was composed of 4 establishments of beauty the municipality of Guimarães. The establishments defined as hairdressers are where the practice of handling and treatment capillary and the establishments defined as aesthetics are those where there are activities for manicure/pedicure, and epilation treatments/body massages. The sites in this study did not have air conditioning and ventilation for one of the sites is natural and artificial and for the other three is natural. The candles and incense sticks were the air fresheners used by professionals. There were two moments of data collection for this study, being the first to travel to establishments, with the objective of characterize the physical conditions of the area to be monitored. The second moment was the evaluation of IAQ in beauty treatments of establishments, since that is the place where they spend more time, using the analytical assessment of chemical pollutants.

There were made 4 measurements in each establishment physical and chemical parameters, which are carried out in a period of 15 minutes, the first of the measurements in the morning before using the air fresheners and the other 3 (in the morning, lunch and evening) when to use. Put the equipment in the workplace of each employee, approximately to the height of the respiratory tract, by the activity that was to be held for the execution of the measurements was taken as reference to NT-SCE-02. It was also necessary to use the portable equipment for measurements of IAQ: the PPM formaldemetertm htv; the IST: Model 8552/8554 Q-TRAKTM Plus IAQ Monitor and the Photovac VOC detection Model 2020 plus. It was considered that with the maximum reference values for the CO_2 to 2250 mg/m^3, for the CO of 10 mg/m^3, for VOC's of 600 ug/m^3 and for the CH_2O of 100 ug/m^3, as referred to in the Decree no. 353-A/2013 of 4 December. For the indicators of thermal comfort were used the following legal acts: Decree-Law no. 118/2013, of 20 August that refers to as reference value 20C to a T suitable for the winter season, and the ISO 7730 that reference the interval between 30% and 70% as the optimum for the Hr. After the collection of the data, conducted their analysis using the software statistical analysis IBM SPSS. The tests used were the t-Student for a sample, the t-test for independent samples, ANOVA and Pearson's correlation coefficient.

3 RESULTS

The establishments were located in different geographical areas, two were located in urban area and the other two in the rural area, as such, interest check in which means if there were higher values of analytical parameters evaluated, as shown in Table 1.

There was also concern that there were no significant differences with respect to the value of pollutants, according to the times of collection and you can see that there were no significant differences for the parameters assessed.

With regard to the concentrations of the parameters assessed in the halls in the morning without using air fresheners in the morning with the use of air fresheners, you can check that for the parameters VOC's and CO_2 values are higher when the use of air fresheners and for the parameter CH_2O, the values were higher before using the air fresheners. On average, the values of the pollutant VOC's, referring to the two moments, were not adequate, that is, are far above the reference values 600 ug/m^3. In relation to the values of CH_2O, you can ascertain, on average, that these were not appropriate in the morning prior to the use of air fresheners, being above the reference values and at the time of collection following, exceeds the value, but not too many as previously. In relation to CO_2, in two moments, this parameter was within the reference value.

The parameters VOC's and CH_2O obtained the highest values at the end of the afternoon, and the

Table 1. Concentration of the parameters assessed in the different establishments on the basis of geographical location.

n=8	Geographical location	M	DP	t	gl	p
VOC's	Urban	9,38	7,93	1,894	8,438	0,093
(ppm)	Rural	3,80	2,56			
CH_2O	Urban	0,076	0,05	−1,004	7,004	0,349
(ppm)	Rural	1,07	2,80			
CO_2	Urban	896,50	279,82	−1,929	14	0,074
(ppm)	Rural	1313,13	542,91			
CO	Urban	1,89	0,387	−2,092	8,347	0,068
(ppm)	Rural	2,85	1,242			

Legend: n = Number of Measurements; gl = degrees of freedom; M = Average; DP = Standard Deviation.

Table 2. Concentration of parameters depending on the time of measurement (morning with/without freshener).

n4	Height measurement	M	DP	t	gl	p
VOC's	Morning without freshener	5,35	6,84	−2,72	6	0,074
(ppm)	Morning with air freshener	6,88	8,99			
CH_2O	Morning without freshener	2,05	3,97	0,99	3,01	0,397
(ppm)	Morning with air freshener	0,09	0,057			
CO_2	Morning without freshener	825,0	335,36	−0,503	6	0,633
(ppm)	Morning with air freshener	955,5	396,02			
CO	Morning without freshener	1,925	0,54	0,00	6	1,000
(ppm)	Morning with air freshener	1,925	0,31			

Legend: n = Number of Measurements; gl = degrees of freedom; M = Average; DP = Standard Deviation.

Table 3. Concentration of parameters depending on the time of measurement (end of lunch/the evening).

n4	Height measurement	M	DP	t	gl	p
VOC's	End of lunch	5,15	4,19	−0.966	6	0,371
(ppm)	The evening	8,99	6,75			
CH_2O	End of lunch	0,08	0,021	−0,566	6	0,596
(ppm)	The evening	0,08	0,029			
CO_2	End of lunch	1383,0	581,04	0,339	6	0,746
(ppm)	The evening	1255,75	476,76			
CO	End of lunch	2,875	1,76	0,129	6	0,901
(ppm)	The evening	2,75	0,79			

Legend: n = Number of Measurements; gl = degrees of freedom; M = Average; DP = Standard Deviation.

Table 4. Concentration of the parameters assessed in the different establishments.

n8	Type of establishment	M	DP	t	gl	p
VOC's	Hairdresser	9,17	7,78	1,716	9,558	0,118
(ppm)	Centers beauty	4,02	3,39			
CH_2O	Hairdresser	1,08	2,8	1,031	7	0;0,337
(ppm)	Centers beauty	0,06	0,032			
CO_2	Hairdresser	945,13	211,25	−1,404	6,67	0,195
(ppm)	Centers beauty	1264,50	607,72			
CO	Hairdresser	2,0	0,54	−1,509	14	0,154
(ppm)	Centers beauty	2,74	1,27			

Legend: n = Number of Measurements; gl = degrees of freedom; M = Average; DP = Standard Deviation.

values of the parameters CO_2 and CO were higher in measurement performed at the end of lunch. As regards the values of CH_2O, it can be seen that, on average, they were within the reference value at the end of lunch, and the limit on the measurement performed at the end of the afternoon. In relation to CO_2, in two moments, this parameter was outside of the reference value. As the measurements were carried out in separate establishments, we decided to check if there were significant differences in the values of pollutants in accordance with the different establishments, and then you can see that there were no significant differences, according to Table 4.

For the designated establishment such as hairdressing, the parameters where the values are higher in comparison with the values of the designated establishment as aesthetics, but were the values of VOC's and CH_2O. Already the highest values for the establishment of aesthetics were the values of CO_2 and CO. For the two types of establishments, the values of VOC's exceeded the reference values. For the parameter CH_2O, only the value was exceeded in hairdressers.

4 DISCUSSION

The values obtained in this study, mean concentration of VOC's was exceeded in two types of establishments, when compared with the reference value, for hairdressers the value was 9.17 ppm and the aesthetic value was 4,02 ppm. With regard to the values of CH_2O, this was exceeded in hairdressers, 1.08 ppm, and the reference value of 0,08ppm. As for the centers of aesthetic value framed within the reference, with 0,064 ppm. For the parameter CO_2, this only exceeded the reference value in the establishment of aesthetics, but very slightly, with the average value of 1264,50 ppm and hairdressers the value was 945,13 ppm.

In all lounges evaluated, the values of CO are within the recommended value by the legislation in force, the hairdressers with 2.00 ppm and the aesthetics with 2,74 ppm. The VOC's are considered hazardous air pollutants, some of which are toxic and carcinogenic, as is the case of formaldehyde, irritating to eyes and respiratory tract, being only described as highly suspect to be a carcinogenic compound (Alvim, 2010). The high concentration of VOC's in the air inside these establishments, can arise from several factors, in particular, the external air, once that road transport is a clear source of these compounds (Strausz, 2001) (Frames & Lisbon, 2010), Also from the introduction of new products and materials of construction, finishing, decoration, furniture and cleaning. But in addition to the previous factors that influence the emission and dispersion of organic vapors in the entire working environment, the activities developed by professional beauty expose workers to different concentrations, when carrying out the work as manicure/pedicure, coloring, among others. These factors all still we have joined the air fresheners, which like other studies indicate, candles and incense sticks emit VOC's, among them a very harmful, the CH_2O. So if you can justify the values exceed the limits for exposure (APA, 2014).

Along the measurements it was found that, the values vary, but not as you would expect, in which the concentrations would increase throughout the day. We have the case of CH_2O, the highest value is in the morning before the use of air fresheners, exceeding the allowed value. It would be expected that the value was higher after the use of air fresheners, but probably the value was influenced by the activity that the professional was to be carried out. In the moments that followed this data collection in hairdressers, where values were higher, the workers were doing sessions in coloring and permanent. For these activities are used products in their composition are part substances in concentrations inadequate become toxic and affect the quality of the air. Also sessions for the manicure/pedicure are used enamels and nail removers varnish, that they show in their composition other substances capable of altering the quality of the air (Lonzerini, 2012, Souza, 2009). The obtained values are not direct results to the conclusion that it is the air fresheners to change the quality of the air, since it was observed that the professional activities also influence. In relation to the geographical location, in rural areas there are higher values of average CH_2O, CO_2 and CO, and in places designated as urban higher values were recorded by parameter VOC'S. According to another study, in the year 2013, we can identify in the same situation in the homes of elderly people who, for the home situated in rural areas the higher values was CO_2 and in the urban environment the high values are VOC'S (Carvalho, 2013). Regarding the correlation between CO_2 and temperature and between the CO_2 and CO, it is most likely due to the fact that the local focus several people for service, the operation of hair dryers during professional activity and even the ventilation is not sufficient to study sites.

5 CONCLUSIONS

As soon as the air fresheners, candles and incense sticks, contribute to that are released pollutants that can harm human health (Thomas, 2013).

In this way, it is necessary to implement strategies and measures for improvement of IAQ, as control at source, education for health professionals or ventilation, which reduces exposure to lower the concentration of pollutants in the air. To improve the conditions of ventilation, the injurious effects of air fresheners and the professional activities of these study sites can be minimized. Alternatively, air purifiers that do not contain harmful compounds, in order to minimize the effect of toxicity.

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The error in aviation is a fault tree that always ends in humans

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ABSTRACT: Guilt is a word which disrupts accident investigations. In the scenario of aircraft with high degree of automation control which resembles computer consoles, point to the need for further research focused on possible conflicts between the "human logic" and "logical automation" checked in control systems for aircraft. It is very important to consider that the logic of automation was also drafted by pilots, so that this assumption is difficult to validate. A pilot in command of the Airbus blurted that "modern technology" was withdrawing men of cockpits. This happened with the radio-telegraph when they got the new communication systems called SSB and VHF. But from there, the pilots were more burdened with the task of transmitting operational information and logistics companies, diluting attention at critical moments of the flight, in congested terminal areas.

1 INTRODUCTION

The Boeing 777: This is a large modern aircraft carrying hundreds of passengers and so much faster. Today the tasks of the pilots were multiplied and increased the weights of aircraft, and the number of passengers, speeds takeoffs and landings were more significant, decreasing the number of men in the cockpit. However, the biological machine called human being is not structurally changed in the last thousands of years to support the increased cognitive and emotional overload. How to know your limits? The professional called Mechanics of Flight (the third man in the cockpit), was extinguished when computers arrived. Until the 70s there was a work station flight engineer. Several procedures were loaded to the pilots that were executed by the Flight Engineer (Mechanic of Flight). Two men just to control a Boeing 777: A huge and modern aircraft that carries hundreds of passengers and on faster way. Several procedures were loaded to the pilots that were executed by the Flight Engineer (Mechanic of Flight). The navigator was more burdened with the task of transmitting operational information when new systems arise like Omega and Doppler Radar. Over a sequence of operations adjustments and manipulations more equipment were transferred to the pilots on this occasion, adding to the known and the complex and overloaded duties of these professionals. This also happened with the mechanics of flight (the third man in the cockpit), when computers arrived. Until the 70s there was a work station flight engineer.

2 FUNDAMENTATION

The following factors are an integral part of cognitive activity in the pilot: fatigue, body rhythm and rest, sleep and its disorders, the circadian cycle and its changes, the G-force and acceleration of gravity, the physiological demands in high-altitude, night-time take-offs and the problem of false illusion of climbing. But, other physiological demands are placed by the aviators. It is suggested that specific studies must be made for each type of aircraft and workplace, with the aim of contributing to the reduction of incidents arising from causes so predictable, yet so little studied. We must also give priority to airmen scientists that have produced these studies in physiology and occupational medicine, since the literature is scarce about indicating the need for further work in this direction. Human cognition refers to mental processes involved in thinking and their use. It is a multidisciplinary area of interest includes cognitive psychology, psychobiology, philosophy, anthropology, linguistics and artificial intelligence as a means to better understand how people perceive, learn, remember and how people think, because will lead to a much broader understanding of human behavior. Cognition is not presented as an isolated entity, being composed of a number of other components, such as mental imagery, attention, consciousness, perception, memory, language, problem solving, creativity, decision making, reasoning, cognitive changes during development throughout life, human intelligence, artificial intelligence and various other aspects of human thought (Henriqson, 2010). The procedures of flying an aircraft involve observation and reaction to events that take place inside the cabin of flight and the environment outside the aircraft (Dekker,2003). The pilot is required to use information that is perceived in order to take decisions and actions to ensure the safe path of the aircraft all the time. Thus, full use of the cognitive processes becomes dominant so that a pilot can achieve full success with the task of flying the "heavier than air." With the advent of automated inclusion of artifacts in the cabin of flight that assist the pilot in charge of controlling the aircraft, provide a great load of information that must be processed in a very short space of time, when we consider the rapidity with which changes occur, an approach that cover the human being as an individual is strongly need. Rather, the approach should include their cognition in relation to all these artifacts and other workers who share that workspace (FAA, 2012).

3 THE DEPLOYMENT OF THE ACCIDENTS GENERATED BY BAD-PLANNED-TASKS ACCIDENTS

A strong component that creates stress and fatigue of pilots, referred to the design of protection, detection and effective handling of fire coming from electrical short circuit on board, is sometimes encountered as tragically happened on the Swissair Airlines flight 111, near Nova Scotia on September 2, 1998. The staff of the Federal Aviation Administration (FAA), responsible for human factors research and modern automated interfaces, reports a situation exacerbated by the widespread use an electrical product and a potentially dangerous wire on aircrafts, called "Kapton" (Dekker, 2003). If a person has to deal with an outbreak of fire, coming from an electrical source at home, the first thing he would do is disconnect the electrical power switch for the fuses. But this option is not available on aircraft like the Boeing B777 and new Airbus. The aviation industry is not adequately addressing the problem of electrical fire in flight and is trying to deal recklessly (Reason, 1990). The high rate of procedural error associated with cognitive errors, in the automation age, suggests that the projects in aviation have ergonomic flaws. In addiction, is has been related that the current generation of jet transport aircraft, used on airlines, like the Airbus A320, A330, A340, Boeing B777, MD11 and the new A380, that are virtually "not flyable" without electricity. We can mention an older generation, such as the Douglas DC9 and the Boeing 737.

Another factor in pushing the pilots that causes emotional fatigue and stress is the reduction of the cockpit crew to just two. The next generation of large transport planes four engines (600 passengers) shows a relatively complex operation and has only two humans in the cockpit. The flight operation is performed by these two pilots, including emergency procedures, which should be monitored or re-checked. This is only possible in a three-crew cockpit or cockpit of a very simple operation. According to the FAA, the only cockpit with two pilots that meets these criteria is the cabin of the old DC9–30 and the MD11 series. The current generation of aircraft from Boeing and Airbus do not fit these criteria, particularly with respect to engine fire during the flight and in-flight electrical fire. The science of combining humans with machines requires close attention to the interfaces that will put these components (human-machine) working properly.

The deep study of humans shows their ability to instinctively assess and treat a situation in a dynamic scenario. A good ergonomic design project recognizes that humans are fallible and not very suitable for monitoring tasks. A properly designed machine (such as a computer) can be excellent in monitoring tasks. This work of monitoring and the increasing the amount of information invariably creates a cognitive and emotional overload and can result in fatigue and stress. According to a group of ergonomic studies from FAA (2010) in the United States this scenario is hardly considered by the management of aviation companies and, more seriously the manufacturers, gradually, introduce further informations on the displays of Glass cockpits. These new projects always determine some physiological, emotional and cognitive impact on the pilots. The accident records of official institutes such as the NTSB (National Transportation Safety Bureau, USA) and CENIPA (Central Research and Prevention of Accidents, Brazil) show that some difficulties in the operation, maintenance or training aircraft, which could affect flight safety are not being rapidly and systematically passed on to crews worldwide. These professionals of aviation may also not be unaware of the particular circumstances involved in relevant accidents and incidents, which makes the dissemination of experiences very precarious.

One of the myths about the impact of automation on human performance: "while investment in automation increases, less investment is needed in human skill". In fact, many experiments showed that the progressive automation creates new demands for knowledge, and greater, skills in humans. Investigations of the FAA (2010), announced that aviation companies have reported institutional problems existing in the nature and the complexity of automated flight platforms. This results in additional knowledge requirements for pilots on how to work subsystems and automated methods differently. Studies showed the industry of aviation introduced the complexities of automated platforms flight inducing pilots to develop mental models about overly simplified or erroneous system operation. This applies, particularly, on the logic of the transition from manual operation mode to operation in automatic mode (FAA apud NTSB, 2010).

4 FUTURE WORK TO MAKE AN ASSESSMENT IN SYSTEMIC PERFORMANCE ON PILOTS

Evaluating performance errors, and crew training qualifications, procedures, operations, and regulations, allows them to understand the components that contribute to errors. At first sight, the errors of the pilots can easily be identified, and it can be postulated that many of these errors are predictable and are induced by one or more factors related to the project, training, procedures, policies, or the job. The most difficult task is centered on these errors and promoting a corrective action before the occurrence of a potentially dangerous situation. The FAA team, which deals with human factors (Green, 1993), believes it is necessary to improve the ability of aircraft manufacturers and aviation companies in detecting and eliminating the features of a project, that create predictable errors. The regulations and criteria for approval today do not include the detailed project evaluation from a flight deck in order to contribute in reducing pilot errors and performance problems that lead to human errors and accidents. Neither the appropriate criteria nor the methods or tools exist for designers or for those responsible for regulations to use them to conduct such assessments. Changes must be made in the criteria, standards, methods, processes and tools used in the design and certification. Accidents like the crash of the Airbus A320 of the AirInter (a France aviation company) near Strasbourg provide evidence of deficiencies in the project.

This accident highlights the weaknesses in several areas, particularly when the potential for seemingly minor features has a significant role in an accident. In this example, inadvertently setting an improper vertical speed may have been an important factor in the accident because of the similarities in the flight path angle and the vertical speed in the way as are registered in the FCU (Flight Control Unit). This issue was raised during the approval process of certification and it was believed that the warnings of the flight mode and the PFD (Primary Flight Display-display basic flight information) would compensate for any confusion caused by exposure of the FCU, and that pilots would use appropriate procedures to monitor the path of the vertical plane, away from land, and energy state. This assessment was incorrect. Under current standards, assessments of cognitive load of pilots to develop potential errors and their consequences are not evaluated. Besides, the FAA seeks to analyze the errors of pilots, a means of identifying and removing preventively future design errors that lead to problems and their consequences. This posture is essential for future evaluations of jobs in aircraft crews. Identify projects that could lead to pilot error, prematurely, in the stages of manufacture and certification process will allow corrective actions in stages that have viable cost to correct or modify with lower impact on the production schedule. Additionally, looking at the human side, this reduces unnecessary loss of life.

5 CONCLUSION

We developed a study focusing on the guilt of pilots in accidents when preparing our thesis. In fact, the official records of aircraft accidents blame the participation of the pilots like a large contributive factor in these events. Modifying this scenario is very difficult in the short term, but we can see as the results of our study, which the root causes of human participation, the possibility of changing this situation. The cognitive factor has high participation in the origins of the problems (42% of all accidents found on our search). If we consider other factors, such as lack of usability applied to the ergonomics products, the choose of inappropriate materials and poor design, for example, this percentage is even higher. Time is a factor to consider. This generates a substantial change in the statistical findings of contributive factors and culpability on accidents. The last consideration on this process, as relevant and true, somewhat later, must be visible solutions. In aviation, these processes came very slowly, because everything is wildly tested and involves many people and institutions. The criteria adopted by the official organizations responsible for investigation in aviation accidents do not provide alternatives that allow a clearer view of the problems that are consequence of cognitive or other problems that have originate from ergonomic factors. We must also consider that some of these criteria cause the possibility of bringing impotence of the pilot to act on certain circumstances. The immediate result is a streamlining of the culpability in the accident that invariably falls on the human factor as a single cause or a contributing factor. Many errors are classified as only "pilot incapacitation" or "navigational error". Our research shows that there is a misunderstanding and a need to distinguish disability and pilot incapacitation (because of inadequate training) or even navigational error.

Our thesis has produced a comprehensive list of accidents and a database that allows extracting the ergonomic, systemic and emotional factors that contribute to aircraft accidents. These records do not correlate nor fall into stereotypes or patterns. These patterns are structured by the system itself as the accident records are being deployed. We developed a computer system to build a way for managing a database called the Aviation Accident Database. The data collected for implementing the database were from the main international entities for registration and prevention of aircraft accidents as the NTSB (USA), CAA (Canada), ZAA (New Zealand) and CENIPA (Brazil). This system analyses each accident and determines the direction and the convergence of its group focused, instantly deployed according to their characteristics, assigning it as a default, if the conditions already exist prior to grouping. Otherwise, the system starts formatting a new profile of an accident (Dekker, 2003).

This feature allows the system to determine a second type of group, reporting details of the accident, which could help point to evidence of origin of the errors. Especially for those accidents that have relation with a cognitive vector. Our study showed different scenarios when the accidents are correlated with multiple variables. This possibility, of course, is due to the ability of *Aviation DataBase System* (Martins, 2007, 2010), which allows the referred type of analysis. It is necessary to identify accurately the problems or errors that contribute to the pilots making it impossible to act properly. These problems could point, eventually, to an temporary incompetence of the pilot due to limited capacity or lack of training appropriateness of automation in aircraft. We must also consider many other reasons that can alleviate the effective participation or culpability of the pilot. Addressing these problems to a systemic view expands the frontiers of research and prevention of aircraft accidents.

This system has the purpose of correlating a large number of variables. In this case, the data collected converges to the casualties of accidents involving aircraft, and so, can greatly aid the realization of scientific cognitive studies or applications on training aviation schools or even in aviation companies (Martins, 2010). This large database could be used in the prevention of aircraft accidents allowing reaching other conclusions that would result in equally important ways to improve air safety and save lives.

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Evaluation of a public safety program based in programme theory

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ABSTRACT: In the last years in Spain, public safety promotion programs in enterprises with high injury rates have been developed. Most of evaluations of those programs show a reduction in the injury rates in the enterprises participating. A program oriented to improve safety management in high injury rate enterprises denominated PAEMSA is analyzed. An strong reduction in injury rates in the enterprises participating was achieved but this study analyzes the effectiveness of a public safety promotion program using program theory. The program according to the results was effective in improving the safety management system. Further research is needed to study the relationship of the improvements in safety management with injury rates reduction.

1 INTRODUCTION

1.1 *Evaluation of safety programs*

Evaluation of safety programs is a complex issue. Most of studies use injury rates as indicator of the effectiveness, although there are many others (Zwerling et al., 1997; Sgorou et al., 2010). Previous studies have shown the need for a clear definition of the methodology (LaMontagne et al., 2004).

Main problem of evaluation of programs and interventions arises when there is a selection bias. Most public programs are oriented to a specific type of enterprises. As experimental design is rarely possible, the only feasible alternative is to find an appropriate control group (Robson et al., 2007).

Some authors (Pedersen et al., 2011) recommend the use of programme theory, specifically effective with complex programs. According to Pedersen et al. (2011) within programme theory the evaluation is centered in the outcomes of the activities of the program and not in the final indicators of performance. In the case of safety programs, the evaluation, instead of being centered in the accident rate, is focus on the activities of the program.

1.2 *Safety interventions in enterprises with high injury rates—PAEMSA*

In Spain, since the nineties, most regional Labor Authorities have designed interventions focused in high injury rate enterprises. First of them was developed in Aragón, a region where the Labour Authority realized that 40% of the accidents occurred in only 2% of the enterprises.

Most of those interventions consist of public assessment oriented to help enterprises to improve their safety management systems. In the literature they are known as “Planes de Actuación Preferente” or simply as PAP (Rodrigo et al., 2007; Benavides et al., 2009). So far the analysis of PAP programs has been done with the injury rate analysis (López-Ruiz et al. 2013) but bias on selection of the enterprises participating is a serious threat for the internal validity of the results.

In Andalusia, one of the most populated regions in Spain, the programs developed in high injury rates enterprises are known as PAEMSA which is the acronym of “Programa de Actuación en Empresas de Mayor Siniestralidad” (Intervention program in Enterprises with High Injury Rates). According to Rodrigo et al (2007) is one of the best designed and developed programs of this kind in Spain.

PAEMSA II is based in an assessment performed by a public assessor, expert in safety management that identified the potential improvements in safety management.

The criteria for an enterprise to be included in PAEMSA II are the following;

– Injury rate higher than 150% of the mean injury rate of the enterprises in the same economic activity using the code at two digits level of the Classification of Economic Activities in the European Community (NACE rev 1) and more than four accidents or one fatal accident.
– One fatal and one severe accident.
– More than one fatal accident.
– More than one severe accident.

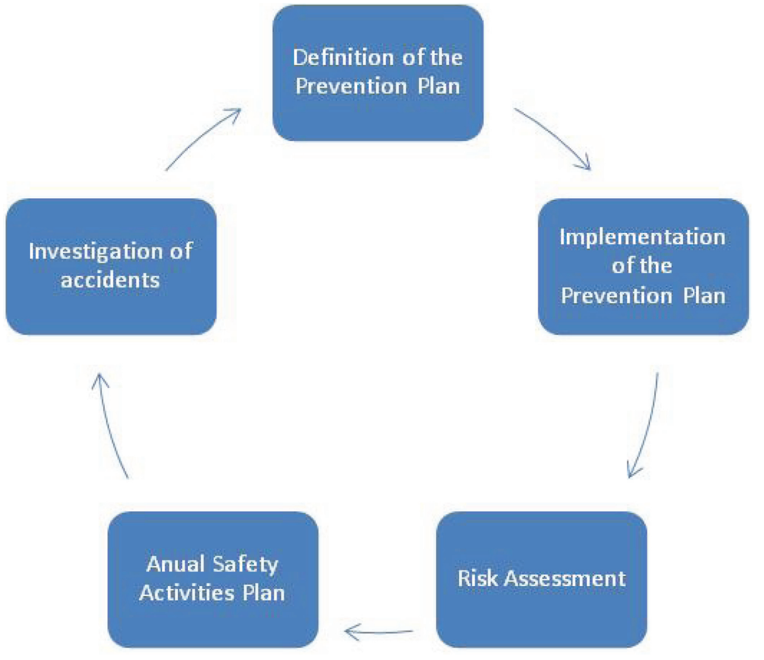

Figure 1. Prevention cycle.

1.3 *Program activities: Safety management questionnaire*

The main tool used to assess the safety management performance of the enterprises assessed is a safety management questionnaire. The safety management questionnaire results are the assessment of the public officer assigned to the enterprise after a visit and interview with the enterprise representatives. In most of the enterprises assessed there are at least two questionnaires, before and after the intervention. The "before" questionnaire results are used to recommend the enterprise possible areas of improvement in the safety management.

The questionnaire is based in the prevention cycle defined in The European Framework Directive on Safety and Health at Work (Directive 89/391 EEC) adopted in 1989, which is the basis of the regulation of safety obligations for enterprises (see Fig. 1).

1.4 *Scope of this research*

This research is based on the analysis of the effectiveness of the program PAEMSA II in small and medium manufacturing enterprises. PAEMSA II was developed in Andalusia from 2006 to 2007. That effectiveness analysis is based in programme theory.

The reason to select only manufacturing enterprises is because enterprises in manufacturing sector are more stable than enterprises in other sectors. Besides, in the last years many studies have been published regarding that sector (Carrillo et al., 2012) (Carrillo et al., 2013). It is important to consider that Andalusia is one of the biggest regions of Europe, and represents approximately 12% of the Spanish manufacturing sector and employs on average more than two hundred thousand workers (European Commission, 2012).

The main purpose of this study is to analyze the effect of PAEMSA II on the safety management performance of the manufacturing enterprises assessed.

2 MATERIALS AND METHOD

2.1 *Effect of the program*

Evaluation of the effectiveness is based in the conceptual framework presented in Figure 2.

2.2 *Safety management questionnaire results*

The data gathered is based in the questions of safety management questionnaire presented in Table 1. All answers gathered are the result of the public officer assessment based on the interviews with enterprises representatives.

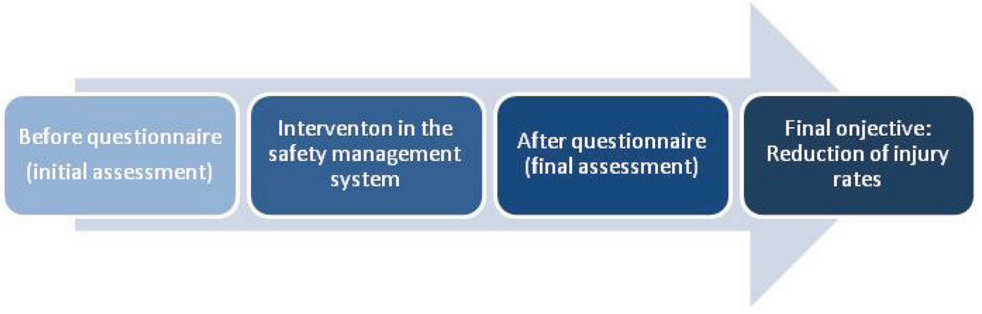

Figure 2. Intervention conceptual framework.

Table 1. Result of the assessment based on the safety management questionnaire. Percentage are calculated for the total number of assessed enterprises where the question is applicable.

	Before			After		
Question	% yes	na[a]	# yes	% yes	na[a]	# yes
2. Is there a prevention plan?	93%	1	601	95%	1	611
2.1. Does it include the needed information?	91%	15	572	94%	10	594
2.2. Does it include the procedures needed?	80%	15	502	84%	10	530
2.3. Does it include the responsibilities?	74%	15	466	79%	10	499
2.4. Does it include the working instructions?	71%	23	441	75%	18	467
2.5. Does it include an emergency plan?	73%	59	425	75%	66	432
3. Is the prevention plan implemented?	73%	12	460	77%	7	490
3.1. Is it known by all workers?	66%	24	412	72%	23	445
3.2. Does it include the training?	67%	28	413	71%	28	440
4. Is there a risk assessment?	97%	0	623	97%	0	627
4.1. Does it include a prioritization?	85%	9	540	88%	4	560
5. Is there an annual plan of safety activities	91%	1	582	92%	0	594
5.1. Is it bases in the risk assessment?	93%	27	572	94%	18	587
5.2. Are the activities well defined?	85%	28	521	87%	19	542
5.3. Does it include the training of workers?	88%	27	543	89%	18	559
5.4. Does it include health surveillance?	86%	28	529	87%	19	546
5.5. Does in include periodic checking?	72%	28	442	76%	18	477
5.6. Does it include schedule and responsible?	62%	26	381	69%	17	431
5.7. Is the schedule being accomplished?	58%	93	320	64%	74	365
6. Does the enterprise investigate the accidents?	79%	1	510	83%	1	535
6.1. Does it include causes identification?	80%	40	484	85%	35	517
6.2. Does it include corrective actions?	72%	40	437	77%	35	469
6.3. Does it include a schedule?	56%	42	340	64%	36	387
6.4. Is the schedule being accomplished?	27%	132	137	24%	116	127
Average of all answers	76%	30	469	80%	24	493

[a]na: not applicable to the enterprise (total number of enterprises is 644).

2.3 *Effectiveness: Injury rates*

The evaluation is centered in the effect of the intervention in the safety management system of the enterprises and the improvement of the items included in the questionnaire.

Nevertheless, in order to know if there is a real association with the reduction in terms of injury rates which is the final objective of the programme, relative injury rates are calculated before and after the intervention. Relative injury rates are calculated using the enterprise injury rate and the mean injury rate in all enterprises in the same activity (NACE rev. 1 with two digits).

3 RESULTS

3.1 *Results of the "before" and "after" evaluation of safety management system: Questionnaire results*

The total number of enterprises included in the program was six hundred fifty-seven. Results of the "before" questionnaire are presented in Table 1.

Only two hundred forty-five of them where assessed and surveyed after the intervention and have an "after" questionnaire, the rest of enterprises with good result in the "before" questionnaire do not have an "after" questionnaire.

In one hundred forty-nine of the enterprises reassessed there is no improvement at all. In the rest, 69 show improvements in less than five of the questionnaire items and 29 show improvements in more than five items. No association was found between improvements in the items and injury rates reduction.

3.2 *Effect on injury rates*

In Table 2, the evolution of injury rates depending on the improvements in the items of the questionnaire are presented. In Table 3, evolution of injury rates in relation to the relative injury rate before the intervention are presented.

Table 2. Association between improvements in questionnaires and injury rates reduction.

	Number of items with improvements		
Evolution of injury rates	None	1 to 5	More than 5
Increase more than 50%	10	4	3
Increase less than 50%	29	9	3
Decrease less than 25%	10	7	0
Decrease between 25% and 50%	10	7	3
Decrease more than 50%	6	42	20

Table 3. Association between relative injury rate before the intervention and injury rates reduction.

Before relative injury rate	Number of enterprises	% Improvement
Less than 50%	33	–58,6%
Between 100% and 150%	66	27,6%
Between 150% and 200%	110	17,9%
Between 200% and 250%	104	26,0%
Between 250% and 300%	76	37,6%
Between 300% and 350%	61	39,4%
Between 350% and 400%	54	45,8%
More than 400%	150	53,8%
Total	654	23,7%

4 DISCUSSION AND CONCLUSIONS

The application of programme theory to the evaluation of PAEMSA II show a clear improvement in the safety management of the enterprises assessed in terms of the results of the questionnaires before and after the intervention.

Considering all the questions, there is a mean improvement of 3% in the proportion of affirmative answers among the enterprises where the question is applicable (see Table 1). There is only one question with a negative comparison before-after, question 6.4 regarding if the schedule of corrective actions after the accident investigation was being accomplished. Nevertheless, the overall assessment shows that on average the enterprises can improve another 20% of the items thus new efforts can be made to adjust the safety management to the requirements of European Framework Directive on Health and Safety.

Although according to programme theory PAEMSA II was effective in terms of the improvement in safety management, the effect in the reduction of injury rates is not clear (see Table 2).

Moreover, a possible regression to mean effect (Barnett et al., 2005) is expected because most of the enterprises participating are chosen because of their high injury rates in the year before intervention. The association between relative injury rates before the intervention and the reduction in injury rates could indicate that part of the effect of the program a regression to mean effect thus further research is needed to estimate the real effect of the program in terms of injury rates reduction.

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Thermal and acoustic aspects an sheds for production of broilers at high density

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ABSTRACT: The worker in the poultry sector is exposed to a number of risk factors in the execution of his activities, including exposure to dust; harmful gases, excessive noise and heat stress, and is also subject to biological, chemical, physical, mechanical, ergonomic, social risks and accidents. This research aimed to evaluate and insert within the environmental variables, air temperature, relative humidity and noise level inside a commercial warehouse with tunnel ventilation system with negative pressure equipped with exhaust and evaporative cooling, for the production of broilers. Despite the high level of technology adopted in this production system, including automated control of environmental variables, the action is still irreplaceable worker performing tasks inside the shed, such as the removal of dead birds and conducting preventive maintenance and corrective in troughs, automatic feeders and misting system. Maps of spatial distribution of the aforementioned environmental variables were generated into the shed, using the method of kriging. Based on the results, we can conclude that workers in general, were not subjected to unhealthy environmental conditions even in the hottest times of the day. The spatial distribution of variables related to the production environment provides for more detailed information on the system studied.

1 INTRODUCTION

The importance of research seeking optimization and adaptation to environmental well-being and comfort of workers involved in the authoring environment and poultry production has been discussed over time, yet the interaction of several environmental factors, such as thermal factors and the noise level to which these workers have been exposed, have not been thoroughly evaluated.

According to Santos et al., (2010), the Brazilian poultry industry is an important activity for agribusiness in the country and although the use of this technology activity involves the replacement of human labor by automating tasks, the use of human labor is still significant.

The poultry industry has been considered one of the most important and efficient activities of Brazilian agriculture, leading Brazil to assume, since 2004, the position of world's largest exporter of chicken meat, ending in 2009 with the mark of 3.6 million tons shipped to over 150 countries. As for chicken production, Brazil currently ranks second with a production of 10 900 tons. Generating more than 4.5 million direct and indirect jobs and responding to 1.5% of GDP Gross Domestic Product (UBA, 2010).

According to Carvalho (2009) Brazil's poultry facilities generally possess low thermal insulation, especially in coverage, and natural ventilation is further used the medium to minimize temperatures in poultry, although this research has been made for the type sheds tunnel with negative pressure, using exhaust fans.

These problems can be reduced or even eliminated through the application of best practices in ergonomics and safety, which has contributed notably through interventions and projects to improve, in an integrated way safety, comfort, well-being and effectiveness of human activities in the urban sector, but may be extended to the rural sector, even this sector had significantly different characteristics, such as education levels of workers, socioeconomic, cultural, and anthropological (Alencar et al., 2006).

1.1 *Job security in poultry*

In industry, production systems are more rigid and jobs are more defined. In contrast, in traditional agricultural labor, workers are not employed in a given task or precisely stipulated, the worker performs various tasks, and should organize their time in order to allow the completion of all of them.

The poultry industry in southern Brazil has been a constant topic of research in the areas of Ergonomics, Hygiene, Health and Safety, however, few studies in this area have been directed to the poultry industry in the Northeast. For this type of activity there are regional factors that differs according to region, for example, climatic, technological and organizational. While there are these differentiating factors, it appears that the implementation of this activity whatever the region, own aspects in the supply chain related to ergonomics and hygiene, health and safety at work that need to be improved. The worker in the poultry sector is exposed to a number of risk factors in the execution of their tasks.

The workers in the poultry industry in any region are exposed to a number of risk factors in the execution of their activities, including exposure to dust, harmful gases, excessive noise and heat stress, and is subject to biological hazards chemical, physical, mechanical, ergonomic, social and accidents.

In Wasteland of Paraiba, northeastern Brazil, where human activity is still present in some tasks, due to the prevailing level of technology in some sheds for creating broiler region, it is estimated that these risks are even greater influence and exercise on worker well being, affecting productivity through increased absenteeism and lack of motivation to perform tasks.

It is therefore of paramount importance that qualifies and quantifies this environment of worker exposure to risks, better understanding the relationship between the types of facilities, the level of technology adopted and inadequate conditions concomitantly with inadequate present acts in various positions work.

The spatial variable thermal and acoustic environment enables to understand the relationship between these factors of production environment and its spatial variation (Tadayuki et al., 2011).

The research aims to contribute to strengthening the scenario of occupational hygiene, health and safety of workers in the sector of poultry production, ensuring the efficiency of individuals, preventing them from occupational diseases, assessing the environmental comfort and the risks inherent in the creative sector broiler, by proposing improvements on working conditions.

2 MATERIALS AND METHOD

The experiment was conducted on a commercial broiler farm in the municipality of Guarabira—PB, Brazil, located at latitude 06º54′07.5″S and longitude 035º27′02.6″.

Data collection was made during the period January 8 to February 20, 2012, The Shed, oriented east-west, has 150 m long, 15 m wide, 3.45 m ceilinged, tiled roof of fibro cement, poultry litter bagasse from sugar cane, side curtains and liners yellow plastic canvas, as can be seen in the image of your 3D model in Figure 1.

The thermal cooling system of the authoring environment is adopted tunnel type negative pressure, with side curtains open until the 12th day of bird life and closed the 13th until the end of the batch, approximately 42 days.

The ventilation system consists of 10 hoods, 08 being on the west side of the shed, associated with a misting system. The variables that make up the thermal environment, air temperature, Tair (°C), Relative Humidity, RH (%), were collected simultaneously by the instrument Psychrometer-AN-4870 portable anemometer manufacturer ICEL and the noise level (dB) was collected by using a Thermo-Hygro-Luxmeter-portable decibel meter, model 400-THDL Instrutherm manufacturer.

The measurements were carried out inside the hangar three times per week on alternate days for 42 days, the period of greatest heat stress from 12 h to 16 h, 100 points allocated inside the shed, to 1.0 m high from the floor, equivalent to the center of mass of the worker, with the exception of noise, which was collected at the time of the hearing center worker, approximately 1.5 m above the floor.

In Figure 2 can be seen the points of measurements inside the hangar, where environmental

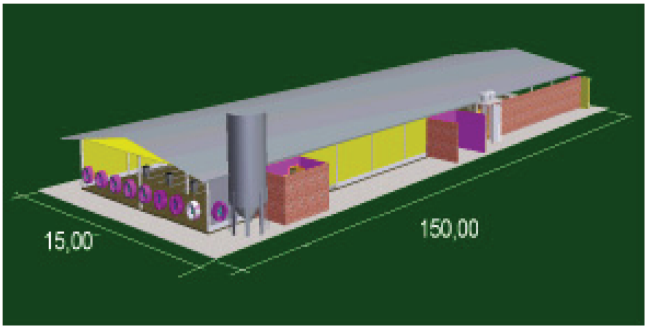

Figure 1. Mockup 3D commercial shed for creation of broilers.

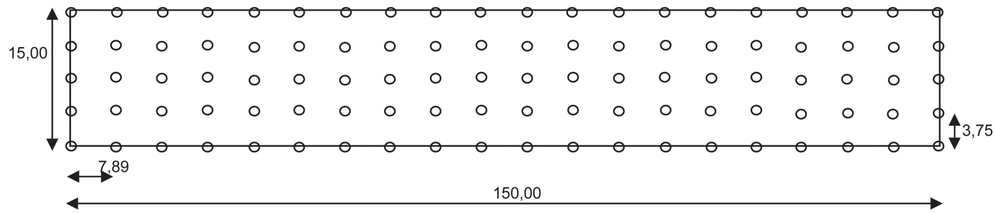

Figure 2. Points collection of environmental variables inside the shed, magnitudes in meters.

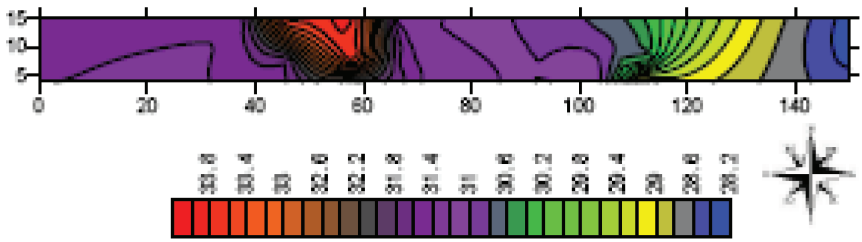

Figure 3. Spatial distribution of air temperature, Tair (°C) inside the shed.

variables were collected, with a distribution of a regular or homogeneous, with spacings of 3.75 m across the width and 7.89 m in the sense in length.

The collection was carried out systematically, moving from the west to east bedside, as opposed to the airflow generated by the ventilation system during the period specified. After positioning at each point were anticipated 10 s to stabilize the movements of birds and made concurrent collection of Tair (°C), RH (%) and noise (dB).

Geostatistical analysis was used to construct maps of spatial distribution of variables, from which it was viewed that the positions have more unfavorable conditions the worker to stay inside the hangar, due to the thermal stress verified.

2.1 *Use of geostatistics*

To describe the environmental variables, Tair (°C), RH (%) and noise level (dB), used the geostatistics technique based on the theory of regionalized variables (Goovaerts, 2001). The spatial dependence was analyzed by semi-variograms settings (Vieira, 2000), based on the assumption of stationarity (intrinsic event).

Thus, the coefficients of the theoretical model for the semivariogram (landing, C0 + C1; reach, the nugget effect, C0) were estimated. Were tested semivariagramas Spherical, exponential, linear, linear and Gaussian with porch (Souza et al., 2004th) adjusted by the GS + program. Statistical analysis was performed using the comparative study of the means (Tukey test, p-value ≤ 0.05) values of environmental variables measured by handheld devices, the points collected. To compose the hypothetical map of the distribution behavior of the variables for the same time, since the samples could only be performed sequentially, the means of each variable of the critical period of 12:00 were used to 16: 00 h. The average value found for Tair (°C) was adopted as the initial value in the most critical position found in the distribution of the differences of Tair (°C) map. And from this point, were traced to Tair (°C) of contiguous positions, calculated by numerical differences, resulting in a distribution map of hypothetical Tair (°C). The same was done for RH (%) and noise (dB).

3 RESULTS AND DISCUSSION

In Figure 3 it can be seen the distribution of ambient temperature or air inside the shed. There is a temperature range of about 6 °C, with a lower temperature located at the back of the shed on the east side, just at the entrance of air by evaporative cooling panel. The maximum temperatures observed are not considered unhealthy, after consultation with the NR-15.

On average, the values of relative humidity, RH, remained in the range considered to be of comfort to workers who are exercising management activities inside the shed, ie between 70 and 80%, as can be seen in Figure 4, which does not characterize how unhealthy environment, according to Standard NR-15 which deals with "unhealthy Activities and Operations." However, minimum and maximum values indicated that, in some periods of the day

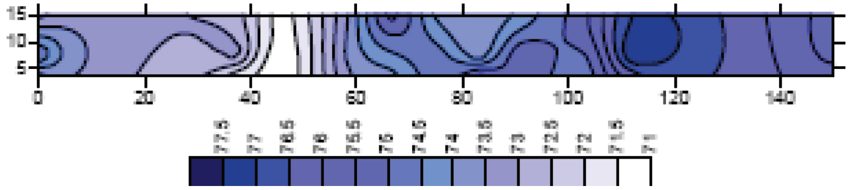

Figure 4. Spatial distribution of relative humidity, RH (%) inside the shed.

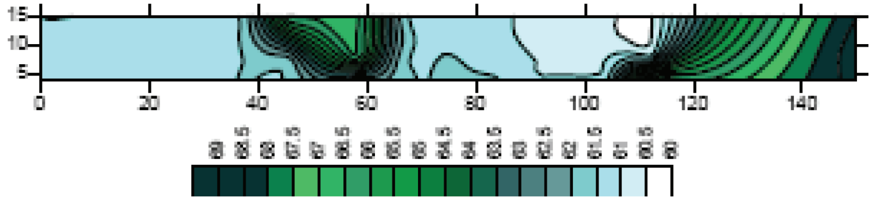

Figure 5. Spatial distribution of noise (dBA) inside the shed.

and in certain parts of the shed, lower and upper levels of the range of comfort RH were observed. With respect to the external environment, it is observed that the UR were lower than the median values of the installation.

In turn, the median values of noise were 68.7 dBA and externally to shed 64.2 dBA, as can be seen in Figure 5 being the highest values found closer to the exhaust.

4 CONCLUSIONS

Even during the hottest times of the day, between 12 and 16 h, and especially close to 14 h, it was found that much of the shed was in a state of thermal comfort, with no need to use cooling device, since UR is comfortable with values, according to the NR 15.

Although some results indicate no spatial dependence, we opted for the generation of maps in order to better visualize the environmental condition during activities performed inside the shed in the production, which can be seen in some time, workers were subjected to homogeneous environmental conditions.

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Heat stress for firemen in urban fire—case study Condeixa-a-Nova

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ABSTRACT: During a firefight, the fireman must wear his own personal protective equipment with the purpose of protecting himself from the various risks that he is exposed to. This study has the purpose to determine the relationship of the temperature that the firefighters are exposed to during their activities, that endangers or influences their physical and mental performance. The study was an observational, developed through literature review, conducting questionnaires to survey the 52 firefighters and temperature conditions that firefighters are subject in an urban fire. We use suitable equipment, monitoring heart function 2 professionals when exposed to elevated temperatures. The equipment used for the measurements were a Holter and the VelociCalc Air Velocity Meter. We can infer, through this study, that exposure to extreme temperatures has serious consequences at physiological level, in particular by affecting cardiac function.

1 INTRODUCTION

The thermal environment is one of the main factors that influence working conditions. Thermal comfort is when the individual expresses satisfaction with the thermal environment, being in equilibrium with the surrounding environment (Ferreira & Talaia, s.d.). Under normal conditions, the human body lying on thermal comfort while keeping approximately the temperature between +37°C –0.8°C by balancing the internal heat production and the heat loss to the environment (Sá, 1999). The thermoregulation of the human body is made through three different mechanisms: blood vessels, sweat and secretion of thermogenesis. Thus, the room temperature is important in determining the rate at which body heat is transferred to the environment and the facility with which the body can regulate and maintain its temperature. In addition to the foregoing, the ascent of the body above the comfort zone temperature can cause psychological problems (discomfort, malaise); psychophysiological (increased workload on the heart and circulatory system) and pathological (worsening of disease).

The firefighting is a physically demanding activity and imposes on firefighters situations of heat stress, which may contribute directly or indirectly to death. According to earlier studies, the firefighters have a higher incidence of heart disease and premature death phenomena often compared with other risk groups (Mourão & Gonçalves, s.d.). In order to prevent certain types of accidents, the firefighter must be found in excellent physical fitness (cardio-circulatory, respiratory, musculoskeletal and neurological) and mental fitness (Guerra, 2005; Mourão & Gonçalves, s.d.; Quintal, 2012). This study is aimed at determining whether the temperatures to which firefighters are exposed for an urban fire have some kind of consequence on their health.

2 MATERIAL AND METHODS

From the universe of firefighters in Portugal were selected as the target population, the Volunteer Firefighters Condeixa-a-Nova for this study. Regarding the level of this study was Level II (observational study). For collection of data, a questionnaire was conducted with a total of 24 questions: In 1st half the objective was to understand the characteristics of our sample in the

2nd half we tried to meet their habits, and understand the kind of perception that each has of the risks involved as well as the personal protective equipment used. The questionnaire was self-administered for a total of 52 firefighters, not any exclusion criteria were defined. At the end of these completed questionnaires were entered into IBM SPSS Statistics, aiming their statistical processing. Statistical tests were applied: Chi-square test of independence and ANOVA.

For the treatment of data regarding the rate of perception of quality of equipment, respondents had to evaluate the used equipment in several aspects (proper clothing, enough, flexible, easy to wear, adjustable, comfortable, safe and heavy), with a score of 1 to 10 (the higher the index the better perception of the equipment). For data collection equipment for measuring the temperature of the air velocity and Holter monitoring was used. A mock fire in a building with 3 firefighters, 2 male and 1 female was performed. The measurement performed with the Holter (heart rate) began to be made 20 minutes prior to being exposed to fire fighter each theater identical during the previous time and 20 minutes after such exposure, as the ambient temperature, making up in this scenario 1h measuring time. Temperature and air velocity assessments were made about 5 meters from the entrance of the container, and posteriorly in front door of the container. With regard to the measurements were not obtained the desired results because the equipment only had the capacity to measure up to 95°C, and error data from this value. The equipment for measuring temperature was VelociCalc Air Velocity Meter, model 9535/9535—A, Serial Number. T95351052004, Year Built: December 2010 Holter monitoring was used Schiller MT—101 Holter, serial number: 300.10806. Please note that guaranteed anonymity and confidentiality of the data collected during the study and this will only be done with academic interest and not submit any economic and financial interest.

3 RESULTS

With regard to the thermoregulatory mechanisms and hydration in order to avoid the occurrence of thermal stress in urban fire, we can see that most respondents firefighters (43 firefighters) had perception that the equipment used hampers evaporation of sweat, or equipment hinders the mechanisms of thermoregulation. On the other hand the majority of respondents were unaware of any firefighters cooling techniques of the body (15 firefighters know, 23 and 14 do not know do not know) however all firefighters put into practice various cooling techniques, without relating to this concept (use appropriate equipment, stripping the equipment as soon as possible, drink water, wet the body with water, use of shorts and t-shirt under the uniform nomex). A total of 46 firefighters said drink fluids after fighting a fire, thus causing a constant hydration and preventing the drastic rise in body temperature.

Table 1 summarizes the information about the number of firefighters (depending on your class) who have suffered episodes of disorientation during a fire. We can see in the table that most of the firemen, in any of the categories (a total of 43 firefighters—82,7%) is never suffered from problems of disorientation. Having only 5 firefighters (9,6%) claimed to have already suffered from problems of disorientation. In Table 2 it can be seen that in general, although there are no significant differences in perception of quality of equipment between the two groups, who are in a commanding position has a better perception of the quality of equipment that anyone who belongs to the active

Table 1. Description of the level of disorientation direction depending on the category of personal belonging.

Personal categoy	Disorintations			
	Yes	No	D.K./D.A.	Total
Command				
n	1	3	0	4
% line	25,0	75,0	0,0	100
% Total	1,9	5,8	0,0	7,7
Chief				
n	0	3	0	3
% line	0,0	100,0	0,0	100
% Total	0,0	5,8	0,0	5,8
Sub-Chief				
n	0	8	0	8
% line	0,0	100,0	0,0	100
% Total	0,0	15,4	0,0	15,4
Fireman 1				
n	1	7	0	8
% line	12,5	87,5	0,0	100
% Total	1,90	13,5	0,0	15,4
Fireman 2				
n	1	11	0	12
% line	8,3	91,7	0,0	100
% Total	1,90	21,2	0,0	23,1
Fireman 3				
n	2	11	4	17
% line	11,8	64,7	23,5	100
% Total	3,8	21,2	7,7	32,7
Total				
n	5	43	4	5
% line	9,6	82,7	7,7	100
% Total	9,6	82,7	7,7	100

Table 2. Perceived quality of personal protective equipment used.

	n	M	DP	F	gl	p-value
Appropriate clothing						
Command	4	7,75	2,217	1,290	1,50	0,261
Active staff	48	6,42	2,258			
Total	52	6,52	2,262			
Sufficient clothing						
Command	4	7,00	1,633	0,925	1,50	0,341
Active staff	48	5,85	2,325			
Total	52	5,94	2,287			
Flexible clothing						
Command	4	6,25	2,217	1,330	1,50	0,254
Active staff	48	5,02	2,037			
Total	52	5,12	2,055			
Easy wear clothing						
Command	4	7,25	1,708	2,225	1,50	0,142
Active staff	48	5,44	2,369			
Total	52	5,58	2,363			
Adjustable clothing						
Command	4	7,25	1,258	3,252	1,50	0,077
Active staff	48	5,21	2,221			
Total	52	5,37	2,223			
Comfortable clothing						
Command	4	7,50	0,577	5,034	1,50	0,029
Active staff	48	4,96	2,240			
Total	52	5,15	2,261			
Safe clothing						
Command	4	8,00	2,160	2,289	1,50	0,137
Active staff	48	6,25	2,227			
Total	52	6,38	2,251			
Heavy clothing						
Command	4	6,25	0,957	0,003	1,50	0,958
Active staff	48	6,19	2,331			
Total	52	6,19	2,250			

Legend: gl = degrees of freedom; M = average; DP = standard deviation.

staff. As regards the comfort of the equipment can observe significant differences.

In Table 3, which refers to the perception that firefighters have the stressful situations they are subject, we can see that the category of chiefs (90,9%), is one that admits pass more psychological stress situations. On firefighters, only 54.1% admitted to going through psychological stress in the activity, this value may be due to the fact that this category meet the firefighters with less experience and training, thus have a correct perception of the risks to which they are subject. A total of 61,5% of the firefighters claims to have been through psychological stress.

The tables below, the results obtained from the Holter for two firefighters reviews will be described. The selection was made by firefighters availability of existing in active staff.

Table 4 we can observe the heart rate before the firefighters to be in contact with the heat in contact with the heat and after the same contact.

Table 3. Perception of situations of psychological stress that each firefighter is subject.

	Stress situations			
Post	Yes	No	D.K./D.A.	Total
Command				
n	2	1	1	4
% line	50,0	25,0	25,0	100
% Total	3,8	1,9	1,9	7,7
Chief				
n	10	1	0	11
% line	90,9	17	0,0	100
% Total	19,2	1,9	0,0	21,2
Fireman				
n	20	17	0	37
% line	54,1	45,9%	0,0	100
% Total	38,5	32,7%	0,0	71,2
Total				
n	32	19	1	52
% line	61,5	36,5	1,9	100
% Total	61,5	36,5	1,9	100

Table 4. Results obtained from the ECG of Fireman 1 and Fireman 2.

	Fireman 1	Time	Fireman 2	Time
Time	1h	15h-16	1h	17h-18h
Heart rate				
Total heartbeat	9042		7419	
HR mín	106	15h 20	64	17h 07
HR medium	153		101	
HR máx	196	15h 37	160	17h 43
Tachycardia	40		10	
Sinusal rhythm				
HR mín	106	15h 20	64	17h 07
HR máx	196	15h 37	160	17h 43

These values have confirmed the fact that the contact with the heat causes changes in cardiac levels as mentioned above. Regarding heart rate, arrhythmias and tachycardias depending on the exposure we find that the periods of exposure was observed with higher heart rate (Fireman 1–152; Firefighter 2–125). Regarding the values of tachycardia, we can observe that the Firefighter 1 had 40 periods, 30 of which when exposed to heat. On the other hand the Firefighter 2 had only 10 periods, most of them (5 periods) at the time of exposure, so there is a little difference. In Firefighter 2 we can also observe a period of arrhythmia (SVPC—extra ventricular systole above) during the exposure period. These values as those in Table 5, that reinforce that exposure causes problems in cardiac levels.

4 DISCUSSION

Despite the Human being have the ability to regulate its own temperature, the ability to work in environments at elevated temperatures decreases considerably compared to low temperatures (Carter, et al., 2007). The body to be subjected to elevated temperatures may run the risk of going into thermal stress, if it is too represents a high risk to the body that can contract pathologies due to heat (Carter, et al., 2006). According to the results obtained from the questionnaires distributed to firefighter can see that, despite a general firefighter were satisfied with the quality of existing equipment, they also admit that they hinder the evaporation of sweat. When it vaporizes, causing cooling of the body temperature (Sharkey, 1999). Thus, once the equipment prevents the evaporation of sweat will impede heat loss through evaporation, increasing the temperature. Regarding cooling techniques, it can be seen that the vast majority said they did not know any, although the practice during a fire. This indicates that the most firefighters knows various techniques for cooling, not only those known as cooling techniques. Thus, it can be seen that all firefighters individually contribute to maintaining their body temperature, putting in practice several cooling techniques.

According to other studies, when fluid replacement is not performed properly, the rectal temperature rises continuously to exhaustion (Ferreira & Talaia, s.d.). The limit loss of sweating is 4 liters in 8 hours of working (or 0.5 every 30 minutes), so it should carry out a correct hydration over time whenever possible. According to the questionnaires, the majority of claims firefighters to a steady intake of liquid (water), thereby helping to hydration and temperature regulation. When analyzing the table referring to the problems of disorientation, we found that 82.7% say they have never suffered from problems of disorientation. This can be justified due to the fact that in instances where these operational work, there is a good personnel management and good control. Thus contributing to some who rarely gets to cases of extreme tiredness. By analyzing the data collected by Holter, it was found that only one of the measurements collected data for 1 minute, being thus reduced our sample to 2 firefighters. This became a limitation for the study because it prevented could make a correct evaluation of the results, due to the decreased sample. Beside cause heart attack and stroke, exposure to extreme heat can cause changes in blood pressure, blood thinning, cholesterol ratios and heart rate (Bem Estar, 2012). Recently, the heart rate began to be a risk factor especially when you have average values in the order of 90 or more beats per minute. By analyzing the data of 2 firefighters monitored, verified in general the two firefighters, who were no significant changes in cardiac levels to be in contact with heat. In Firefighter 1 shows that the mean heart rate increased from 148 to 152 to enter the fire site, and the number of periods of tachycardia was also higher. With regard to the second firefighter heart rate increased from 95 to 125 (very disparate values) to enter the site of fire, and had a total of 5 tachycardia during the exposure time. In the case of firefighter 1 it already has a high baseline heart rate, so that the increase was small, but has so much exposure as firefighter 2 which also has a high baseline heart rate and a greater increase, in short both firefighter´s have high baseline heart rates immediately increased cardiovascular risk. We conclude by analyzing these facts that exposure to environments that cause thermal stress can bring overload to the heart, thereby contributing to possible future heart problems.

5 CONCLUSIONS

According to this study we can conclude that exposure of firefighters to high temperatures can cause serious psychological problems (discomfort, malaise), psychophysiological (heart and respiratory overload) and pathological (worsening of disease). It should be noted that assessments were made by Holter in moments of rest and in simulated combat, what evidence that height where there are needs greater physical effort, and greater psychological stress overloads to be much larger cardiovascular system. Although there have not been frequent episodes of disorientation, you should never overlook safety and steady management that makes the whole team during a fire in order to contribute to the continued safety of firefighters. For best results, it is suggested that there is continuity of this study in the future in order to analyze and assess in greater depth the temperature to which firefighters are exposed in fact. Thus, we can realize a better way what is the capacity of thermal mitigation equipment, used and comparing the temperature outside and inside the uniform.

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Physical working performance in cold thermal environment: A short review

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ABSTRACT: Exposure to cold thermal environment is a significant risk factor in industrial activities, influencing the human physical performance. The aim of this work is to contribute with a short review on physical working performance of humans exposed to cold thermal environment, by classifying different studies conducted in that area. Using appropriated keywords and expressions, a short review of English articles has been done, by searching electronic databases. Only articles related to worker's physical performance while exposed to cold thermal environment were included. Ten experimental articles were included. The number of participants varied from 6 to 30 workers. The findings of this short review indicate that moderate and severe cold environment in general reduces physical performances. However the amount, level and quality should be enlarged, considering different tasks, both genders and exposure to different cold conditions.

1 INTRODUCTION

Exposure to cold environment is a significant risk factor in industrial activities, present in outdoor during the winter season and indoor present in all seasons (Tochihara, 2005). Indoor exposure in mostly related to working activities in the fresh food industry with temperatures from 0–10ºC and frozen goods at temperatures below –20ºC, while cold exposure in outdoor activities is present in occupations such as marine, army, agriculture, forestry, mining, factory work, construction work and related occupations (Mäkinen et al., 2006).

Outdoor exposure to cold is of particular interest for regions in high latitude environments where winter seasons last for several months (for example Finland with winter lasting for 3–7 months (Mäkinen, 2007)). The degree of exposure to cold is dependent on several factors such as occupation, gender, age, health, exercise activity, and education (Mäkinen, 2007). Exposure to cold thermal environment, increased muscular strain, different musculoskeletal complains and symptoms are common (Juha Oksa, Ducharme, & Rintamäki, 2002). The cooling of the tissues leads to discomfort, deterioration of performance and finally to work accidents (Mäkinen & Hassi, 2009).

There is a need to increase the quantity and quality of studies dealing with the effects of exposure to cold thermal environment on physical working performance. Although cold thermal environment is known to influence performance in all working activities, its real influence is unknown and requires further investigation. The aim of this work is to contribute with a short review on physical working performance of humans exposed to cold thermal environment, by classifying different studies conducted in that area.

2 METHODS

2.1 *Searching strategy*

The academic and clinic PRISMA Statement for Reporting Systematic Reviews and Meta-Analyses was used in creating and modeling of this article (Liberati et al., 2009). References were managed using Mendeley.

The process of creating the database of papers related to the area of cold thermal environment was divided into searching methods. The first searching method was to the Meta Search of databases. Access/login for searching databases was attempted by using the institutional IP address or University of Porto federate credentials. For searching purposes, keywords were defined, afterward to be expanded to expressions and terms created by their combination as follows: "cold environment & ergonomic",: "cold environment & health problems", "low temperature & health problems", "occupational disease & cold environment", "professional disease & cold environment" and "cold environment & biomechanics".

After defining keywords combinations to use in queries, two electronic database types were

Table 1. Selected articles: the summary in order of level of evidence, with main data and characteristics.

Reference/year	Subjects	Gender/age	Temperatures	Conclusion
1. (Wiggen et al., 2011)	12	Male/mean 23	22°C, 5°C, –5°C, –15°C, –25°C	During low work intensity the current protective clothing at a given cold exposure leads to lowered body and skin temperatures, especially in the extremities, and to reduced manual performance when wearers are exposed to ambient temperature conditions of –5°C or lower. Finger temperature was found to be an important indicator of hand and finger dexterity. The study suggests that a finger skin temperature below 20°C result in impaired manual performances.
2. (Muller et al., 2011)	14	Male/mean 21	5 ± 1°C	Finger temperature influence subjective perception of pain and lower manual performance in moderate cold.
3. (Leppäluoto et al., 2014)	6	Male/mean 21	10°C	When the cold air exposures were repeated daily, thermal sensations became habituated first. Hand, foot, and general thermal sensations already became warmer after the first exposure.
4. (Chen, Shih, & Chi, 2010b)	24	Male and female/mean 25, 24 years	34°C water and 11°C water	Gross and fine hand dexterity, grip strength, and muscular activity were found to be positively correlated to skin temperature.
5. (Clark & Jones, 1962)	30	*n.a.	–12°C	There appeared to be three sets of factors influencing the warm-up scores: the inhibition resulting from 2 days without practice; the mechanical facilitation associated with warm flexible hands; the inhibition produced by changing the thermal aspect of the stimulus complex eliciting the manual responses.
6. (J Oksa et al., 1997)	8	Male/mean 31 years	27°C, 20°C, 15°C and 10°C	Low level of cooling was sufficient to decrease muscle performance. The results showed a dose-dependent response between the degree of cooling and the amount of decrease in muscle performance.
7. (Holewijn & Heus, 1992)	9	Male/18–24 years	15°C water and 40°C water	There is a significant reduction in isometric force due to cooling of the muscle. Cooling the arm at 15°C reduced the maximal grip frequency by 50%. Cooling the muscle did not affect endurance time compared to that at 32°C.
8. (Ozaki et al., 2001)	13	Male/ mean 20 years	20°C, 10°C –25°C,	Exposure to severe cold at night had an asymptomatic effect on workers that decreased both their rectal temperature and their manual performance.
9. (Juha Oksa et al., 2002)	8	Male/mean 31 years	25°C and 5°C	Forearm blood flow during systemic cooling was significantly lower. Repetitive work in the cold causes higher muscular activity and fatigue of forearm muscles than in thermo-neutral conditions.
10. (Chi, Shih, & Chen, 2012b)	24	Male and female/mean 25 and 24 years	34°C water and 11°C water	Finger skin temperature dropped about 20°C after 40 min of cold immersion at 11°C, and cold adaptation ceased the perceived discomfort even when the hand skin temperature, the **MVC declined further. On the other hand, warm immersion increased the skin temperature, muscular activity, and the MVC. The MVC resumed its baseline after 5 minutes of warm immersion which indicated full recovery of muscle fatigue.

*n.a.—not applicable.
**MVC—maximal voluntary contraction.

searched: "E-Journal" and "Index". In addition to the Meta Search, databases Informaworld (Taylor and Francis) and MEDLINE were searched thoroughly by using keywords and expressions: "cold" crossing with other keywords "musculoskeletal", "MSD", "knee injury", "shoulder injury", "lower back injury", "neck injury", "wrist injury", "hand injury", "elbow injury", and: "cold temperature" and "cardiovascular", "heart" and "cold temperature", "food industry" and "cold temperature", "construction industry" and "cold temperature", "cardiovascular disease" and "cold temperature". In addition, databases "PubMed", "PsycArticles" and "BioMed Central Journals" were searched thoroughly by using keywords and expressions: "cold exposure" crossing with the keyword "work".

2.2 *Inclusion criteria*

Articles were eligible if they met the criteria of being related with physical working performance in cold thermal environment. Articles published before 2000 were not considered in the Meta search, although articles found as references of chosen articles, that were published before 2000 and were strongly connected with the objective were included. Only articles published in English language were included.

3 RESULTS

In the identification process, the Meta Search resulted with 7349 articles, searched through electronic databases: IEEE Xplore, Informaworld (Taylor and Francis), PubMed, SCOPUS and Web of Science. The review of articles identified through database searching was restricted to articles published after 2000. Repeated articles and articles without an author name were excluded. Afterward, 2364 articles were excluded by screening articles titles. If article's abstracts were not related with physical working performance in cold thermal environment, they were excluded. Additional searching process was conducted by using Google Scholar, through which 45 more articles were found.

In total, 90 articles were assessed in a full-text version and screened thoroughly. Full-text articles were excluded if they were not related to physical working performance in cold thermal environment; if abstracts didn't have crucial parts as background, objective, methodology, results, discussion and conclusion; if objectives were not well defined; if the experimental methodology was not enough specified; if conclusions were made without any connection to experiment outcomes.

Finally, 10 articles were included in this short review, shown in the Figure 1. Included articles were

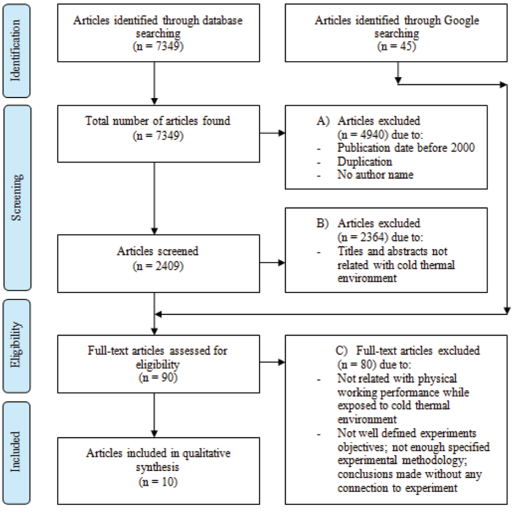

Figure 1. Selection of studies: summary of studies in order of level of evidence, with extracted data.

published between 1962 and 2014. Main results of this short review are shown in the Table 1.

4 DISCUSSION

Exposure to cold air temperatures was found to reduce physical working performance, increasing fatigue and lowering performance of muscles (Muller et al., 2011; J Oksa, Rintamäki, & Rissanen, 1997; Juha Oksa et al., 2002; Ozaki, Nagai, & Tochihara, 2001), reducing maximal grip frequency (Holewijn & Heus, 1992), hand and finger dexterity and grip strength which leads to impaired manual performance (Chen, Shih, & Chi, 2010a; Chi, Shih, & Chen, 2012a; Wiggen, Heen, Færevik, & Reinertsen, 2011) and maximal voluntary contraction (Chi et al., 2012a).

While it could be understandable to have just male volunteers for some industries and working activities such as for example the construction industry, there are many industries where a high percentage of female workers is found, such as in the food industry. Therefore, there is a need to conduct experiments considering both genders and differently aged groups. Although cold thermal environment is known to influence physical performance, its real influence is unknown and requires further investigation. More experiments should be conducted in different cold thermal environment temperatures, with different relative humidity and air movement (moderate and severe cold), and considering different tasks, on non-habituated and on habituated subjects, both genders, differently aged and physically healthy subjects (without bias factors mentioned in the section "limitations") for making consistent conclusions on physical performances while exposed to cold thermal environment.

5 LIMITATIONS

This study has several limitations. One of them is that not all of the bias factors were taken into consideration in chosen articles: sleeping hours, alcohol consumption, eating spices food, drinking coffee and tea, physical exertion, medicine taking and smoking cigarettes. Controlling those biases might improve results and therefore conclusions from the experiments. The phase of the menstrual cycle of female volunteers was not taken into consideration. A common limitation relies on voluntary participation, due to self-selection of the study members.

6 CONCLUSIONS

The findings of this short review indicate that moderate and severe cold thermal environment reduces skin body temperature and therefore physical working performance, lower muscle performance, maximal grip frequency and grip strength, hand and finger dexterity, maximal voluntary contraction, while increase muscle fatigue. Experiments should be conducted on non-habituated and on habituated subjects, taking in consideration different tasks, both genders, differently aged subjects, with different time exposure in order to get consistent conclusion on physical performances.

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Ergonomic analysis—case study of passenger transport company

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ABSTRACT: Ergonomics is the science that allows you to adjust the workplace to man, in order to ensure efficiency and welfare directly. Aimed at the relationship between man and his environment, optimizing the working conditions. The objective of this study was to conduct an ergonomic analysis to the official sector, working out some measures to improve the quality of jobs. The study was carried out through an ergonomic analysis on site, using the methodology REBA to analyze the tasks of existing activities in the official sector. Administered questionnaires to employees with issues relating to personal data, historical process of progressive scale and local discomfort or pain. The results obtained indicate that a large part of the tasks of each activity, were an assessment of high risk and very high, requiring implementation of preventive measures (ex: more lightning points).

1 INTRODUCTION

With the progress of time, technology has been introduced and improved in the world of work, in order to help workers to perform their tasks. Stress factors and musculoskeletal lesions are the main diseases that relate to the work (Carneiro, 2005).

Studies carried out indicate an incompatibility between the dimensions of the furniture and the anthropometric measurements of its users, evidencing the musculoskeletal system disorders as well as derogatory effects the cognitive level and low productivity (Sousa, 2013). Concerning the automobile industry this is referred to as having ergonomic due to unfavorable postures and repetitive work (Lick, 2003). To avoid musculoskeletal lesions, stress and work-related symptoms (Tozzi, 1999), the work conditions and postures should be exhaustively analyzed in order to minimize and restrain the risks to the worker's health and their activity (Marziale & Carvalho, 1998).

Therefore, it can be performed ergonomic analysis consisting of various stages of intervention, such as field observation as well understanding and studying complaining about work conditions and finally as implementing new methods learned from new studies involving ergonomic postures, to improve the physical and psychosocial conditions to the worker (Marziale & Carvalho, 1998). Some of variables that must be studied are the worker, machine, work's space, the physical environment and the organization of work (Pinto, 2009).

The objective of this study consisted in carrying out an evaluation at the level of ergonomic postures to passenger transport shops, featuring some corrective measures to improve the conditions of the workplace.

2 MATERIAL AND METHODS

The location of the study for the current work was a public transport company, headquartered in the region of Coimbra, having as target population workers employed on the company. This sector consists of mechanics, auto electricians, lubricators, tires managers, locksmiths, lathe operator, warehouse technicians and painters. The type of sampling was probabilistic, not once the technique is used for convenience. The sample was composed of 33 workers and by 46 tasks.

We used a retrospective cohort study through observational drawing. The nature of the study consists in the identification of ergonomic risks to which workers in the workshop of a passenger transportation company are exposed during the various carried out activities. In order to cover all these activities it was performed a set of ergonomic evaluations.

For collecting data, it was defined two types of tools: questionnaires and semi structured ergonomic assessment (risk assessment and evaluation of luminance).

The questionnaire, was based on questionnaires of other authors (Luís, 2009), to support ergonomic analysis, included, historical issues in the workplace and a progressive scale of discomfort or pain where the worker stated to 1 the 5 (no pain to a pain intolerable) the intensity you feel in every part of the body (Lima, et al., 2014).

This research was carried out between September (2013) and June (2014) and the data was collected during the months of January to March. Ergonomic analysis was performed by the investigator and each worker observed twice considering workers switching shifts.

Regarding the ergonomic evaluation, has been a risk assessment using the methodology REBA (Rapid Entire Body Assessment), since this has as main objective the determination of the effect caused by inadequate postures and attitudes of workers. On the end of the analysis the levels of risks and the necessary interventions were evaluated according to the following interpretation: Level 1—Negligible risk; Level 2—Low risk (need to some preventative measures); Level 3—Medium risk (the risk must be investigated in depth; create preventive measures); Level 4—High risk (investigate the risk and implement corrective measures); Level 5—Very high risk (implement corrective measures) (Junior, 2006).

For the evaluation of luminance, it was used the following instrument: Luximeter HD model 9221, brand OHM. For this evaluation it was performed various measurements on workplaces, and the average calculated. The values were subsequently compared with the standard EN 12464-1: 2011-06 to verify its compliance.

After collecting the data, the same have been worked in the software Ergofellow 3.0, Microsoft Excel and IBM SPSS statistics software SPSS version 22.0. The test applied to this study was the Fisher exact test.

3 RESULTS

In order to deepen the study, a descriptive analysis was carried out to characterize the sample. The activities belonging to the workshop were grouped into warehouse technician; technical assistant; auto electrician; Oiler; mechanic; locksmith and other activities (painter, lathe operator and tire manager) to better characterize the Group of respondents.

Of the 33 respondents, it was found that 19 have suffered accidents at work, being the vast majority belonging to the mechanical activity (42,1%). One of the issues of the investigation "During the course of his business, in the last year, ever felt discomfort or pain?" 23 of 33 respondents answered affirmatively, being the most hit, mechanics (30,4%). It was noticed that, of the 23 respondents who answered "Yes" to the previous question, 17 reported that the pains were applicants. Since it is important to rest during the labor period it was found that 69,7% of respondents breaks are at least 5 minutes.

Asked about work accidents, pain or discomfort, there has been a tendency in the affirmative answers for the presence of pain. This tends to focus on the region of the "upper back", "medium" and "back-bottom", The "neck" had a statistically significant difference (*p-value* ≤ 0,05), that is the difference in responses about whether suffered accidents at work or not.

In Table 1 it is possible to verify that the activities of the mechanical activity evident with high risk and very high are those indicated in the table. It should be noted that the task "disk change" is

Table 1. Risk assessment concerning the mechanical activity.

Activity: Mechanical Tasks	N	Time (hours)	Neck (1–3)	Trunk (1–5)	Legs (1–4)	Arms (1–6)	Forearm (1–2)	Hand (1–3)	Weight (0–2)	Take ((0–3)	Activity (1–3)	Total (1–15)
Eliminate diesel leak	1	[4–8[	2	3	2	4	2	2	0	0	1	9
Repair of motor	1	>8 *	2	3	2	2	1	3	1	0	2	8
Compressor repair	1	[2–4[	3	4	2	4	2	1	0	0	1	10
Disk change	1	>8 *	3	4	4	3	2	3	0	0	1	12
Brave shims	1	<1	3	3	3	2	1	1	1	0	1	9
Maintenance of motor	1	<1	3	4	4	3	2	2	0	0	2	12
Placement of rim	1	<1	3	3	2	3	2	2	0	0	1	9
Placement of suspension	1	[2–4[	3	3	4	4	2	1	0	0	1	11
Detect oil leak	1	[2–4[	3	3	3	4	2	2	0	0	0	10
Disassembly of arm extension	1	[1–2[	3	5	4	3	1	2	0	0	1	11
Removing the windshield brushes	1	[1–2[	3	3	3	4	2	2	0	0	1	11

* > work 12 hours.

an activity that takes more than 12:0 am running). The remaining tasks were medium risk of ergonomic assessment. In relation to reference values for lighting in this activity the Rank 1 registered much lower values to admitted, being the average of 32.2 lux with fixed bar lighting. However, the stand 2 to introduce portable Chinning bar lighting showed an average of 411 lux with values permitted for the workstation (300 lux).

In Table 2 can verify that all tasks related to the tires managers are among the very high risk and high risk. Showing the tasks of "dismount" and "mount wheel", with a possible 15. The levels of luminance of this activity, shows the rank 2 with an average of 15.3 lux in a location without lighting and conducive to shadow situations corresponding to values well below the reference value (300 lux).

Regarding auto electrician activity, it was found that there are tasks with a level of medium and high ergonomic risk (Table 3), highlighting tasks such as "repair of suspension", with the high level of risk. As for the lighting level, this registers an average of 153.8 lux, value below the reference value (300 lux) having fixed bars fixtures.

For the lathe operator, the tasks under consideration, was the task of cutting pipe bars "presented a very high level of ergonomic risk (Table 4). As for the luminance on jobs, both posts are below the reference value, and the rank 1 is close to the reference value.

Regarding the activity of lubricator it was found that the level of risk of most tasks is average with the exception of the task "checking oils on the wheels" in which the level of ergonomic risk is very high, IE is situated on 12 points.

Concerning the activity of painter, it turns out that the task "polishing and painting" meets an ergonomic risk level of 8, i.e. high.

In the activity of locksmith, reached levels of high risk and very high, demonstrating the task of cementing cracks in the roof. The remaining tasks were medium risk level and low risk. All jobs have lower values of luminance, in relation to the reference value (500 lux), distinguishing the rank 3 with an average of 158.5 lux.

In relation to the activity of warehouse, the task of "customer service" was the one that presented a high level of risk with 8 points. The task of

Table 2. Risk assessment concerning the activity of tire manager.

Activity: Tire managers Tasks	N	Time (hours)	Neck (1–3)	Trunk (1–5)	Legs (1–4)	Arms (1–6)	Forearm (1–2)	Hand (1–3)	Weight (0–2)	Take (0–3)	Activity (1–3)	Total (1–15)
Taking out the screws	2	<1	3	4	2	2	3	1	3	0	2	13
Dismount wheel	2	<1	3	5	3	3	1	2	3	0	2	14
Scroll wheel	1	<1	1	2	2	2	1	2	3	0	2	8
Mount wheel	1	<1	3	4	2	3	2	2	3	0	2	14
Tighten wheel	1	<1	2	3	3	3	1	2	3	0	2	12

Table 3. Risk assessment concerning the activity of auto electrician.

Activity: Auto electrician Tasks	N	Time (hours)	Neck (1–3)	Trunk (1–5)	Legs (1–4)	Arms (1–6)	Forearm (1–2)	Hand (1–3)	Weight (0–2)	Take (0–3)	Activity (1–3)	Total (1–15)
Placement of wiring in the engine	1	>8 *	3	4	3	0	2	1	2	0	1	9
Change light bulbs	1	<1	2	5	2	0	3	2	2	0	1	10
Suspension repair	1	>8 *	2	3	3	1	4	1	2	0	1	10

* > work 12 hours.

Table 4. Risk assessment concerning the activity of lathe.

Activity: Lathe operator Tasks	N	Time (hours)	Neck (1–3)	Trunk (1–5)	Legs (1–4)	Arms (1–6)	Forearm (1–2)	Hand (1–3)	Weight (0–2)	Take (0–3)	Activity (1–3)	Total (1–15)
Cut tubing bars	1	[2–4[	3	4	3	0	4	2	2	0	1	11
Cut material at roulette	1	[1–2[	1	3	3	0	3	1	2	0	1	6

Table 5. Evaluation of risks related to the activity of locksmith.

Activity: Locksmith Tasks	N	Time (hours)	Neck (1–3)	Trunk (1–5)	Legs (1–4)	Arms (1–6)	Forearm (1–2)	Hand (1–3)	Weight (0–2)	Take (0–3)	Activity (1–3)	Total (1–15)
Repairing cracks on the roof	1	[2–4[	2	5	4	3	3	1	2	0	1	11
Repair sticks	1	>8 *	2	3	2	3	3	2	2	0	2	8
Axis preparation	1	[2–4[	3	4	2	3	3	1	3	1	2	10
Grinding lathe parts	1	[2–4[	3	4	4	2	1	3	0	0	1	10

"gathering material" presented medium risk, IE 7 points. Both points of measurement of luminance values were below the reference value by highlighting the area of the counter with a average value of 185.1 lux.

Regarding to ergonomic analysis of the tasks it is an established fact that 2.17% feature low risk, medium risk level 33.33%, 35.71% high level of risk and very high risk level 28.57.

According to EN 12464-1: 2011-06, the luminance values showed in most jobs values under intended showing the jobs of mechanic working in the pit to register tire operator and lux 32.2 in place of shadow with 15.3 lux.

4 DISCUSSION

Musculoskeletal problems are injuries that may be a consequence of an accident at work. Therefore, this study revealed that the vast majority of workers at the shop, shown more symptoms of pain or discomfort in the area of the back and cervical region. In many work tasks performed daily, the column is maintained in stress (axial rotation) which becomes a factor conductive to situations of low back pain and degenerative lesions of the disks (Bolonha, et al., 2012).

Workers in the present study are inserted as risk group, because there are based on manual tasks and most of these contain repetitive movements. In the course of the study it was found that the workers are not performed enough breaks compared to the tasks carried out, besides of the enough breaks they should perform stretching exercises for decompression of the muscles.

In the course of study was performed an assessment a few ergonomic tasks, in order to analyze, diagnose and correct certain situations on workstation (Concicovski, et al., 2010). It turns out that the vast majority of the activities were a high level of ergonomic risk (35.71).

In this way should be urgently implemented corrective action/preventive for reducing the risk level of jobs. Should be placed more points of enlightenment or change some tiles for transparent tiles; equipment and tools for easy handling; auxiliary equipment for removal and installation of wheels on the bus; transport system of wheels, other tools and heavy equipment, training, information and awareness of employees with regard to the risks to which they are exposed.

With the ergonomic assessment method, you can verify that the trunk and neck area in all activities are those that hit mainly the maximum values, relating the effort made during the task corresponding to areas of discomfort or pain for workers (Serranheira & Uva, 2006). Some activities carry small loads manuals transport (ex: tires managers) as the transport wheels of 80 kg and the postures in all sectors, repetitive motions, applying excessive force in hands and exposure to vibration (Veiga & Cabral, 2005), indicate that all tasks show high levels of risk.

An assessment was conducted of luminance, once in the course of the study many workers complained of the lack of visibility. In fact all the locations shown values below the stipulated under legislation. Therefore, it is important to implement new measures to correct this situation (Nunes, et al., 2013).

It is possible to verify that this activity can be placed as a group of workers with high risk.

5 CONCLUSION

In the course of the work it has been observed that many workers complain of pain or discomfort in the neck and back, arising from the physical effort made during the performance of the tasks and consequently may arise musculoskeletal injuries. The perception of pain/discomfort is related to the results of the evaluation of ergonomic risk. These state that most workers are exposed to high and very high levels of risk, and the variable that influences the level of risk is spine and neck. It is concluded that some of the jobs are conditioned by reduced visibility, this factor can be one of the causes of incorrect postures, especially when, in itself, the tasks require the postures. That's how important being carried out measures of correction/implementation to reduce risk levels.

The present study had minor limitations, since the sample could be more representative to check how is the high level of risk and very high in many tasks. Sometimes, on different days the worker's attitude can be changed. But as the period of evaluation was small, it was not possible the repetition of many tasks. For best results we suggest the continuity of this study, in order to apply methodologies relating to the manual handling of loads, new risk assessments of proposed measures and draw up measures to prevent listing more exhaustive. It's still important that they are made available to workers, training actions in relation to workplace attitudes and methods getting better. These, to meet improvements in health and consequently best quality of life and possible encouragement to their colleagues to fulfill some measures.

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Mercury emissions, hazards and preventive measures: A review

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ABSTRACT: The impact of mercury emission on environment by natural and anthropogenic sources makes the global village worried recently. In particularly, in Europe, its level of emission is quite high due to power plants and their industrial processes. Thus, more attention is paid to it on account of its potential hazard for workers and environment. It is vital that its level of pollution should be decreased by emission sources. The paper highlights the basic mercury sources in Europe. It also provides details about transportation of mercury into human body via different systems. Moreover, the associated hazards and preventive steps are widely discussed. Finally, mercury removal technologies are presented.

1 INTRODUCTION

In the last decades, a great attention is paid to environment quality which reflects the level of the environment condition (Mrugalska 2013, Kawecka-Endler & Mrugalska 2014) and its influence on human health, comfort, and psychological state (Górny 2014, Mrugalska 2014). Modern companies and individuals have become really interested in minimizing their negative impact on environment taking up environmental friendly actions (Jasiulewicz-Kaczmarek 2013, Nazir et al. 2013, Nazir & Manca 2014, Nazir et al. 2014). In spite of this fact, there are still many harmful substances emitted into soil and air.

One of the most hazardous heavy metal emitted to the atmosphere due to its toxicity is mercury. It is released to environment naturally and through human activities in three forms such as elemental (Hg^0), oxidized (Hg^{2+}) and particulate (Hg^p). The examples of natural emission source are emission from ocean and volcanic eruptions, whereas, fuels used for energy production and raw materials used in industrial processes are anthropogenic source of mercury (Pacyna et al. 2006, Pirrone et al. 2010). The latest data revealed that the global pool of mercury mainly results from anthropogenic emissions (Nelson et al. 2012). The major contributions are the following: fossil-fuel fired power plants (810 $Mg \cdot yr^{-1}$), artisanal small scale gold mining (400 $Mg \cdot yr^{-1}$), non-ferrous metals manufacturing (310 $Mg \cdot yr^{-1}$), cement production (236 $Mg \cdot yr^{-1}$), waste disposal (187 $Mg \cdot yr^{-1}$) and caustic soda production (163 $Mg \cdot yr^{-1}$) (Pirrone et al. 2010).

This paper highlights the problem of mercury emissions in Europe. It also discusses the issues of transportation of mercury via human body and presents health hazards and their preventive actions. Finally, the limitations of existing technologies along with emerging technologies are widely summarized.

2 MERCURY SOURCES IN EUROPE

According to the statistical data, the burning of coal for energy production is estimated to be the major source of mercury in Europe as in 2010, 87.5 tons of this metal was emitted into the air, followed by non-ferrous metal industries and cement production. (UNEP 2013). The iron and steel, chlor-alkali production, oil and gas refineries and product waste were indicated as the other main contributors of mercury emission in Europe

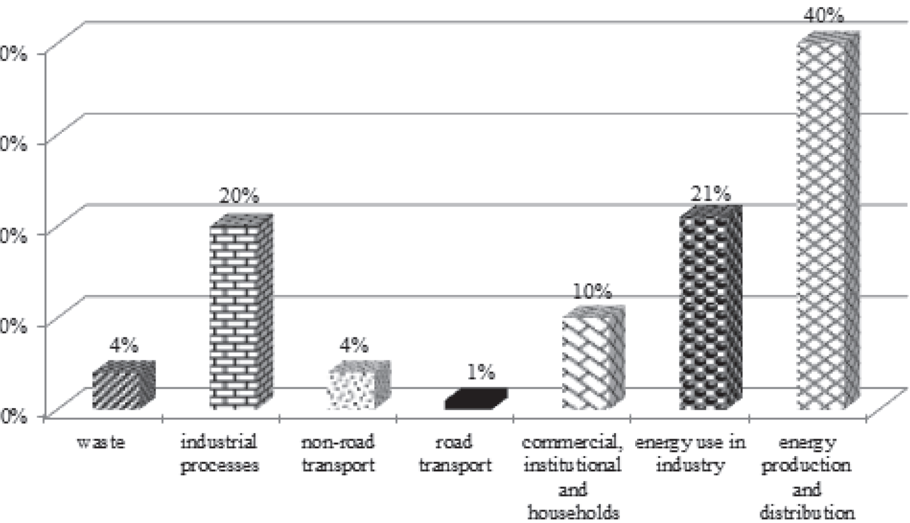

Figure 1. Mercury emissions in EU-27 (EPA 2013).

(UNEP 2013). Figure 1 shows the contribution of mercury to total EU-27 emissions in relevance to particular sectors (EPA 2013).

It is worth to emphasize that mercury emissions depend on spatial scales, its chemical formulation in which they are emitted i-e Hg^0 in gaseous form can remain in the atmosphere for up to a year, transporting globally, whereas Hg^{2+} and Hg^p are short lived, resulting in localized deposition. For example, in industrial areas of Europe, the deposition of mercury emissions from European sources constitute up to 60%, whereas in the Mediterranean area it is 20% or even less (Elsie 2013). Furthermore, the data show that the growing population and expansion of industrial sector will influence the increase of the demand for energy. Thus, in the nearest future, the growth of the mercury emission through anthropogenic sources is expected, mainly due to power generation using coal and natural gas.

3 TRANSPORTATION OF MERCURY AND HEALTH ISSUES

Mercury is mainly identified in three distinct forms in flue gas of coal power plant such as: (Hg^0), (Hg^{2+}) and (Hg^p) (Pavlish et al. 2003). The Hg^{2+} and Hg^p are soluble in water and hence they are deposited on a local and regional scale, whereas Hg^0 is present in vapour phase what enables its transportation worldwide (Rao 2010). As it settles in the water bodies, it is converted to a highly toxic compound called Methylmercury (MeHg). MeHg bio accumulates in the bodies of aquatic animals, so people are exposed to it mainly by consuming contaminated fish and sea food. However, the main exposure to MeHg is not only restricted to fish, but also to rice meals (Feng et al. 2007). It is the rice which could assimilate and accumulate MeHg even on the level as high as 174 µg/kg (Qiu et al. 2008).

In industrial settings such as chlor-alkali and power generation plants, workers and local residents are also likely be exposed to mercury through the respiratory tract (Li et al. 2009, Zahir et al. 2005). In humans, approximately 80% of mercury vapour (Hg^0) is readily absorbed through the respiratory tract, but only 0.01% by the gastrointestinal tract and to a limited extent via the skin (0.024 ng Hg/cm^2 skin per 1 mg Hg/m^3 present in air) (Holmes et al. 2009). When this vapour is absorbed, it is distributed to fat-rich tissues. However, its great lipophilicity enables its easy transfer across placental and blood-brain barriers. On the other hand, its inorganic forms allow to reach most of human organs, but low lipophilicity limits their ability to penetrate the blood-brain and placental barriers (Holmes et al. 2009). The impact of mercury toxicity on various organ systems is presented in Table 1.

However, there are many factors which determine the level of severity of the expose of mercury on human health. Among the most crucial ones, the following can be determined:

– the chemical form,
– the dose,
– the age of the person exposed,
– the duration of exposure,

Table 1. Mercury toxicity on various organ systems (Zahir et al. 2005).

Type of system	Examples of health problems
Nervous system	Memory and vision loss, insomnia, lack of attention, hypoesthesia, ataxia, dysarthria, tremor, increased fatigue, neuromuscular effects, headaches, cognitive dysfunction, mental retardation, ataxia, cerebral palsy, seizures, vision and hearing loss, delayed developmental milestones, language disorders, visual spatial abilities, and memory deficit in language, memory and attention, autism, spatial cognition
Motor system	Decreased muscular strength, increased tiredness, problems with motor function
Renal system	Increase of plasma creatinine level
Cardiovascular system	Alternation of normal cardiovascular homoeostasis
Immune system	Decrease of overall immunity of the body, exacerbation of lupus
Reproductive system	Decrease of fertility in both males and females, fetus, birth defects: microcephaly, cerebral palsy, severe mental retardation, seizure disorders, blindness, deafness, malformations

Table 2. Mercury removal systems with their limitations.

Mercury removal systems	Limitations
Adsorption on activated carbon	Less capacity, cheap but bulk quantity of adsorbent required, handling problem
Sulphur impregnated carbon	Less efficient and lose of sulfur in contact with liquid hydrocarbons
Adsorption on molecular sieve	Low capacity, big beds, poor performance and unloading difficulties
Oxidizing solutions-potassium permanganate, sodium hypochlorite, and sodium vanadate	Regeneration problems, system contamination, not capable to deal with all forms of mercury
Acid absorption of mercury-acidic permanganate and chromic acid	Increased corrosion, low saturations, system contamination, less efficient
Chemical reaction with H_2S	Increased corrosion, limited H_2S access, impact on marketing
Condensation and separation	Poor removal efficiency: liquid contamination
Metal sulfide alumina	Only capable of Hg^0 removal, pre-treatment required if other forms of mercury present in the feed

– the route of exposure,
– the state of health (http://www.epa.gov/mercury/effects.htm).

So, the health of people exposed to mercury will depend on its various forms and different circumstances.

4 PATHWAYS FOR REDUCING MERCURY HAZARDS

As the impact of mercury on human health is enormous there is a need to take preventive steps to reduce mercury hazards in the environment. For this aim it is advisable that the governments of most mercury emitted countries should establish strict legal regulations. Following them industrial units should monitor its level to the limit set by EPA. Moreover, the proper disposal of mercury garbage should be practiced. It is also advised that non-mercury technology in chemical industry and mining should be practiced. Furthermore, efficient and cost effective technologies must be developed and practiced to reduce mercury emission through power plants. To meet energy demands, renewable energy sources should be exploited such as wind energy, solar energy and geothermal energy. On the other hand, plant operators should be educated and trained, especially in Asia, as now they are not much aware of dealing with mercury emission in environment. Therefore, proper health and safety program is required to be established. The advanced training methods may also speed up the learning process. Proper safety and preventive measures should be followed before and during changing the mercury adsorbent; The unloading of spent bed should be under inert environment (no presence of oxygen as elimination of O_2 ingress would prevent chain of reactions that lead to heat and toxic gas release) i.e. unloading under positive N_2. The usage of tent/shed on mercury removal unit can prevent the entering of water during rainy days. The bed temperature should be noted after each 30 minutes during unloading activity. The external pyrophoric oxidation and heat release can be prevented by soaking the spent adsorbent (activated carbon) in half filled disposal drums with water (Ismail 2011).

5 PROGRESS IN MERCURY REMOVAL TECHNOLOGIES

At present, a number of technologies and products, which meet the specifications for downstream processing, are commercially available. However, not all systems are capable of treating the full range of mercury emissions in a single action (Mahpuzah Abai 2011). The limitations of some of mercury removal technologies are summarized in Table 2.

In the case of petroleum gas and liquid feeds the usage of activated carbon impregnated with a catalyst, e.g. sulphur (for gasses) or iodide (for liquids) is very often practiced (O'Dowd et al. 2006). Moreover, it is also proven that ionic liquids, particularly Solid Supported Ionic Liquids (SSILs), can capture all types of mercury in a single step more efficiently than other techniques (Mahpuzah Abai 2011). SSILs can adsorb mercury three times more than other commercially available adsorbents even without modifications to the plant infrastructure (Shariff 2011).

6 CONCLUSIONS

The increase in mercury emissions through anthropogenic sources is a challenge for the modern society where environment condition is a vital and crucial issue. The level of mercury emission is quite high in Europe so it is advisable to take up activities which can help to reduce its impact. Currently, the best effective methods to reduce the mercury emissions in the environment are based on the capture of it from emission sources. SSILs seem to be the best available technology to adopt for mercury removal efficiently.

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Risk assessment of work-related musculoskeletal disorders at a workplace from metalworking industry

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ABSTRACT: With constant changes at work, industries demands workers to perform small movements with high frequencies. The repetitive movements are frequently present in metalworking industry and constitute an important Work-Related Upper Limb Musculoskeletal Disorders (WRMSD) risk factor. The main goals of this study were: (i) assess the risk of developing WRMSD, by applying the method Rapid Upper Limbs Assessment (RULA); (ii) suggest possible preventive measures; (iii) with RULA action level results, rank priorities for implementing these measures; (iv) explore if the implemented rotation scheme decreases risk of developing WRMSD; (v) examine association of pain, discomfort and nuisance reported by workers, with presence of WRMSD risk factors in the workplace, through Nordic Musculoskeletal Questionnaire and Ergonomic Workplace Analysis application. RULA' results showed that these workers are exposed to a high risk of WRMSD development, being in agreement with reported symptoms pointed out by the questionnaire applied. Additionally, the obtained results demonstrated that the task rotation scheme seems to be insufficient relatively to the WRMSD prevention. Therefore, a more complete study is needed in order to achieve better ergonomic interventions on workplaces of metalworking industry.

1 INTRODUCTION

The incidence of WRMSD in Europe is growing and making them one of the most important causes of absenteeism due to long term illness (Esteves, 2013). Currently, with constant changes and developments on work, industries are using cutting edge technology and sequential work that requires workers to perform small movements at high frequencies, which can produce an overreaction on upper limbs muscles recruited and a static overload on the shoulders and spine. This situation leads to the development of WRMSD which are getting even more often and raising more concern (Fernandes, Moreira, & Tavares, 2011).

The main risk factors for the development of these injuries are: (i) activities executed mainly by actions that involve the adoption of extreme postures; (ii) excessive physical efforts; and (iii) high repeatability of movements. The diagnosis of WRMSD' risk situations is the first step in any strategy to improve working conditions, from the perspective of occupational ergonomics, health and safety (Serranheira & Uva, 2006). There are multiple methods for identification of factors and risk assessment procedures, from simple checklists, through the observational methods of integrated assessment, to the use of analytical methods of assessment (Aguiar, 2012).

The present work was developed in a metalworking industry. The production process consists in stamping, welding and assembly of metal components. The assessment risk of developing WRMSD was done in workplaces included in the component assembly line. In this sector, complaints of pain on the upper limbs are related to the work carried out in a "Riveting machine", with history of work accidents associated with WRMSD. Essentially, there are three tasks performed with this machine: mounting components, screw driving, riveting components, and finally verifying the quality of the assembled parts.

This study aims to: (i) determine the risk of WRMSD development, by applying the method RULA in 3 different tasks; (ii) suggest possible prevention and/or correction measures; (iii) with RULA action level results, rank priorities to implement these measures; (iv) explore if the implemented rotation scheme at the 3 assessed tasks decreases the risk of developing WRMSD; and (v) examine the association of the pain, discomfort and nuisance reported by workers, through Nordic Musculoskeletal Questionnaire application, with the presence of WRMSD risk factors in the workplace.

2 METHODOLOGY

Initially, an exhaustive characterization of tasks associated with the "Riveting machine" was performed, as well as a characterization of its workers.

Concerning this workplace, relevant data were collected through direct observation during normal work activities and these were recorded by video and photography, as well as through workers interviews. The Nordic Musculoskeletal Questionnaire (NMQ) (Kuorinka *et al.*, 1987), adapted to the portuguese population (Mesquita *et al.*, 2010) was applied to workers in order to determine the prevalence of complaints on their different body regions, as well as the level of pain and discomfort perceived by them. In this diagnosis phase, it was also applied the Ergonomic Workplace Analysis (EWA) method (FIOH, 1989), which allows the identification of the most important work factors that contribute to ergonomic problems and therefore require intervention.

According to the results obtained in diagnosis phase and in order to develop a more specific ergonomic assessment, the RULA method was applied. This method allows to assess WRMSD risk, mainly for the upper limbs (McAtamney & Corlett, 1993). RULA was applied to the 3 workers of the 3 workstations that constitute the "Riveting machine".

This evaluation was performed individually for each task, and was subsequently made their weighting according to the time exposure for each worker. Afterwards it was chosen the most frequent position in each of the three tasks and performed to evaluate the respective RULA score. For each task, it was also evaluated the posture in which the worker had greater postural overload in order to ascertain what level of action was assigned to this task. All assessments were unilateral, having been chosen the side considered critical to safeguard worker health.

3 RESULTS AND DISCUSSION

3.1 *Workplace description*

"Riveting machine" consists of a total of three separate tasks, called Workstations 1, 2 and 3. In Workstations 1 and 2, tasks of assembly components and screw driving are developed; in Workstation 2 is also performed the verification of some components of the piece. The cycle time is very short and workers have to perform all tasks in a standing position, with an intensive-local muscular work at the upper limbs. The industrial screwdriver is coupled to the job itself. Workstation 3 features three visual tasks in order to check the parts, also featuring the task of verification of its mobility. This task is very repetitive and executed quickly and several times per minute. A visual check of the piece is performed without bench, having the operator to hold the piece manually and turn it to check all the components. The piece weighs approximately 2 kilograms and its mobility verification is performed through several rapid movements of the upper limbs, and when the part is faulty, needs to be rectified. This correction consists in a part alignment. To make this correction, operators resort to the use of intense local muscular work at upper limbs and the low back.

3.2 *Nordic Musculoskeletal Questionnaire (NMQ)*

The NMQ, that evaluates musculoskeletal complaints, as well as the level of pain and discomfort perceived by workers, on a scale from 0 to 10, was applied in all shifts and at all workers that perform the 3 tasks at "Riveting machine". The sample study was constituted by 30 workers, of both genders, with an average age of 38 (±9.13) years. The anatomical regions that presented greater prevalence of symptomatology in the last 12 months were "Wrist/Hand" (86%), followed by "Shoulder" (80%) and "Low Back" (73%) (Figure 1). Regarding the mean pain intensity, the body regions with the higher values were "Shoulder" and "Wrist/Hand", with a level of 5.4 in both, as it is shown in Figure 2.

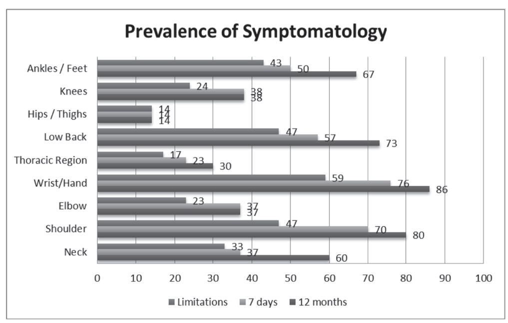

Figure 1. Workers symptomatology prevalence.

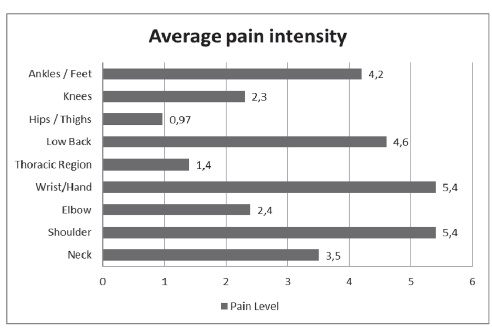

Figure 2. Average pain intensity by workers.

3.3 *Ergonomic Workplace Analysis (EWA)*

Through the application of EWA to the 3 evaluated tasks, it was possible to conclude that all of them present a score of 5 for the following factors: "Posture and Movements", "Work Restrictiveness", "Work Repeatability" and "Thermal Environment". This means that the working conditions have a great difference from the recommendations considered acceptable by this method, in other words, the existing conditions are inadequate or even dangerous to workers health, thus is necessary to give special attention to these factors. Regarding the subjective evaluation done by workers it doesn't differs from analyst evaluation in the referred factors. The workers consider that the worst conditions of their workplaces are associated with the factors already detected by the analyst.

3.4 *Rapid Upper Limbs Assessment (RULA)*

The application of RULA, demonstrates that all the evaluated tasks enhance the development of WRMSD, with a range of scores between 5 e 7 corresponding to a C action level (5 or 6 score: indicates the need for a careful investigation and introduction of short term changes) and D (7 score: indicates the need for further investigation and introduction of immediate changes). In all the evaluations, the obtained action levels indicate that is necessary to introduce modifications in the workplaces, in order to reduce the workers' ergonomic risk. Therefore, it was applied a rotating scheme between the 3 evaluated tasks. In this sense, weighted values were applied to RULA. In Table 1 it is possible to observe the obtained results of weighted RULA: 5,9 when the worker perform tasks 1 and 2; 7,9 when 2 and 3 are executed; and 6,1 when 3 and 1 tasks are performed. To these values, RULA classification is action levels C and D, where both are associated to a necessity of workplaces modifications. It is important to notice that action level D requires an immediate intervention.

These results shows that rotation between tasks, as a risk reduction measure is not effective, once the muscular groups that are more requested are the same at all tasks (upper limbs). The obtained score through the weighted RULA, allowed to determine that the priority for ergonomic intervention should be when the worker perform, in a 8h work day, the tasks of "assembly components and screw driving" in Workstation 2 and the tasks of "verification and rectification of pieces" in Workstation 3. Nevertheless, when the worker executes 3 and 1 tasks or 1 and 2 tasks, the RULA' final score and consequent action level still high and therefore imply also ergonomic intervention.

3.5 *Preventive measures*

It is suggested an intervention at the workplace, through the improvement of ergonomic work conditions, as there is a need of urgent modifications in all evaluated tasks. In this sense, eliminating or reducing awkward trunk and upper limbs postures should be considered. All the workplaces should have a half-standing bank with back support, and anti-fatigue mats, especially Workstation 3. These measures would allow greater comfort to the workers.

Improving pieces quality is another relevant factor, once it would allow reducing the rectification pieces tasks and, consequently the risk level of developing WRMSD. Indeed, in Workstation 3 the risk would be reduced, leading to a decrease in the static muscular work with application of force by the upper limbs.

Another measure of extreme importance would be the modification of the actual job rotation scheme. It should accomplish the assumptions that are related to rotating tasks scheme, namely have into account that in different tasks should exist a difference between patterns of exposure, the postures adopted, level of concentration required and the intensity of work (Pombeiro, 2011).

It is also important to implement a training plan for workers, focusing the following topics: essentials of ergonomics, manual handling loads and adopted postures. The worker health surveillance is also crucial to stop possible WRMSD evolution and prevent the appearance of new cases.

Table 1. RULA score for each individual task and weighted RULA according with the rotating scheme implemented.

	Workstation 1	Workstation 2	Workstation 3	Workstation 1
Individual RULA score	5	7	7	5
Weighted RULA	5,9	7	6,1	

4 FINAL CONSIDERATIONS

The application of ergonomic analysis and specific evaluation methodology, in the 3 tasks associated with the "Riveting machine", made possible determine that there is an urgent need to intervention. The intervention must be executed in the following order: Workstations 2 and 3, Workstations 3 and 1 and Workstations 1 and 2. The elimination/reduction of unfavourable postures should be the main focus of the changes to be implemented. Although the rotating task scheme is already implemented, through the analysis of weighted RULA results, it was not possible to perceive advantages regarding the risk reduction, since all tasks had similar levels of physical demands. The results obtained by the application of RULA are in accordance with the symptomatology reported by the workers in the NMQ, meaning that the body areas that had a higher score on RULA were the ones that workers more complained about. In fact, perceived symptomatology may be used as an alert indicator for the need of intervention in workplaces.

RULA method has some limitations, particularly in terms of evaluating the frequency of tasks execution, the time of operations, and does not take into account the fingers position. These factors were the major limitation to this study, since the evaluated tasks are repetitive, meticulous and with short cycles. It is considered as an important future work to do an ergonomic analysis of this workplace through another method, namely, the Strain Index (SI). This will allow to evaluate the risk of WRMSD at the extremities portions of the upper limbs, taking into account the intensity and the duration of contraction, and also the duration of recovery periods. It would also be important to conduct this study in other shifts, with the implementation of EWA, RULA and SI, in order to verify if there are significant differences between the different shifts.

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Prevention in underground construction with Sequential Excavation Method

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ABSTRACT: This paper aims to describe the Sequential Excavation Method, used for excavation in underground works, as well as the related risks and preventive measures. This method has characteristics that differentiate it from other tunnelling techniques: it uses a larger number of workers and equipment; it has a high concurrency of tasks with various workers and equipment quite exposed to hazards; and it uses many potentially aggressive chemicals. Firstly, it is given a broad overview of this issue. Afterwards, it will be presented the results of a survey to a sample of experienced technicians, aimed at gauging the relevance of a set of guidelines relating to the design and work phases, applicable to the domestic market and prepared following technical visits to works abroad.

1 INTRODUCTION

Underground works have particular characteristics (dust, harmful gases, noise and vibration, high temperature) that distinguish them from building or surface infrastructure construction or rehabilitation. This Sequential Excavation Method, which is not automated (unlikely the tunnelling boring machines), uses a larger number of workers, equipment and materials. So, by the simultaneity of high risk tasks in the same space, it brings different risks than tunnels made with tunneling machines. These factors are worsened in Portugal by the construction sector state that requires increasingly high production rates and budgets with low financial margins that give way to a gradual disinvestment in the prevention area.

This method was created in Austria during the 1960s. It consists in applying a thin layer of sprayed concrete on the support of the excavation as quickly as possible, to create an auxiliary arc, and the deformation of the ground is a function of time until equilibrium is reached.

The constructive process includes several phases (Fig. 1). Following, it is described and presented the sequence of all phases.

1. Topographic marking of the excavation face;
2. 3. and 4. Sequential excavation of the rock mass, by mechanical means or with explosives. The excavated section shall have such dimensions (length and transversal section) that the value of the tensions that hinder its self-support is not reached;
5. Ventilation of the excavated area. Given the dust released during excavation (dust and gases from explosives), it is necessary to renew the atmosphere to ensure the minimum standards of breathability;
6. Debris removal. The excavation products are removed from the excavation face to free space for next activities;
7. Mechanical or manual cleaning of excavation, to remove unstable rock mass pieces;
8. Application of a sprayed concrete layer and stabilizing devices—the deformations of the mass

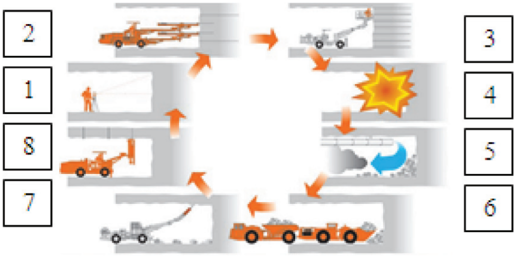

Figure 1. Diagram of the construction sequence with SEM.

are minimized by applying a thin and flexible layer of concrete, and stabilization devices such as sprayed concrete, metal crankshafts or forepoling may be used, to allow for the rearrangement of stresses in the mass.

The method is particularly suitable in the excavation of sections with irregular shapes and galleries between parallel tunnels. It has the advantages of a lower cost and the possibility of having different cross-sections, but presents some disadvantages, such as the instability of the excavation face, the dependence of monitoring and the increased vulnerability to human flaws (Health and Safety Executive, 1996).

Most work accidents with this method happen due to falling blocks or contact with equipment and tools. As for professional diseases, these occur due to contact with hazardous chemicals (Tender, 2014).

2 METHODOLOGY

The lead author conducted technical visits to works in the UK and found several preventive choices unusual or non-existent in Portugal. After analysing their technical and economical feasibility in the national framework, a set of guidelines were drafted to allow for the improvement of Health and Safety at Work conditions. Based on these guidelines it was drafted a multiple choice questionnaire (5 choices ranging from "Very important" to "Not important at all"). A pilot questionnaire was carried out with two of most experienced technicians in order to collect inputs and contributions to improve the questionnaire. Then the questionnaire was sent to a group of technicians working in the most important underground works construction sites in view to assess the relevance of these guidelines and test the importance they give to each of them. 110 valid responses were collected: 36% from technicians working for the Contractor, 27% from the Construction Safety Coordination, and 16% from the Project Owner. Most of the respondents (70%) had between one and ten years work experience.

3 RESULTS AND DISCUSSION

Following are presented and discussed the results of the questionnaire to a sample of experienced technicians regarding to the relevance of the set of guidelines suggested.

Guideline 1: Include preventive measures in the design: exploratory hole in each advance of excavation (for detection of areas of poorer quality or pockets of water or gas); reduction excavated section (it reduces the likelihood of falling blocks); thicker concrete for spraying—61% of the respondents said it was "very important" and 35% said it was "important".

A sound project should include the general principles of prevention, to minimize the risks that make it through to the work phase and to have enough time to identify and treat any deviations before the risk becomes unbearable. (Crossrail, 2013) states that 47% of the accidents in recent years could have been avoided during the design phase. It is important that the Designer makes design options that are safe, in terms of techniques, materials and equipment used, looking beyond the mere cost or performance.

Guideline 2: Electronic access control to the tunnel to minimize the risk of non-compliance with the traditional manual procedures of identifying plates—41% of "very important" and 46% of "important" replies. In Portugal there is usually a manual system of identifying plates, to comply with the Dec. Law 273/2003 referring to the access control of authorized personnel, which demands a very strict implementation. However, the worker tends to not comply with the procedure of putting the plates on/off. The electronic system, as can be seen in Figure 2 below (taken from Venda Nova III Hydroelectric Power Station Construction procedure), consists of an individual electronic chip that is registered when the person enters or exits the tunnel. At any given time the system can tell how many people are inside the tunnel and who those people are (e.g., if evacuation was needed, in a case of accident or fire).

Guideline 3: Equipment with video camera to decrease crashing hazard—35% of "very important" and 47% of "important" replies. In the transalpine tunnels, for instance, several accidents had occurred where the victims had been hit by vehicles. After the fitting of rear video cameras in all of the vehicles no more crashes or hitting accidents occurred (Vogel and Kunz-Vondracek, 2013).

Guideline 4: Exclusive use of emulsions for excavation with explosives—36% of "very important"

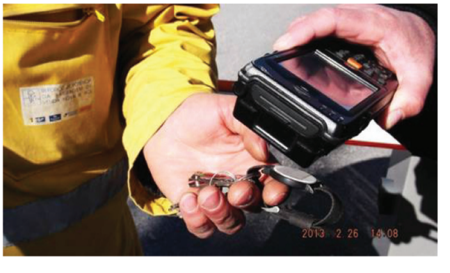

Figure 2. Electronic access control (Source: Venda Nova III Constructor).

and 50% of "important" replies. For commercial reasons, in Portugal it is still used ANFO (ammonium nitrate and diesel based explosives, with very toxic fumes). The workers who handle this explosive show a temporary reduction in lung function, caused by being exposed to nitrogen dioxide peaks, when compared to those who do not handle it (Furuseth et al., 2013). The emulsions consist of two phases, which are only explosive when mixed together. They are more stable during transport and handling, have a lower degree of toxic contaminants and are highly resistant to mechanical or thermal actions. Pumped emulsions are more reliable during charging—the cartridges are less likely to get stuck in the holes, thus minimizing the risk of non-explosion due to the lack of contact with the adjacent cartridges.

Guideline 5: Ensure that the debris are wetted before removal and that the threshold and gables are periodically cleaned to minimize the risk of dust accumulation—42% of "very important" and 52% of "important" replies. The rock mass allows for the emergence of quartz dust (causing silicosis) and sprayed concrete brings about alkaline dust (from non-alkaline accelerators, causing damage in eyes or mucous membranes). In the case of quartz, having a worker with a water hose close to the deposit of debris (in an area where there is no risk of fragments falling from the mass) minimizes the accumulation of dust. Nevertheless, there can exist a water spray system in the drilling/excavation equipment head. These dusts also accumulate in tight places and may become air-borne in case of higher temperatures. This is why the cleaning of such areas is so important. In the second case, the projection must be wet (as already required in other countries) with non-alkaline accelerators, to minimize mists with caustic characteristics.

Guideline 6: Measure gases before each shift—68% of "very important" and 29% of "important" responses. There is a high risk of gases, e.g. carbon monoxide and dioxide and hydrogen sulphide. Therefore, measurements should start before the beginning of each shift and should be continuous, through fixed or manual devices. There should also be a ventilation system in place (to have enough oxygen in the air and to comply with the relevant Exposure Limit Values), adequate to the number of workers and equipment, inside and outside temperature, and air speed.

Guideline 7: Concreting the pavement from the portal to the access of the excavation front—37% of "very important" and 52% "important" replies. Concreting the pavement after each advance, exemplified in the picture below (Fig. 3), improves the quality of the pavement for the debris removal equipment. In addition to aiding in the introduction of a proper drainage system in the rock mass,

Figure 3. Access to excavation front with concreted sills (Source: Venda Nova III Constructor).

Figure 4. Refuge chamber (Source: MineArc).

it brings about significant yield increases (travel times between excavation face and lower landfill), lower costs of maintenance and repair of equipment and lower impacts (in terms of dust, mud and noise) in areas away from the front, where other works are being carried out (e.g. waterproofing).

Guideline 8: There must be a refuge chamber in place—48% of the respondents said this was "very important" and 44% said it was "important". In Figure 4 is shown a refuge chamber, from refuge chamber's supplier "Minearc", which is a relatively safe place for the workers to use as a meeting point in case of collapse, fire or explosion. Workers can stay there until rescue teams arrive or until it is safe to exit the tunnel. It has autonomous ventilation and air purification systems, basic life support and first aid kits. The refuge chamber also allows for the head-count, thus minimizing the need for rescue teams to be used.

Guideline 9: All the people underground should have emergency masks—41% of the respondents said this was "very important" and 40% said it was "important".

This type of mask supplies the worker with uncontaminated air, for a set period of time, for the cases where the worker is in an area filled with smoke (e.g., when escaping from a fire). It must be stressed here the fire hazard potential in these works, mainly due to oil leaks from equipment (Vogel and Kunz-Vondracek, 2013).

The survey has also tried to see if underground works are more prone than building works to creating stress situations. Most of the respondents answered affirmatively (81%). This can be explained by the diversity of risk factors in this kind of works.

4 CONCLUSION

Safety should always be safeguarded, regardless of deadlines and economic interests, an approach that requires a change of mind-set. The involvement of management, heads and employees is essential and issues such as prior experience in similar works, training (properly assessed) and competence must be guaranteed since the design phase. The design and planning and respective monitoring (e.g. through work permits and continuous measurements of gases) are of paramount importance, together with the use of adequate equipment (e.g. electric-powered) and materials (not harmful and treated so as to create minimal dust or gases in the atmosphere). In terms of emergency, the use of emergency masks and the existence of refuge chambers are crucial. It is urgent to create a specific regulation for this kind of works. By looking at the percentages of "Very Important" and "Important" responses to our survey, it can be affirmed that the proposed guidelines are very relevant and appropriate to the Portuguese market. These guidelines would fill in some gaps in terms of prevention, thereby providing the minimization of risks of accidents at work and occupational diseases.

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Noise Induced Hearing Loss estimation and sound pressure limits' main issues—a systematic review

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ABSTRACT: The aim of this article was to analyse the actual issues about the sound level limits that cause Noise Induced Hearing Loss (NIHL). It was done a systematic review irected to the search in the electronic databases: SCOPUS®, WEB OF SCIENCE® and PUBMED®. The obtained results lead to some crucial aspects when NIHL is assessed. These shortages are related to assumptions that must be taken in account: contribution of non-occupational noise, impulsive noise, susceptibility to noise and use of hearing protection. Non-occupational noise, in some circumstances, can have a significant contribution for NIHL. The impulsive noise, which can also be found in non-occupational noise, has a particular contribute to NIHL and it is basically neglected. Individual susceptibility can also be an important factor. By other way, the audiometry and the use of hearing protection could infer a large bias. The actual limit levels don't contemplate the integration of all this variables.

Keywords: noise exposure; ISO 1999; threshold shifts; Noise Induced Hearing Loss

1 INTRODUCTION

Nowadays the communication ability of a person is perhaps the most valued talent as communication is highly necessary for our Society. Communication is essential to interact with Society, to learn, to teach, to make relationships and to maintain them, to education, to update oneself, to entertainment, to understand the world and one of the main channels is the sound. This physical phenomenon is also known by noise.

The auditory system is responsible for transforming this physical phenomenon to something capable to be understandable for our brain. However, as a person becomes older, the auditory system will show the cumulative damage caused by noise, especially in susceptible persons. This, impair the quality of life and in fact, someone who has no job and suffers from poor communication skills, will have more difficulties to find a job.

Noise is one of the most occupational assessed risk, and the main external factor for hearing loss. Based upon the current understanding of the causes of Noise Hearing Loss (NIHL), it would not have been expected to find significant hearing losses in humans before the age of metals, except for those associated with diseases and aging (presbycusis). Although there are ancient reports of this problem, it was with the Industrial Revolution that new sounds of high intensity were introduced in a greater scale than ever before. This problem has induced governments to take measures to control exposure levels (Thurston, 2013).

The possible adverse effects of excessive noise exposure on hearing have been well-established (Sliwinska-Kowalska et al., 2007, Nandi et al., 2008). To prevent occupational noise-induced hearing loss, collective measures can be taken to reduce the overall noise level at the work layout (Bies et al., 2003). Hearing protection is only used when these interventions are insufficient or unfeasible. Noise can be controlled by blocking the noise at the source, along its path from the source to the receiver, and at the end receiver (Hsu et al., 2004).

Although it is widely recognised that implementing collective measures, such as engineering and/or administrative controls, is the more efficient way to minimise the risk of hearing loss, Hearing Protection Devices (HPDs) are still widely adopted in noisy workplaces. The popularity is most likely related to its ease and low-cost implementation, especially compared to the complexity and the high cost associated with implementing technical and organisational noise reduction measures (Arezes et al., 2013).

Noise is intrinsic to work activity, but its problems are particular marked in the industry. The hearing loss due to occupational noise exposure is the most prevalent industrial disease (Sataloff et al., 2005).

The European Directive 2003/10/EC, of 6 February 2003, states that hearing protection should be available when noise exposure over an 8 h working day ($L_{EX,\,8h}$) equals or exceeds 80 dB (A), and for $L_{EX,8h}$ from 85 dB (A) its use is compulsory. Despite these regulations, occupational hearing loss persists (Mrena et al., 2008).

The international standard, ISO 1999 Acoustics—Estimation of Noise Induced Hearing loss (NIHL) presents a methodology to estimate the relationship between noise exposure and "Noise-Induced Permanent Threshold Shift" (NIPTS) considering age, gender and exposure to noise (L_{Aeq} and years of exposure) at frequencies between 500 Hz and 6000 Hz. The model assumes that Hearing Threshold Level (HTL) of an occupationally noise-exposed population is a combination of hearing threshold level associated with age, according to ISO 7029, and Noise-Induced Permanent Threshold Shift (NIPTS). It can be applied to the calculation of the risk of hearing loss due to occupational noise exposure. It uses a data base of three populations, Norway, Sweden and United States to define correlations between hearing disability and hearing factors, being therefore only applicable in populations with the same characteristics. Nevertheless, Noise Induced Hearing Loss isn't only the result of occupational noise exposure but also of the total noise exposure of the population. It may be important to take in account the non-occupational exposure of individuals (at home and during recreational activities). Only if this non-occupational exposure is negligible compared with the occupational exposure, is this estimation allowed. Otherwise it should be used to calculate the hearing loss to be expected from the combined (occupational plus non-occupational) total daily noise exposure.

One of the other limitations is that the ISO 1999 undertakes the concept of equal acoustic energy assuming the value of 85 dB (A) for 8 hours a day and in some cases this concept may be not valid when impulsive noise is considered. As a matter of fact, most important strong impulses are practically ignored by ISO1999 (Rabinowitz et al., 2007).

In the end, the individual susceptibility can depend on the interaction of intrinsic and environmental factors. (Pyykkö et al., 2007).

This systematic review starts to question the basis of the occupational noise safety, the exposure limits values, as the key to preventive programs and also the approach of ISO 1999 standard. Are this values the safety barrier to ensure hearing protection? What are the main concerns? The Hearing Conservation Programs (HCP) are mainly based on that issues.

2 METHODS

This systematic review was conducted in the electronic databases: SCOPUS®, WEB OF SCIENCE® and PUBMED® and presents the most important articles related to the theme. The searching terms were the same in all the used resources: "Any word = ("occupational noise") AND Any word = ("hearing threshold")" and "Any word = ("occupational noise") AND Any word = ("hearing impairment")". The number of articles found in the used databases was consistent with expectations. Only the articles that complied with the eligibility criteria were used in this review.

The identified articles were screened by date, titles and abstracts of all retrieved references. The search was limited to articles, written in English, since 2004 to present. Electronic copies of articles were also identified. The articles retrieved for this review of the electronic databases were complied with the following inclusion criterion: relationship between sound levels and hearing loss.

To allow a direct comparison of the data across the studies reported in the retrieved articles, the data extraction was conducted according to the following criteria: authors, year of publication, objectives, methodology, results and conclusions.

3 RESULTS

From the article selection process, 2342 articles were found. After eliminating the duplicate articles (n = 610), published before 2004 (n = 656) and revision articles (n = 18), 1731 articles were screened. The abstract articles were then read and the articles that did not meet the inclusion criteria were excluded. Thus, 22 full articles were assessed for eligibility and 11 studies were included in this systematic review (Fig. 1).

4 DISCUSSION

The main objective of any Hearing Conservation Program (HCP) must be the prevention or, at least the limitation of NIHL. After that, the other objectives are the reduction of employees' stress and absenteeism, the reduction of workplace accidents as well as workplace quality. The current regulatory levels for occupational noise exposure (European Directive 2003/10/EC and ISO 1999) were based on cross-sectional studies performed a few years ago and before the implementation of hearing conservation programs.

When analysing these studies it could be find some shortcomings like variable use of hearing protection by study subjects, fairly crude assessment of ambient noise exposure levels, and limitations of hearing assessed at only one point in time. They had limited or even no data to address the effects of noise exposures below 85 dB (A) (Rabinowitz et al., 2013).

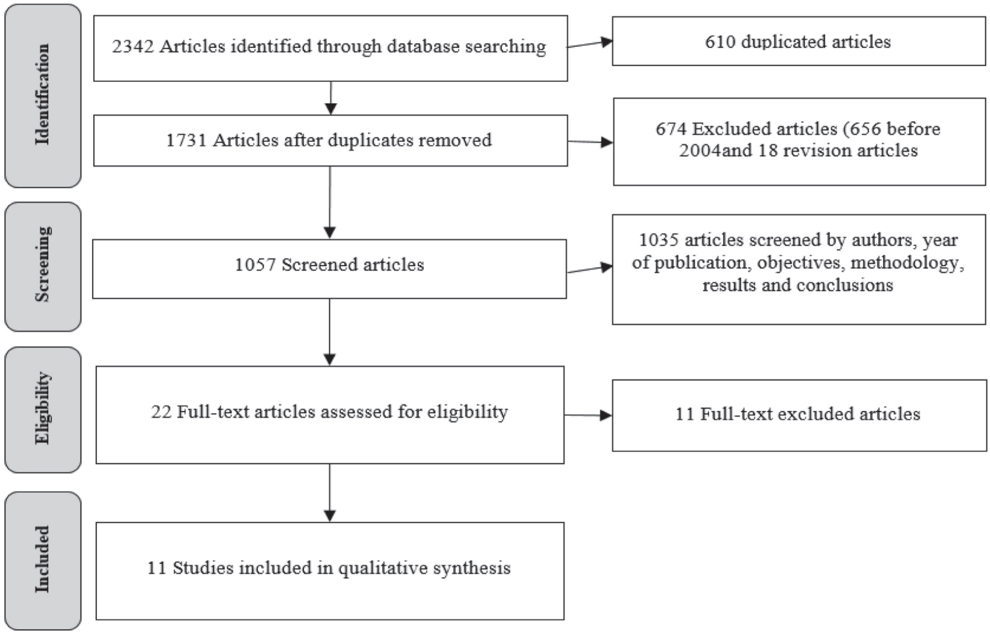

Figure 1. Flow of studies through the review, based on PRISMA.

There are two independent harmful mechanisms that lead to NIHL: chronic degeneration due to long-term high noise-levels and acute acoustic trauma due to powerful impulses close to the ear. (Fleischer, 2008).

The relationship between noise exposure and "Noise-Induced Permanent Threshold Shift" (NIPTS) can be expressed in the relative standardised scale based on the ISO 1999 standard that allows to compare hearing status of subjects of different age and noise exposure *(Dudarewicz* et al.*, 2010)* but some results lead to data indicating that hearing loss at low noise exposure levels are much greater than predicted and by the other side at high levels hearing loss is lower than predicted. (Leensen et al., 2011). Also the interpolation described in the ISO model, that predicts hearing loss developed during the first 10 years of exposure, is not consistent with data and seems to be inapplicable as referred by Leensen, (2011). One reason may be the hypothesis of pre-existing hearing loss from non-occupational noise exposure. (Leensen et al., 2011). Occupational exposure limits are based on damage criteria that assume non-occupational time is spent at noise levels which allow the ear to recover. (Neitzel et al., 2004).

In the old studies the non-occupational effects were not considered and its contribution could have more influence the lower was the L_{ex8h}. Exposure to non-occupational noise should be assessed for example through individual responses on an annual hearing questionnaire (Rabinowitz et al., 2007). This kind of information should be contained in the databases. Pyykkö et al., 2007, include four separate entities in their study that most contribute for non-occupational noise: music noise, shooting noise, military noise and power tool noise. But toys, fire-crackers, pistols, celebrations, are a source of non-occupational noise and consequent ear damage as well. Some of this noise has characteristics off impulsiveness, and one single event is enough to provoke damage. Rarely occurring, impulses cause much more damage than continuous noise. (Fleischer, 2008). The peak level of the impulse may be the critical factor in the development of hearing loss (Aranda De Toro et al., 2011). Even exposures lower than permissible levels may lead to acoustic trauma (Rezaee et al., 2011).

Rabinowitz et al. (2007) found that workers with higher ambient noise exposure experience had less hearing loss than co-workers in less noisy areas. The presented explanation could be related to the differential use of hearing protections, The majority of workers who developed standard threshold shifts in hearing had average noise exposures of 85 dB(A) or less. This indicates that more could be done to prevent hearing loss in moderately noisy jobs. Hearing protection may have its greatest effect at high ambient noise levels. Workers exposed to higher noise intensities are obliged to wear hearing protection and are more bothered by ambient noise, making them more consistent in wearing their protection (Rabinowitz et al., 2007).

Even though, contribution of non-occupational noise could have less weight, as mentioned by (Neitzel et al., 2004), that nearly 80% of the cohort examined in his studies would be at low risk of hearing loss resulting from non-occupational exposure it shouldn't be neglected.

The risk of hearing loss depends on several factors: work noise and its characteristics, leisure noise and its characteristics, exposure to ototoxic agents and individual susceptibility and the use of hearing protection devices (Pyykkö et al., 2007). All these factors potentiate the risk, so interactions between them are important to better understand its effects and to develop hearing prevention programs.

5 CONCLUSION

Exposure to noise tends to vary and workers are often exposed to different tasks with different noise levels, in their work and out of work. An integrated approach is needed to combine the different levels into a single number that is related to risk of hearing impairment. The actual limits levels do not contemplate the integration of all this variables.

The auditory damage caused by noise, NIHL, depends on exposure type: sound level, duration, type of noise, and frequency, as well as personal factors like susceptibility to noise, age, smoking, prior history of hearing/ear damage (Rezaee et al., 2011). The approach to evaluate and prevent this should be multidisciplinary task covering all aspects related to noise and noise effects and their combined interactions. Actually, these interactions, impulsiveness of noise, genetic susceptibility, ototoxic chemicals and leisure noise cannot be modelled (Rabinowitz et al., 2013).

The HCP's should take in consideration non-occupational noise exposure, medical history and details of hearing protector usage, audiometric measurements at much more frequencies than those declared important in ISO 1999 and particularly for higher frequencies extensive information on job history, serial audiometry with a baseline measurement at job, pattern recognition. The knowledge about the exposure pattern may facilitate the introduction of counter-measures against work noise, environmental and behavioural factors (smoking, and socioeconomic status). To further reduce rates of occupational hearing loss, more attention needs to be directed towards prevention in workers in jobs with noise exposures lower than 85 dB (A).

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Comparing three risk analysis methods on the evaluation of a trench opening in an urban site

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ABSTRACT: Working accidents are due to several factors which include collapse of structures, lack of proper safety training and unrealistic risk assessment. The opening of a trench in "urban" spaces usually don't have a great complexity which in many cases leads to a lightening prevention measures causing mortal accidents. This paper presents the results of the assessment by tree different methods (William Fine, NTP-330, MIAR), one of them in an development stage (MIAR). The same activity was evaluated by fifteen Safety Experts using the tree methodologies. This study concluded that: (a) MIAR methodology allows identify hazards and determine risk assessment minimizing the subjectivity factor of the applier; (b) provides truthful results and it is adjusted to the real activities of trench opening works; (c) it is influenced by specific criteria for each activity such as exposure time and impact extension.

1 INTRODUCTION

Working accidents are often connected to structures collapse, damaged equipment or old working tools, absence of appropriate safety training and unrealistic risk assessment. These factors are very common in construction works such as excavation.

In general, the excavations in urban environment have small width, depth, and opening time. These works are done for installation or maintenance of urban infrastructures. Usually do not have too much complexity what, in many cases, decreases the prevention actions causing mortal accidents. The nature of work is variable from severe physical tasks to full mechanize ones, often performed under extreme climate conditions and in isolated areas or on the other hand in very crowded areas. The specifics of the work on construction industry entail that uncertainties are inherent in every condition (Tam et al. 2004).

Many authors (Kentel and Aral, 2004, Faber and Stewart, 2003, Nilsen and Aven, 2003, Tixier et al., 2002, Pender, 2001, Harms-Ringdahl, 2001, Wang and Ruxton, 1997) have discussed the limitations of traditional semi-quantitative methods for Occupational Safety Risk Assessment (OSRA) and state that the kinds of uncertainties include data scarce or incomplete, measurement error, data obtained from expert judgment, or subjective interpretation of available information which cannot be treated solely by traditional statistical or probabilistic methods. So, probabilistic OSRA methods are not objective and fail simply because they do not recognize their own subjectivity (Pinto, 2014).

This article compares the results of risk assessment of opening a trench in an urban site by two methods traditionally used—William Fine (Fine, 1971) and NTP-330 (Belloví, and Malagón, 1993)—with an assessment by a method in the validation phase (MIAR) (Antunes et al. 2010).

2 MATERIALS AND METHOD

This comparison study started with a literature review. First, searching all technical and safety requirements for trench opening activity. Second, searching for specific data in the literature and identifying of applicable legislation. Third, analyzing City hall regulations and for last the documentation inherent to the Health and Safety Plan for the construction project.

The activity of digging a slit trench at an urban site takes place in a day-work system to extend gas distribution network. The developer knows the working project as well as the detectable local restrictions. There is an almost total ignorance of the local buried infrastructures and from the sustainability conditions of the visible ones.

The trench working conditions were analyzed in order to identify which risks the workers are exposed to—Negative impacts. From this analysis thirty-eight risks were identified. Each risk was assessed by three methods.

To ensure a substantial sample of evaluators that allows showing the reliability of the method the author asked to 86 level V Safety technicians to apply the three methods. Forty two answers were obtained. However, only 15 evaluators applied the three methods to all situations.

To ensure that all evaluators analyses the same activities, it was realized a short video (four minutes and five seconds) with the different stages of the process. That homogenizes the knowledge of the evaluators for the activity in question. In order to assess how each applicator analyses the situation, were introduced in the video some intentional fails.

All observers received three drafts (one for each method) all with the same hazards and risks and all of them containing in the bottom several free fields to list some new risks identified from the video.

3 RESULTS

After analyzing the results of risk evaluations with the three methods done by the 15 observers, data was treated in order to compare the obtained results that are shown in graphics of the Figures 1, 2 and 3.

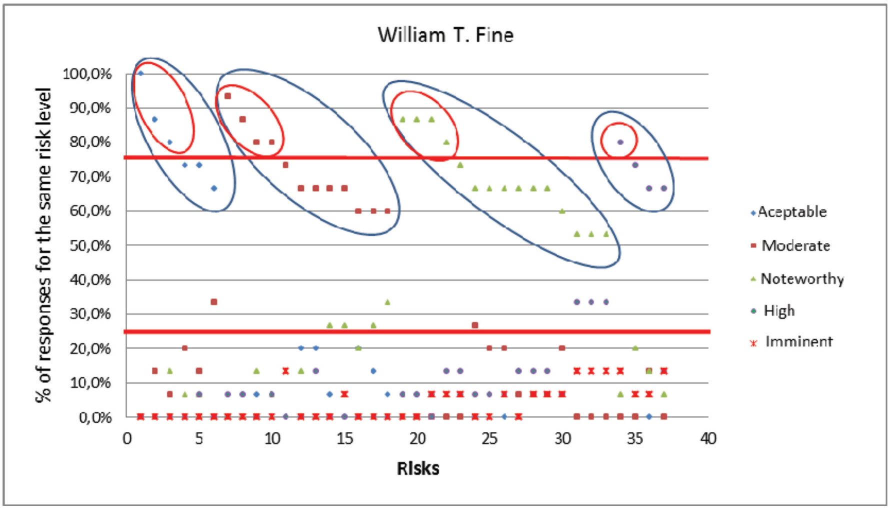

Figure 1. Evaluation results by 15 evaluators, for each risk, by William Fine method.

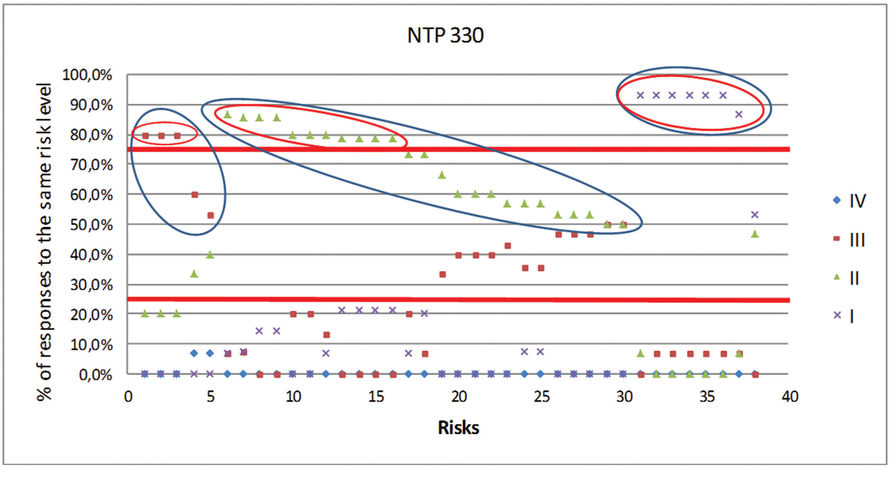

Figure 2. Evaluation results by 15 evaluators, for each risk, by NTP330 method.

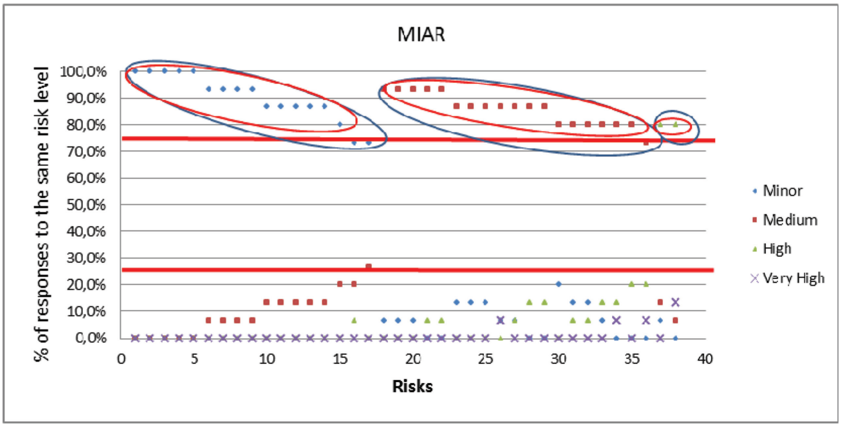

Figure 3. Evaluation results by 15 evaluators, for each risk, by MIAR method.

Table 1. Highlights of the results.

	William T. Fine	NTP 330	MIAR
Risk that all observers evaluated the same way	1	0	5
Convergence above 75% of the responses	13	23	35
Number of unidentified risks	9	14	0
Risk assessments on the upper level	24/570	130/558	5/570
Risk assessments in the lower level	100/570	0	250/570
Evaluations in the highest level of risk	109/570	409/558	49/570
Evaluations in the lower level of risk	261/570	147/558	521/570
Risks evaluated in all risk levels	5	0	0
Risk evaluated with the two lower risk levels	2	0	22
Risk evaluated with uncontiguous levels of risk	9	2	0
Risks evaluated by all evaluators in the highest level	1	0	0
Risk that can't be evaluated by this method	0	11 (1 observer) 1 (1 observer)	0

Table 2. Dispersion of the results of carried out evaluations.

	William T. Fine	NTP 330	MIAR
Average of the coefficient of variation	78,31%	56,15%	20,86%
Standard deviation of the coefficient of variation	38,73%	14,51%	10,43%

In NTP330 method, the lowest level is IV and the highest is I (Fig. 2). In the evaluation by MIAR, the lowest level is 1 and the highest is 4 (Fig. 3). In Table 1 can be seen a compilation of the obtained results. Comparing a *change rate*, calculated by the ratio of the Standard Deviation (SD) and the mean (M) (SD/M) for each risk assessed by the 15 evaluators, it is possible to detect significant differences ($p < 0.05$) between the results obtained by the three methods (Table 2) applying ANOVA.

4 DISCUSSION

The risks upcoming from vertical infrastructures (streetlights, traffic lights, walls, etc.) near the trench were evaluated by William Fine's method as "Acceptable" and by NTP330 as "for correction and controller actions". This situation is repeated all over the risk evaluation work.

After analyzing the results for the thirty eight risks identified and assessed with the application of the three methods, it can be seen that the results of the method MIAR are concentrated at lower levels of risk than those obtained by other methods.

It is noteworthy that eleven risks were considered not evaluable by NTP330 method by one observer and another observer considered that the risk of vehicles collision with other vehicles or work equipment also can't be evaluated by this method.

With the application of NTP 330 method most risk lies in the level II intervention, which may indicate that the tasks are susceptible to accidents, which is not reflected in the history of accidents of this activity in Portugal. The existence of 23% of the assessed risks with level I, reinforces the idea that this method is lagged from reality for this activity.

The NTP330 is influenced by the subjectivity of assessing the level of consequence made by the observer as well as the accident history of the company.

The existence of nearly a third of the risks evaluated (32%), with valuations distributed in 4 or even in the 5 possible levels of evaluation, corroborates the view that the application of William Fine, as the sole evaluation method for the analyzed activities can easily cause the implementation of excess prevention measures or by the contrary, minimizing the risk and increasing the susceptibility for accidents.

As the NTP330, William Fine method is influenced by the historical accidents of the company. This method is greatly influenced by the subjectivity of the observer, with regard to the quantification of the injuries and damage and the assessment of risk exposure. Considering the history of accidents at work in this activity, MIAR reflects the best of the reality of the activity.

5 CONCLUSIONS

Safety in digging a slit trench work is a topic of high importance especially in an urban environment. Trenches in urban environment are characterized by the density of infrastructure found and the lack of space for normal street traffic and pedestrians during the works. Some of these works of digging a slit trench depend on workers' perception and experience on site, due to absence of entries or downgrade of local buried infrastructure.

The principal hazards and risks of digging a slit trench in a urban scene are the unpredictability of the local constraints and its surroundings.

It is fundamental to develop and implement methods to improve safety in urban works. This means finding or defining a methodology for hazard identification and risk assessment that reduces the influence of the subjectivity of applicator thus becoming a factor of improvement rather than being more variable.

The basis of a credible assessment of the evaluated methods was the full analysis of activity for hazard identification and risk assessments in order to guide the applicator to the most relevant aspects. Observers were informed that they could identify new hazards and risks and assess them if they thought it was relevant. This opportunity was not used by any observer.

The NTP330 methodology leads to some situations in which a few observers consider that the risk is not assessable and other observers believe that the *situation is critical and needs a urgent correction*. These situations lead to the discredit of the identified measures to be applied in the prevention and minimization of the risk. This methodology is influenced by the subjectivity of assessing the level of consequence made by the observer and also influenced by the accidents' historical of the company.

Like the NTP330 method, William Fine's method is influenced by the accidents' historical of the company. This method is widely influenced by the subjectivity of the observer regarding the quantification of the injuries and damage and the assessment of risk exposure. William Fine's method as well as the NTP330 methodology, do not take into account the number of workers exposed to a certain risk. The MIAR methodology although not fully consensual achieves a convergence of results for the same risk evaluation that becomes almost accurate.

The proposed methodology allows the hazard identification and risk assessment, in which the subjective factor of the observer is minimized in comparison with the other two methodologies. The MIAR method is validated to the activity of digging a slit trench in an urban environment. This validation does not exclude in any time, new developments to the methodology in this activity and especially in other activities related to construction.

Concluding, the MIAR methodology is influenced by specific criteria for each activity such as exposure time and impact extension. This feature distinguishes it from the other two applied methods. The MIAR provides reliable results, but still not free from the subjectivity of the applicator. It is adjusted to the reality of the activities developed to dig a slit trench.

The MIAR should be a methodology to be considered in the activity of open trench in an urban environment for safety assessment. Finally, there are still open issues in the MIAR method, e.g. expanding the evaluation to all construction industry. There are other potential improvements to the method such as adapt the results to effective risk assessment measure.

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Worker's safety at road works with high traffic

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ABSTRACT: This research work studies the importance of traffic management in road construction works, in order to ensure safety of all the interveners at the construction site. In this case, it was studied a road infrastructure called Transmontana Highway. This construction was chosen because of the particularity of being built simultaneously with the movement of road traffic, mostly due to the fact that the construction currently uses certain parts of the Principal Itinerary 4 (IP4). The work started with bibliographic review, followed by conducted meetings with the responsible in order to know the whole current process and the project itself, before going to the construction site.

1 INTRODUCTION

1.1 *Legal background*

The promotion of Health and Safety matter requires the identification of obstacles for adopting preventive measure in order to eliminate them. The Decree-Law nº 273/2003 of 29 October 2003 [1], revises the regulations relating to safety and health at work at temporary or mobile construction sites, requiring a document about safety planning in the project and construction phases, designated health and safety plan. The health and safety plan contains all the relevant information and instructions on safety and health matters, which are required in order to reduce the occurrence of accidents, as well as to protect the health of all the involved workers. In a road project, where there's a simultaneous movement of car users, the work-accident, as well the accident risk, are very high. For that, there's a special care of the risks, with the implementation of preventive measures, such as temporary signs, regulated by the Regulatory-Decree 22-A/98 of 11 December [2].

1.2 *Safety routes construction*

The type of roads has evolved over the time by the society needs. In a road construction, due to its complexity, it's necessary the safety and health coordination in order to prevent the occupational risks inherent in this type of construction.

To follow up this research, the highway "A4" has been chosen, since this has the particularity of being built simultaneously with road traffic, increasing the probability of work related accidents. This study involves the management of the road traffic during the construction phase of the highway, concerning the safety of all the participants on the construction site. For this task, the cooperation of the construction company CAET XXI—CAE Buildings C.A.E. was an added advantage. Another objective of this study was to analyse the ergonomic posture of the workers while doing their tasks, in order to prevent accidents and/or health problems at work.

2 BACKGROUND

2.1 *Safety coordinator*

Throughout the history of human evolution, the mankind had always the concern to proceed accordingly certain rules. Nowadays, despite a rigorous project management and a good health and safety conditions, work-related accidents still continues to occur in the construction sector. The safety matter has not been neglected and has been suffering a lot of changes especially since the Industrial Revolution in the late 18th century, where some productive sectors began to demand an increasing concentration of skilled labour, followed by World War II, where there was need's awareness to reduce work accidents and occupational illnesses by promoting a safety structure in companies, allied to production, for the prevention of occupational risks [3]. Nowadays, in Portugal, there's an extensive legislation related to work safety. In this particular case, the constructions such as the road works, the legislation provides prevention from initial phase designated project phase, to the construction phase. The contractor has the duty to nominate the Safety Coordinator in Project (SCP) and the Safety Coordination in Construction (SCC) [1].

2.2 *Safety Coordinator in Project (SCP)*

According to the Decree-Law nº. 273/2003 of 29 October, art. 9, paragraph 1 [1], the safety coordinator in project is nominated by the developer, every time the project has been developed by more than one subject, containing such architectural options and complex techniques. It's also required a safety coordinator in project if the work to be performed on the basis of this project has special risks or, if there's a prediction involvement of two or more construction companies. If the conditions are not the mentioned above, the author of the project's role is to ensure coordination in the project phase.

The purpose of the appointment of the safety coordinator in project is to elaborate the Health and Safety Plan (HSP) at the project phase, to ensure the safety and health of all staff involved in the construction site, support the developer for the negotiation of the contract issues and the implementation of preparatory work with regard to safety and health matter. The safety coordinator in project has the duty to organize the safety File and to complete the most unfavourable situations, in case there is no safety coordination in construction (SCC). There should be special caution when scheduling tasks, in order not to overlap incompatible tasks in terms of space and time, in order to ensure proper management of simultaneous and successive work.

2.3 *Safety Coordinator in Construction (SCC)*

The contracting of the Safety Coordinator in Construction (SCC) is made in the event that there is intervention of two or more companies in the execution of the contract, by the developer. If eventually there is only one company in construction phase, it's only applied the normal regime of Health and Safety at Work.

There are a series of obligations relating to the SCC, briefly described:

- Ensuring good organization on the construction site, promoting other obligations of the contractor, subcontractor and independent workers;
- Ensure proper compliance regarding job scheduling;
- Ensure the fulfilment of the work program that invokes special risks;
- Ensure the adaptation of the Health and Safety Plan;
- Ensuring the proper functioning of the hierarchy when it comes to responsibilities;
- Organizing inspections visits to the various works, in order to observe the equipment in operation, materials and work processes;
- Organizing meetings between the coordination and the interveners in the construction site;
- Ensuring the safety File updates of possible project changes;
- Ensure the integration of the project owner in terms of relationships with the interveners of the work;
- Conduct inquiries into possible workplace accidents, analysing the causes of the major accidents;
- Analyse the adequacy of safety procedures sheets, proposing if necessary some changes;
- Promote the fulfilment of HSP.

2.4 *Prevention instruments*

The Transmontana highway connects Vila Real to Bragança, uses most of the ex-route of the Principal Itinerary, adapting its own route to a highway profile. To perform this operation, and due to its high traffic, it was decided to carry out in a simultaneous way, the works and the traffic users. Because of its length, the project implementation was divided into constructions lots, for a better human resource management and a greater control in the safety and health control matter.

One of the safety intervention applied, goes for the signage application, in order the drivers adjust their driving conditions imposed by the various conditionings existent along the route, so that the work proceeds in a safety way for the workers and also for the traffic users, minimizing the work-accident risk, as well traffic accidents. In this research work, is granted special attention to the detours implemented by carrying out an analysis of those same factors, in terms of signalling and all the preventive measures applied, in order

Figure 1. Highway route in study.

to reduce the risk of accidents. Figure 1 shows the route of the highway studied in this research work.

3 SAFETY CONSTRUCTION

3.1 *Detours and traffic conditionings*

After a detailed project analysis of the 158 traffic detours, carried out until June 2012, a signalling type study was preceded, also involving, the signage condition implemented, in order to verify the reliability of safety for the workers, as well the drivers.

It was also performed, a study of three detours implemented cases, by doing a comparison between what is projected, and what is implemented on the terrain.

3.2 *Signaling and ergonomy conditionings*

The ergonomy is an important factor to consider when it comes to the health of workers. Sometimes it's observed that the workers do not take the correct postures in terms of load lifting or carrying something, such as is the case with signalling. These incorrect postures are due to a lack of employee training on how to adopt the correct postures in order to prevent serious injury in the short or long term.

Regarding the use of machinery, due to the conditions of the machines (such as comfortability level), as well as the terrain conditions on which they operate, workers tend to adapt postures in order to become more comfortable, which does not mean they are correct.

4 CONCLUSIONS

After understanding the role of the safety coordinator in construction, but also in order to understand how it was made the traffic management, made by that same coordinator, it was carried out the traffic detours/conditionings analysis, implemented until June 2012, which allowed concluding that the correct use of the signage, it helps to decrease the probability of occurrence of work-related accidents, as well as traffic accidents. This analysis allowed to conclude the differences between what is a traffic detour and a traffic conditioning, since there's often an improperly use of the terms. It can be identified the types and causes to implement the detours/conditionings and also in the analysis of studies cases of implementation of signage applied in different situations.

It can be seen that in this construction, there were a greater number of conditionings followed by traffic detours, as shown in Figure 1, since in most of the lots, in order to follow the work, it was necessary to proceed the tilt transit, suppression lane and berm, and even alternating movement, thus conditioning the flow of traffic, as can be seen in Figure 2.

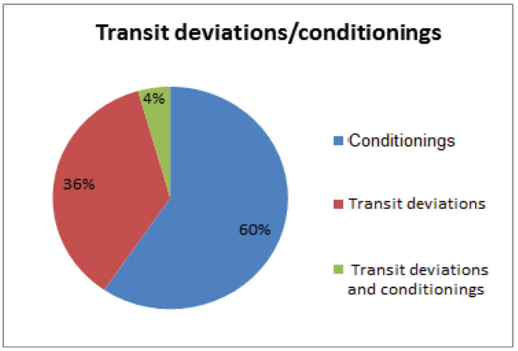

Figure 2. Traffic deviations/conditionings implemented [%].

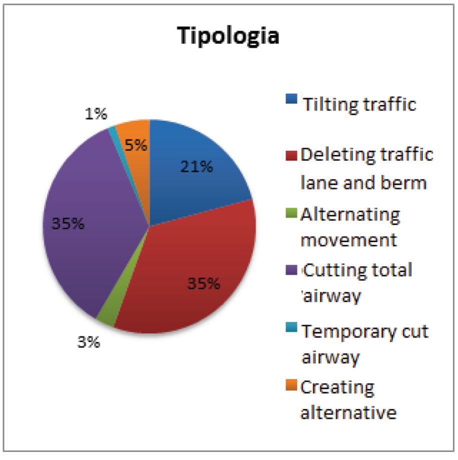

Figure 3. Traffic detours/conditionings types [%].

In Figure 3 is presented the typology of traffic detours/conditionings, where it's found that 35% are by suppression method of the side band, and another 35% by total suppression of the route, followed by 21% for tilting the track.

When implementing the detours/conditionings, there was a need for the constant presence of worker's protection, and in most cases, the necessity of creating a safety perimeter for the workers, and at the same time, guaranteeing a safe traffic movement.

Due to the works on the construction site, the same that automobiles use, there's a need to divert traffic, depending on the needs. For this purpose, it's presented an example of a work zone in Figure 4, which reflects the causes that originate the detours.

Regarding signage, it was proceeded an analysis of their placement and their sate of maintenance in different work locations and different situations. It was concluded that the terrain conditions limit the conditions required by law, which regulates the Decree nº 22-A/98 [2]. The use of signs used in the construction for the highway, causes if they had used in detours for national road signs larger than regulated. It also should be noted that often in traffic detours project, a particular solution is recommended and often on the terrain, there's the impossibility of its application, as can be seen in one of the monitoring visits for implementation of one of the detours. For the fact this construction presents, due to their characteristics, a high risk level and, good safety coordination, as well a good traffic management, the work was carried out with good safety conditions, although there have been traffic accidents records as a result of over-speed, above recommended.

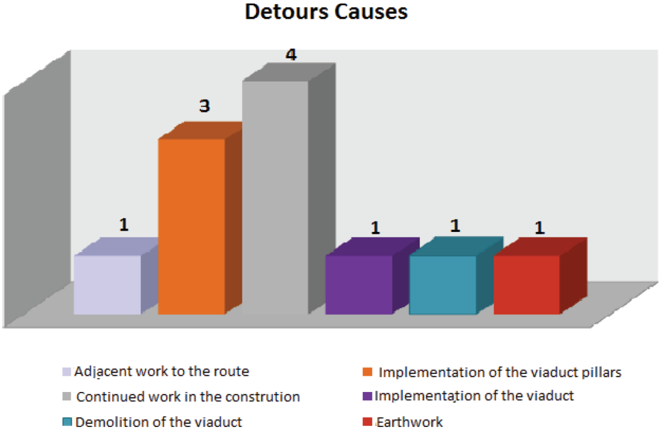

Figure 4. Detours cases.

There must be a higher-level control posture of workers, through their formation, to acquire knowledge of the possible consequences of poor posture.

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Integrating Lean Six Sigma and ergonomics—a case study

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ABSTRACT: Lean Six Sigma resulted from the integration of two powerful management philosophies: Lean Manufacturing and Six Sigma. It is a process-improvement approach focused on process acceleration, efficiency increase, and reduction or elimination of variation. In this paper a case study is presented where a Lean Six Sigma implementation is performed in an industrial plant with the support of Ergonomics, contributing for achieving the objectives defined by the company management. The company produces salted fish. The goals outlined for this study were focused on increasing productivity and productive capacity, while ensuring adequate levels of workers' health, safety and well-being.

1 INTRODUCTION

Nowadays, the market is experiencing a constant increase of competitiveness. Due to the economic conjuncture and the internationalization of markets, consumers are more demanding regarding the products they purchase. Therefore, companies feel the need to continuously improve their performance in all areas, such as in operations, organization or even in the adopted management strategy. This necessity leads many companies to implement Lean Manufacturing and Six Sigma principles, in order to optimize performance and keep up with competitors, or even overtake them (Melton, 2005).

Both Lean and Six Sigma philosophies are very important to reach a good productive performance. However the impacts may be very demanding from a human physiological perspective, because the intended goal is to ensure maximum production with minimum resources. Considering this fact, Ergonomics has a great relevance during the implementation of these paradigms, in order to preserve good health, well-being and safety of workers. One has to note that, even with the best production systems, human performance may not reach an adequate level if good working conditions are not provided to workers.

Along this paper a case study is presented where Ergonomic principles were implemented in combination with a Lean Six Sigma implementation. Metrics of productivity, production capacity and physical demean were used in order to assess the improvements obtained with this integrated approach.

2 THEORETICAL FRAMEWORK—LEAN SIX SIGMA AND ERGONOMICS

Lean Manufacturing is a production philosophy that appeared after World War II. This philosophy is derived from Toyota Production System that was based on Just-In-Time, which consists in adjusting production to demand in order to manufacture just enough quantity to satisfy the order, thus avoiding an unnecessary accumulation of stocks (Suzaki, 1993).

Lean manufacturing is based on five main pillars (Womack & Jones, 2003):

- Specifying the intended value by the client;
- Identifying the value chain, and eliminating all processes that doesn't aggregate any value to the final product;
- Promoting continuous flow production;
- Applying Pull system, where the customer calls for the product;
- Looking for perfection in a continuous way.

Lean Manufacturing is based on the revaluation of all company processes that contribute to its performance, maximizing the value added through cost reduction and increased agility (Cruz-Machado, 2007). It focuses on the elimination of eight types of waste, namely production defects, transportation, excessive inventory, unnecessary movements, over-production, over-processing, waiting time or even human capital under-utilization.

Six Sigma was developed by Motorola Company, in the 80 s, in response to an increase of the international market competitiveness created by Japanese companies. To cope with this situation, Motorola felt the need to improve the process quality, due to an excessive amount of defective production parts (Arnheiter & Maleyeff, 2005). The Six Sigma philosophy is based on a set of tools and methodologies and seeks to improve processes' output quality by detecting and removing defects causes. As a consequence of this philosophy, the waste of organizations decreases and the production variability is reduced as well improving production control and forecasts (Montgomery & Woodall, 2008) (Vinodh et al, 2011).

Ergonomics is a science that studies the interaction between human and the work environment. It is based on a systems approach oriented to optimize production systems by reducing incompatibility between human and productive process (Nunes, 2012). When the concern for human well-being is absent, it makes room to health and safety issues, and ultimately may result in low productivity. Adjusting working conditions to workers needs enables better performance (failure reduction, increased productivity, efficiency, quality, and flexibility) and well-being (Nunes et al., 2012).

The implementation of Lean Six Sigma seeks to improve performance of production processes by reducing waste, variability and costs (Dul & Neumann, 2009). This kind of strategies requires special attention from an Ergonomic perspective, since higher productivity is expected with fewer resources, which can compromise the working conditions.

According to Pepper et al. (2003), a decrease of the working conditions is often related to the implementation of Lean Six Sigma in companies. In order to minimize incompatibilities between workers and workplace, the integration of Ergonomics is quite helpful to ensure adequate working conditions which enable good productivity (Wilson, 2005).

Therefore, Ergonomics is an important contributor to add value to productive environments, in complement of Lean Six Sigma. In fact, it has been noticed that results of interventions targeting only higher productivity fall shorter than expected when workers needs are not valued.

3 METHODOLOGY

In this case study an integrated approach combining Lean Manufacturing, Six Sigma and Ergonomics methodologies was used in order to obtain a sustainable optimization of a salting fish production process, taking in consideration workers' well-being, health and safety.

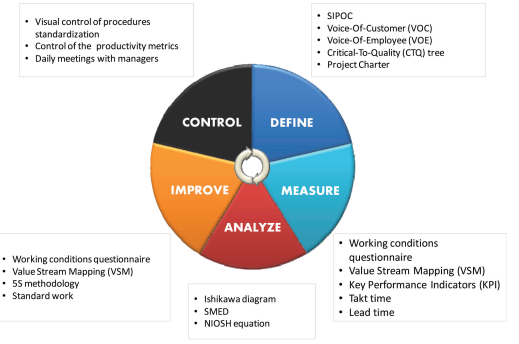

Figure 1. Lean Six Sigma and Ergonomics tools and methods (DMAIC cycle).

Due to confidentiality clause the company name and the type of processed fish are not referred. The company operates in Portugal and its core business is salting fish.

The methodology used in this case study was based on the DMAIC cycle (Figure 1). DMAIC is an abbreviation of the five improvement steps it comprises: Define, Measure, Analyze, Improve and Control. All of these process steps are required to be performed in the given order. DMAIC is the core tool used to implement Six Sigma projects. In the study tools and methodologies from the Ergonomics domain were added in order to improve also the working conditions. Such tools and methodologies are also presented in Figure 1.

4 CASE STUDY

4.1 *Process mapping*

The company salting fish production process (Figure 2) comprises 8 distinct processes.

The fish arrives frozen to the factory, headless and without bowel in 25 kg bags packed in pallets. At the end of each workday the frozen fish is placed in defrosting tanks (*Defrosting*) were it remains all night, allowing the processing on the next day. This process is performed by workers allocated to other production processes, namely *Opening*, *Cleaning* and *Salting*, which means they need to stop their effective production earlier to participate in this task. The *Opening* process consists in handling the fish coming from defrosting tanks and direct it to the "opening machine". Then the leftovers of blood or bowels that the previous process didn't remove are taken out (*Cleaning*).

In the *Salting* process workers place the clean fish into vats, which are filled with alternate layers of salt and fish. The fish remains in such vats during the *Maturation* process, involved in liquid brine. After this the fish is sent to the *Washing* process to remove the salt and is placed in dryers to dehydrate (*Dehydrating*). Finally the dehydrated fish is sent to the *Packing* process, where it is packed and shipped to the customer.

The study addressed the improvement of the first 4 processes, namely *Defrosting*, *Opening*, *Cleaning* and *Salting*.

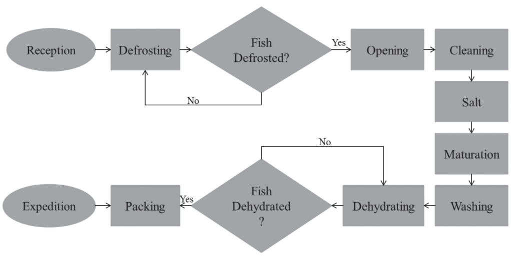

Figure 2. Production process flowchart.

4.2 *Results and discussion*

Due to space constraints only some results will be presented, however the entire study can be found in (Freitas, 2014). Results from the **Define** phase highlighted the opportunities for improving the production process, for instance in the *Defrosting* process two improvement opportunities were identified: *high physical demand* and *lack of process standardization*. At the end of the 1st phase (Define) the Project Charter was defined. Table 1 is an extract of such charter. The project duration was 8 months, the team members and the deadlines were also defined.

In the **Measure** phase the Value Stream Mapping (VSM) was designed (Figure 3) and the unbalance between the capacities of the different processes was perceived. The Lead Time (LT) is 257.5 hours; however the cycle time is 12.9 seconds which represents just 0.0014% of LT.

A questionnaire about the ergonomic aspects of the working conditions was applied to 15 workers. The physical effort was perceived as 'High' in the *Defrosting* and *Salting* processes. This justified a deeper analysis of these processes, in order to identify possible causes.

Table 1. Project charter (extract).

Title	Increase production efficiency and ergonomics in salted fish processing
Opportunity	With the current price reduction of salted fish and the increase of national and international consumption, it has become essential to increase the production of salted fish and simultaneously to optimize resources usage.
Project purpose	(1) Increase process productivity; (2) Reduce workers fatigue.
Problems to focus	(1) Loss of productivity caused by workers fatigue; (2) Need to stop production earlier to prepare fish for the next day.
Goals to achieve	(1) 10% productivity increase in *Defrosting* and *Salting* processes; (2) 15% production capacity increase in *Defrosting* and *Salting* processes; (3) Reduction of workers fatigue.
Project constraints	(1) Not enough time to complete Control phase; (2) Limited budget; (3) Improvement implementation must be coordinated with daily production.

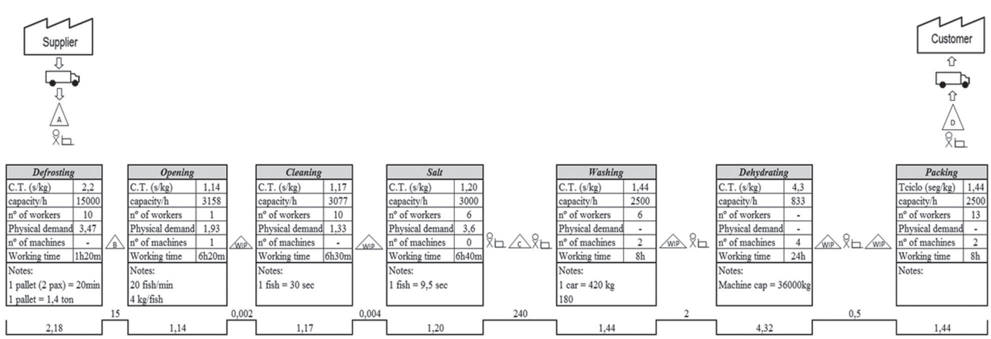

Figure 3. VSM before improvements implementation.

In the **Analyze** phase the production processes were analyzed, in order to identify problem causes and eliminate the problems and constraints. As an example, the NIOSH equation was applied to the *Defrosting* process. A *Recommended Weight Limit* (RWL) of 13.6 kg was obtained, since each bag weights 25 kg. This gives a *Lifting Index* (LI) of 1.83 meaning that this process could be physiologically injurious and can compromise workers' health.

Considering that the objective was to improve the results both in ergonomic and productivity terms, the goal of the **Improve** phase in the *Salting* process was to reduce, or even to eliminate the exertions made by workers when they spread salt on the fish using a shovel. Using brainstorming, the solution found was the installation of an automatic saltshaker positioned above the vats. The workers just need to press a button to activate the system, and it will automatically stop when there is enough salt over the fish. With this system the manual task of spreading salt is totally eliminated, thus suppressing much of the physical demand of this process. With this change productive improvements were achieved as well. The number of workers allocated to this process decreased to 3 and the cycle time increased slightly.

In the last phase, **Control**, commitment of all project stakeholders is mandatory to ensure the adequate monitoring of the improvement implementations and of the KPIs (Key Performance Indicators). The implementation of standards and visual control, afforded the following advantages: more accurate production forecast with less variations; more motivated workers by creating daily goals; faster integration of new workers due to tasks' procedure standardization; higher production quality and better organized workplaces.

5 CONCLUSIONS

All the production processes of the company changed due to direct or indirect improvements. Table 2 shows the metrics calculated before and after the improvement process. The improvements originated an increase from 20 to 24 tons in the salt fish daily production, which means an increase in production of 16.7%. Regarding the improvements obtained in productivity, measured in kg of salted fish produced per hour per operator: the higher increase was achieved in the *Salting* process (48%), followed by the *Defrosting* process (8.3%) and the *Cleaning* process (4.9%). Regarding the ergonomic improvements, reflected by the decrease of the tasks' physical demand and measured using the Likert scale: the higher physical demand reduction was in the *Salting* process (44.4%) and in the *Defrosting* process (37.1%); while the other two processes (*Opening* and *Cleaning*) maintained the same value. Besides this, the number of workers exposed to physical demands decreased from 10 to 2 in the *Defrosting* process.

As conclusion we can say that the implemented improvements had a very positive impact on the production process performance and also on the physical demand perceived by the workers. The goals initially set were achieved.

Table 2. Metrics calculated before and after the improvement process.

		Metrics					
		Productivity		Production capacity		Physical demand	
		(kg/h/op)	Profit	(kg)	Profit	Likert scale	Profit
Defrosting	Before	1500	8.3%	20000	16.7%	3.5	37.1%
	After	1636		24000		2.2	
Opening	Before	3158	0.0%	20000	16.7%	1.9	0.0%
	After	3158		24000		1.9	
Cleaning	Before	308	4.9%	20000	16.7%	1.3	0.0%
	After	324		24000		1.3	
Salting	Before	500	48.0%	20000	16.7%	3.6	44.4%
	After	1000		24000		2.0	

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Health and safety plans analysis

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ABSTRACT: Safety conditions at work are often poor leading to a worrying numbers of accidents, which are frequently serious and fatal. This reality is a consequence of the lack of preventive measures based on risk assessments as well as on deficiency of the responsible entities obligations. As a consequence, there is a Decree of law (No 273/3003) which enforces rules for organization and planning of Civil Construction Contracts and Public Works. Its main aim is to have a preventive approach to the construction activity, which attends to the hierarchy set out in the General Prevention Principles. This legislation provides the development of a single plan for Health and Safety for each work, which requires the participation of both, the work developer and the Project supervisor. In this way, the employer is bonded to the responsibility of preventing occupational risks ensuring to the workers safe, hygiene and health conditions in all work related aspects. This paper makes an analysis of the Vila Real city safety and health plans. The development and implementation of these plans will be evaluated accordingly to its proper legislation, ensuring its applicability in different construction areas. Proposals for possible adjustments between legislation and reality will be presented.

1 INTRODUCTION

1.1 *Objectives*

The health policy promotion requires the obstacles identification in order to adopt the correct preventive policies outside from the health sector, with the purpose to eliminate them.

The main objective of the elaboration of a Health and Safety Plan (HSP) is to list the evaluation of the risks at different construction phases and create preventive measures to them. As so, this document must be initiated with the project, as well as it must be adapted and developed during the execution of such work, being this plan an open and dynamic one. It is also important that these documents are disclosed in the work, allowing a good liaison with other governing documents of construction activity. The new plan establishes responsibilities of each intervening part in safety matter. The evaluation of risks in order to perform its prevention must be initiate at the project phase, analyzing all the works to be executed and involving the draftsperson in this evaluation, since the diversity of the risks to take in to account are stipulated by his options. It is, therefore, in this phase, that the planning of the preventive measures gets started as well as its site management.

2 METHODOLOGY

2.1 *Methods*

In a first phase of this paper, the Decree of Law No 273/2003 content was studied, as well as its requisites in safety construction and requirements to elaborate the Health and Safety Plan. Since this study main aim is the Safety plan analysis, it was of utmost importance to find out which elements must be included on it. For this, the Safety and Health Plans of Vila Real city in 2009 were analyzed. The total sum of these plans was sixty. A check-list was created based on the pretended answers in order to obtain a quality analysis of the Safety and Health Plans in the project phase (Pinto 2011). Taking into account that the elaboration of such a plan must contain all useful documents to risk evaluation and prevention, the HSP was subdivided in 3 chapters:

- Descriptive memory;
- Undertaking characterization;
- Risks preventive actions.

2.1.1 *Descriptive memory*

The descriptive memory must contain all the data concerning the subject safety undertaking, but not the ones that defined it directly. As it was previously said, it is an introduction to the HSP, and must contain:

- Definition of HSP objectives and reason for the elaboration of the plan;
- Previous communication content (when necessary), defined by current legislation;
- Current applicable regulation list, which could be necessary in order to consult;
- Organizational structure in work place containing: functional organization chart; areas of responsibilities; information system and working hours;
- Work accidents insurances and others, in order to guarantee that the company and all workers, or independent workers are covered by insurance.

2.1.2 *Undertaking characterization*

In the enterprise characterization there must be the characteristics of the work, in association with the foreseen risks for each execution phase. There must also be requested the documents that may be of use for the evaluation of risks and prepare a list of actions that could harm the workers safety, also defining associated risks. Making the follow subdivision:

- Undertaking description, with the general characteristics of the work and existing setbacks;
- Work execution, containing a list of all executable works, construction work schedule; constructive methods, man labor and equipment's schedule;
- Work place project, identifying all necessary support installations;
- Risk identification, by preparing a list of works with special risks; dangerous materials, with risk evaluation.

2.1.3 *Risk preventive actions*

After all the risks identification, the preventive measures to be adopted must be presented in order to remove or minimize it. This part is elaborated taking into account the previous risk identification and as such it must contain:

- Existing setbacks actions and action plans, where the evaluated prevention measures of the previous part must be present and the preventive measures are presented for the work and materials subjected to risk and also containing its register of the inspection;
- Work place accesses, signalization and circulation, in which it must be inserted the plan of access (visitors), signaling plan, circulation plan and pedestrian safety plan (case interferes with public streets);
- Collective and individual protection plan;
- Use and control of equipment, with the documents that they must contain and preventive measures relatively to all the equipment to be used in work place, such as: type of equipment, owner, dates of entry, dates of exit, revisions and inspections registration;
- Workers health plan which consists in the list of the workers physical and psychological periodical checking through medical examinations;
- Register and actuation of accidents, proceedings to apply whenever an accident takes place in work place, being elaborated a record which indicates the causes, monthly rate register of accidents. Indication of proceedings to be undertaken in case of an accident and indications of the circumstances in which it must be communicated to the Work Conditions Authority;
- Workers formation and information tutorials, where it must be the formation planning as well as the proper divulgation of information to the workers;
- Emergency plan, containing safety plan against fire risks, emergency procedures and first aid.

2.2 *Data gathering*

After the elaboration of the questionnaire allowing the evaluation of the safety and health plans quality, a detailed study of sixty processes of licensing of Vila Real was performed, in order verify that the questionnaire in question was in conformity with the existing legislation.

Table 1. Analysed processes identification.

Type of building	Type of work	No of plans	Percentage (%)
Single-family	Construction	27 (with demolition, 1)	54%
	Reconstruction and broadening	9 (with demolition, 3)	18%
	Broadening	3	6%
	Reconstruction/renovation	7	14%
	Total	**46**	**92%**
Others	Multifamily building	1	2%
	Day care centre, nursing home	1	2%
	Day care centre	1	2%
	Agricultural warehouse	1	2%
	Total	**4**	**8%**

Of these sixty processes, six refer to habitation legalizations. As the Portuguese Law does not compel to the elaboration of safety and health plans for habitation projects these projects where excluded from the sample of study. And there were other four projects that didn't have any information or indication of any type of preventive action, being also excluded. As so, ten of the previous sixty processes where exclude from the study sample.

2.3 *Data analysis*

In order to an objective data analysis, the previous presented subchapters were divided in simple elements, which can be directly responded with "yes" or "no", meaning the Health and Safety Plan contain or does not contain the element in question. As such, setting in the verification of the established elements inclusion, were assigned the grades from 1 (very weak) to 5 (very good). The grade 1 was assigned when it didn´t existed none of the necessary elements and the grade 5 when there were all included. In each chapter was defined the elements that should or shouldn't be included for the attribution of the other grades, 2 (weak), 3 (reasonable) and 4 (good). Subsequently, by calculating the weighted average was assigned a rating for each chapter and finally, following the same methodology it was obtained an overall score.

3 RESULTS

In order to attribute punctuation to the quality of the safety and health plans, different grades were given from 1 to 5 to each parameter of the parts presented in section 2. The lowest grade (1) was attributed when intended elements didn't existed and the highest grade (5) when the parameters included all the elements. Subsequently, through the calculation of the average, being that the weight of each parameter varied, a grade was given to each part, and finally another average of the global grade was obtained. The results of each part of the safety plan are going to be presented separately.

After the analysis of the descriptive memory, it was verified that:

- In the objectives definition, almost the totality of the plans (94%) indicated that this is of obligatory elaboration, despite that more than half (62%), didn't present the risk prevention;
- In 14% of the plans previous communication wasn't mandatory, being verified a lack of information relatively to the intervenient parts in safety matter;
- Most of the plans (86%) had enclosed a list of applied regulation updated, although approximately half presented it in excess, turning it in an exhaustive list;
- As for the work place safety and health management, very poor results were obtained, being that, only 12% of the plans presented a functional organization chart of the company, 30% the areas of responsibility, 16% referring to the information system and 24% indicated the working hours;

Work accidents insurances, in most of the cases, even though appear in the process where not mentioned on the data.

As it can be seen in Figure 1, only one of the total number of analyzed plans contains all the intended elements. On the other hand, only eight of the plans didn't have the minimum necessary elements. Relatively to the parameters of the descriptive memory it can be seen that the grades that prevail are the 2 and 3, which means unreasonable results.

Of the analysis of the part referring to the undertaking characterization, was verified that:

- Around 1/3 of the plans didn't contain any information about the land characteristics, although almost half presented the ones referring to the work;

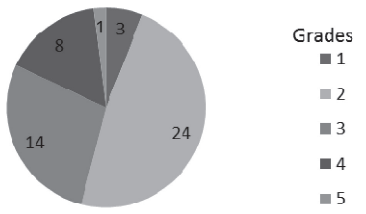

Figure 1. Number of plans per grade on the descriptive memory chapter.

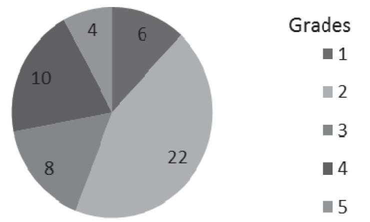

Figure 2. Number of plans per grade of the undertaking characterization chapter.

- There was especially little information relatively to undertaking setbacks, being that more than 80% of the plans did not even mentioned this parameter;
- There was incongruence relatively to the work place project, since small undertakings predicted social installations, such as, dormitories and dining places;
- Approximately 75% of the plans presented a list of works with special risks, although only 66% had identified the associated risks and 30% had described a list of dangerous materials with all the identified risks;

The final results for the analysis of the undertaking characterization are presented in Figure 2.

For this part analysis it was taken into account, for the data analysis, that it is more subjective than the other parts, because it depends on the previous parts, since only after having the risks identified it is possible to prevent them. On all effectuated analysis it was verified that:

- 80% of the plans, didn't had any type of action prepared for the existing setbacks;
- In 6% of the plans had prevention for demolitions, despite that it was not predicted as a risk;
- Approximately 50% presented plan of actions relatively to rubbles;
- 50% of the plans, were given the minimum grade (1) for the preventive measures relative to the proposed actions;
- Although approximately 20% presented access, signalization and circulation plans, only approximately half of these presented its prevention measures;
- The collective protection measures were mentioned in 80% of the plans, 90% revealed individual protection measures, although only 26% had the indication about the protections to be used;
- Almost all plans had some type of equipment control;
- There was not any indication relatively to the workers health plan in 72% of the cases;

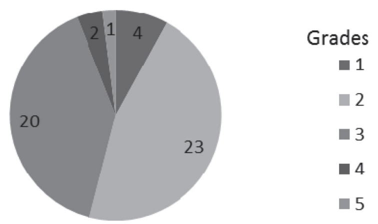

Figure 3. Number of plans per grade final results.

- Approximately half, presented conditions and planning for formation tutorials as well as for information divulgation to the workers;

The final results for the risks preventive actions can be observed in Figure 3.

4 CONCLUSIONS

The undertaking characterization, and considering the importance that it has on risks prevention, being that the risks can only be evaluated if their execution is predicted in detail, it was verified that since the project phase there is not a correct approach to it. How can the risks be avoided, if they cannot be predicted? As for the risks prevention, considering that there is an insufficiency of the previous information in order to obtain an understanding of the work complexity, it is realized that even when risks were detected, it doesn't exist much effort on trying to prevent them, starting in the project phase. Independently of the work to execute the Safety and Health Plan does not vary when elaborated for the same technician, being detected several errors, as it is the example of the existence of a demolition plan, without demolition works. It was noticed that in most of the cases, the analysis of existent risks is not done in the project phase. In practice a base model is used for all the projects, independently of the type of work. From study we concluded that in general there is a huge lack of HSP elaboration, despite of being an important document for prevention. However, relatively to the requirement of the elaboration of the plan there is a concern of the actual legislation fulfillment, though there is not, in most of the times, a preoccupation in the way it is executed. It must be mentioned that in this inquiry it was only studied the HSP quality evaluation in the project phase.

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Nanoparticles characterization and potential hazard assessments

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ABSTRACT: Researchers count about 1300 different types of nanomaterials. To a large extent they are present in cosmetics, drugs, cleaning chemicals, textile clothes, paints and fuel, rubber of car tires, i.e, things that humans are easily in contact with. Although some time may pass before the risks of nanomaterials can be accurately determined, an urgent need exists to consider the possible impact of nanomaterials production and manipulation. Also the way how these materials wastes will be stocked and in which manner the wastes should be handled are important issues.

1 INTRODUCTION

1.1 *What are nanomaterials?*

According to "The Economist", each human inhales 10^6 nanoparticles/minute. Growth, in this industry, is occurring rapidly. The National Scientific Foundation and Nanobusiness Alliance estimate annual growth rates of 20–40% [1].

Nanomaterials are defined as a set of substances where at least one dimension is less than approximately 100 nm. Nanomaterials are of interest because at this scale, unique optical, magnetic, electrical, mechanical and other properties emerge. These emergent properties have the potential for great impacts in electronics, medicine, and other fields. OECD lists the representative manufactured nanomaterials using fourteen categories, as it may be seen in table 1.

Table 1. OECD list of representative manufactured nanomaterials [2].

- Fullerenes (C_{60})
- Single Walled Carbon Nanotubes (SWCNT)
- Multi-Walled Carbon Nanotubes (MWCNT)
- Silver nanoparticles
- Iron nanoparticles
- Carbon black
- Titanium dioxide
- Aluminum oxide
- Cerium oxide
- Zinc oxide
- Silicon oxide
- Polysterene
- Dendrimers
- Nanoclays

The observation of table 1 shows, not only very different chemical compositions, but also that the geometry can be a variety of shapes (sphere, rod, tube, ring, etc.) and is dependent on the synthesis methods.

Nanomaterials may be either organic (dendrimers, polymers, etc.), inorganic (metals, metal oxides, metal hydroxides, etc.), carbon (carbon nanotubes, buckyballs, etc.), or a combination of these materials. Even more complex systems are possible if surface functionalization is used to control surface charge and interactions.

1.2 *Nanomaterials release*

Nanomaterials may come from manufacturing, landfills, and wastewater effluents or by non punctual sources like, wear/attrition of tires, sunscreen brake pads, storm-water runoff, and wet deposition. Biochemical cycling of nanomaterials may involve photochemical reactions in the atmosphere, aggregation, accumulation, transformation and degradation. Nanomaterials in groundwater and surface water will be subject to conventional treatment methods, such as flocculation, sedimentation and sand membrane filtration. Human exposure to nanomaterials is most likely during manufacturing, but inhalation of nanomaterials released to the atmosphere, ingestion of drinking water or food (e.g., fish), that accumulated nanoparticles and dermal exposure from sunscreens and cosmetics is also possible.

1.3 *Types of exposure*

Inhalation may take place by workplace exposure, or at open air. Ingestion occurs in food, drinking water, and incidental. Dermal exposure may take place by the use of sunscreen or cosmetics. Although defense mechanisms exist, alveolar tissue is not as well protected as skin or gastrointestinal tract, against environmental insults. Currently researchers are trying to understand the effect of nanomaterials and determine how they interact with the ecology of the planet. They have already revealed violations of the embryonic development of fish, such as the zebra danio, caused by nanoparticles [3]. Changes in the respiratory system of the coast rainbow trout have also been revealed. Researchers are even more concerned with the fact that some nanoparticles are able to transport poisonous substances, specifically Cd and As [3], into the body of fishes and accumulate there. This affects, mainly, fishes that are widespread as carp. Carp enters in both, human and animal food chain.

1.4 *Transport and fate*

The higher mobility of nanomaterials implies that they are dispersed over greater distances and their effective persistence in the environment increases [1]. The capacity to produce aggregates and to attach to surfaces is one factor that may reduce exposure.

Due to their small size it would be expected that they were highly mobile in porous systems. However, if all other factors are equal, smaller particles are not very mobile because their large difusitivity that produces more frequent contacts with the surface. Similar considerations lead to a high deposition rate of ultrafine airborne particles in the lungs.

Particle deposition and aggregation are two close phenomenons. Factors that favor particle removal by deposition often tend to favor aggregation and subsequent removal by settling. In the case of very small particles (<2 nm) the simplified assumptions commonly applied in theoretical considerations of particle attachment may no longer be valid.

1.5 *Disposal*

Direct disposal involves landfill, incineration or removal during wastewater treatment. Mueller and Nowack [1] have estimated the potential material flow. Their work suggests that up to 95% of the nanoparticles (Ag, TiO_2, CNT), used in cosmetics, paints, coatings and cleaners are more likely to end up in water treatment plants.

Carbon Nanotubes, used primarily in composite material for plastics, sporting equipment and electronics, will remain intact until their individual disposal in landfills or incinerators. If this material is not removed during incineration or water treatment or if leaching occurs from landfills, they will ultimately be released to the environment where they can undergo bioaccumulation.

2 ELEMENTS OF RISK

For nanomaterials to present risk there must be both, a potential for exposure and hazard. Toxicity, results after exposure.

Exposure varies on the basis of conditions such as the manner in which the materials are handled in the workplace, how nanomaterials partition to various phases (e.g., water and air), their mobility in each of these phases, their persistence and the magnitude of the sources (e.g., size of the market).

Evaluation of potential worker exposure in fabricating facilities has focused largely on airborne pathways. Recent evaluations of aquatic media have focused mainly on damage to lung tissue, after inhalation. Although some nanomaterials, like fullerenes, have very slow solubility in water, functionalization may increase their affinity for the aqueous phase and their potential reactivity with cells.

Numerous studies have investigated cell interactions and toxicity of nanoparticles [4,5,6,7,8,9,10]. In table 2 a short resume of these studies is shown.

Currently scientists are studying the effect of nanomaterials in the planet ecology. Orberdorster [11] made a pioneering study on the impact of nanoparticles on the health of aquatic systems. He concluded that stable colloidal suspensions of C_{60} buckyballs in water exerted oxidative stress and caused severe lipid per oxidation in fish brain tissue.

On the other hand, numerous observations have been made of fullerenes acting as antioxidants. Actually, antioxidant behavior of fullerenes has been compared with those of vitamin C and E. This apparent contradiction underscores the need for research on nanomaterial-cell interactions and the resulting effects on metabolic processes and cell physiology as a function of dose and exposure conditions.

Microorganisms are the foundation of all known ecosystems. They may serve as mediators of nanoparticles transformations that affect their mobility and toxicity. Thus, a better understanding of these interactions is important because will ensure that nanoparticles evolve a tool to improve material and social conditions without exceeding the ecological capabilities that support them.

Table 2. Nanoparticles toxicity studies.

Nanomaterial	Observed effects
Fullerenes, C_{60} water suspension	Antibacterial, cytotoxic to human cell lines, taken up by human keratinocytes, stabilizes proteins
C_{60} encapsulated	Damages eukaryotic cell lines, antibacterial
Hydroxylated fullerene	Oxidative eukaryotic cell damage
Inorganic SiO_2	Pulmonary inflammation
Anatase (TiO_2)	Antibacterial, pulmonary inflammation in rodents
Zinc Oxide (ZnO)	Antibacterial (micrometer scale), pulmonary effects in animals and humans

Some eukaryotic cell can assimilate large nanoparticles (up to 100 nm) [12], but bacteria, generally cannot assimilate particles bigger than 5 nm, including C_{60}. So we may assume that antibacterial activity involves direct contact of nanoparticles with the cellular surface. These conclusions show the importance of surface chemistry and morphology in nanoparticles toxicity.

Theoretical considerations indicate that the smaller nanoparticles may be more toxic due to their large specific surface areas. Thus, factors that promote coagulation and precipitation of nanoparticles in the environment will probably decrease their toxicity.

Metal and metal-oxide nanoparticles have been proposed to water treatment, groundwater remediation and removal of toxic contaminants from air [13]. Their widespread use could expose biological systems, thorough inhalation, dermal contact or ingestion and absorption through the digestive tract.

3 CONCLUSIONS

Definitive answers on the risks posed by nanomaterials are perhaps years away and, in any event, are likely to emerge on a case-by-case bases.

Some countries are trying to control this problem. France created a Committee for Monitoring Microtecnologies and Nanotechnologias with 250 scientists and researchers.

The British Standards Institute (BSI) issued the Published Document (PD) 66992:2007 "Nanotechnologies—Part 2:Good Practice Guide to Safe Handling and Disposal of Engineered Nanoparticles." The British Manual, not being a standard, has the status of PD. This is a peculiar "pre-standard," and is, undoubtedly, a prototype of a future British, European, or International Standard [14].

The United States National Nanotechnology Initiative (NNI), which includes several government agencies (e.g., the U.S. EPA, the National Science Foundation, the National Institutes of Health), supports research programs to investigate the fate, transport, and life cycle of nanoparticles in the environment and their potential toxicity to humans and the environment. In the year 2004, 3–5% of NNI's $849 million budget was targeted to research on nanoscale processes in the environment, as well as the environmental and social implications of nanotechnologies.

But there is still the need to constant studies and the effort of many researchers in order to understand and protect the planet from the new materials that, spite of all the problems, may be the 21st Century revolution.

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Possible uses of Augmented Reality as a tool for guidance of users of packages

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ABSTRACT: Currently, with the current advancement of Augmented Reality (AR) technology it is now possible to note a significant increase of possibilities for using use of its tools in the process development and use of a product. By inserting virtual objects/information in the real environment, AR can contribute to the interaction of objects with its users, as well as to develop and test products. With AR systems applied to product it is possible, for example, to simulate different uses and to guide/inform users. Thus, from the perspective of informational ergonomics and safety, the aim of this research is to explore some possibilities of using AR as a guidance tool for users of consumer packages. With thus purpose, a literature review was carried out in order to identify AR applications for this type of product that are focused on users' guidance, and possible ergonomic issues, usability and safety involved.

1 INTRODUCTION

The target product of this research—the package—is a product of regular consumption and daily use. In most cases, a single model is presented to several types of audiences, ages, gender, levels of experience and different needs. This can result in a number of difficulties with different forms and degrees of severity. These difficulties can range from a not understanding a simple product label and/or opening/closing mechanism to the occurrence of discomfort, or even some incidents/accidents during product handling.

All packaging must meet the minimum requisites for safety and comfort. In this sense, Poças & Moreira (2003) present as one of the functions of packaging—'the service'—i.e., besides contributing to the user safety it should also be designed so as it not constitutes a hazard to the user.

In general, instructions are not common in consumer packs, mainly because people understand that most of products are just a regular and simple object to use, that can be used easily and intuitively, but also because there are some dimensional restrictions in the product and therefore the area for information is generally restricted to the label. Information on how to use, such as how to open or close or if there is a need for a specific tool to open the pack, does not appear on most labels. Generally, the information is limited to data relating to the product, brand, manufacturer, and how to use the content (in some cases) according to the legal requirements (in the case of containers for flammable products, for example). Some packs have instructions of use, presented textually and/or by pictograms. However, this information often have problems of legibility/understandability by users, due to several reasons: inappropriate design of information, whether it is textual or pictorial, excessive text on the label, or even the lack of interest of the user to seek such information.

Bonfim *et al* (2013) states that intoxication is one of the major problems related to the use of packages, especially for children and packages of medicines, household cleaners and chemicals. To Dahrouj (2009) warnings on the labels are the most conventional methods for accident prevention of intoxication in Brazil. However, these warnings are not highlighted enough and may be not enough to prevent accidents.

To Zunjic (2011) the lack of clear instructions on how to open pack often leads to the emergence of consumer frustration and to apply aggressive methods for opening, which often are not appropriate for the type of pack, which may also increase the possibility of injury of the user.

The big challenge in user interface x pack interaction is mainly to eliminate or minimize the difficulties in interfaces—usability problems and risks of accident. Both regarding the design of the product and in the information provided to the user. A flaw in the design of a package or not understanding a warning can have fatal consequences for the consumer, as in the case of a drug package.

Accordingly, the use of AR, which emerged from the Virtual Reality, may contribute to the process of communication between users and consumer packaging, "increasing" the necessary information for ensure user safety through applications with graphical user interfaces (two and three-dimensional) and sound.

AR technology has been an important tool used by industry to let the users being more familiar with their products, mainly through the current improved usability of portable devices such as notebooks, PDAs, tablets and even mobile phones, when used as display interfaces for mobile applications of AR.

Thus, from the perspective of informational ergonomics and safety, the aim of this research is to explore some potential uses of AR technology for the guidance of users of consumer packages.

2 METHODOLOGICAL PROCEDURES

This article is basically a literature review and it is part of the definition of the state of art to be included in a doctoral thesis under development in a Brazilian university. The main challenge of thesis is to verify, through the application of some usability tests, if the use of AR systems can be effectively used in the communication process regarding the guidelines and warnings for users of commercial product packages.

With this purpose, a literature review of scientific papers in conferences and journals, theses and dissertations (national and international) related to ergonomics, usability and safety of packaging and Augmented Reality was conducted. The outline presented here refers to the AR applications in research carried out in Brazil.

3 USES OF AR IN PACKAGES AS A GUIDANCE TOOL

Augmented Reality is known as a technology, or extension of Virtual Reality (VR). They differ primarily by the environment created—totally artificial (VR) or hybrid and real (AR). Augmented Reality has come to make the interface user interaction as natural as possible, allowing the handling of objects without the aid of expensive and complicated technological devices.

Augmented reality consists of a combination of informational elements of virtual reality with scenes of physical reality. With the use of devices and techniques (semi-transparent mirrors, semi-transparent screens, stereoscopic projection) can be added synthetic visual information to complement existing physically visual information in a scene. (Silva *et al.*, 2009).

Using AR techniques all human senses can be involved in their applications, however, according to Zorzal *et al* (2011) the most developed work in this domain is still focused in the increase of the visual sensation. The authors also state that there are a few studies with applications involving the other senses such as tactile and hearing, with results as good as those obtained with application developed to the visual sensation.

Applications in packaging systems in AR are already adopted, especially in regards to entertainment, information and promotion actions (currently most used for nutritional information), demonstration of the packaged product, among others. However, its use is relatively recent and only a few products use this feature, if we consider the overall quantity of packages in the market. Despite the access technologies is being increased, the use of AR among the general population is still scarce and applied basically for presentation purposes.

In Brazil, the first experience was carried out in 2009 by PepsiCo Brazil in the package of a special edition of Doritos—Doritos Sweet Chilli. A marker on the back of the package, when positioned in front of a webcam, enabled the brand website and a small 3D cartoon was shown to users, the Doritos Lover. (Packaholic, 2009).

The survey found some research about applications consists of AR in packages with a focus on user guidance. Three surveys conducted in Brazil are briefly described in this paper. Two applications of AR in packages and another one with a different type of consumer product, which was chosen due to the fact that AR was used here as an usage guidance tool.

In the first study, Tavares *et al*. (2006) present an application of AR to the presentation of nutritional information of food products for its users—the NUTRI-VISU. The authors justify the proposal, by referring the location difficulty as well as the placement of the necessary information in the same areas of the labels. The research was conducted with supermarket customers. Figure 1 shows a scene generated by the application.

The DART (Designer's Augmented Reality Toolkit) integrated with Macromedia Director was used as development environment for this application of AR. Further, for the construction

Figure 1. Example of a scene generated by VISU-NUTRI. (Tavares *et al*., 2006).

of three-dimensional objects that make up the environment Autodesk 3DStudioMax software was used. Each product is associated with a label. Graphics were designed in AR on the actual product, where the customer can analyze and compare the nutritional data of different products more clearly. The article presents the development and evaluation indicates that the system would occur later.

The research developed by Forte *et al* (2012) presents a proposal for use of Augmented Reality technology in developing an application with the function of assisting consumers who have reduced visual acuity in order to allow them autonomy in the selection process of products arranged on a shelf. The autors also assess the possibility of using tablets by this public so that AR is an enabling element of the process. The EYEBUY was marked on the Android Operating System, and a tablet device as standard was used. As tools for the implementation of the project, we used the Unity 3D game engine and the Vuforia SDK. With the projected applications could graphically display tables with nutritional information, and even narrations with the same visual information. Preliminary experiments to test the efficiency of the application in the laboratory, which counted with the participation of five volunteers, of whom 80% had some problem associated with decreased visual acuity were performed. The authors state that, even with a small sample, the use of EYEBUY shows the downward trend for these volunteers, the time required to search for the requested information. The Augmented Reality, in this context of use, it was considered important and presented a real possibility of technology to be employed in the quest for facilitating access by persons with special needs. Figure 2 shows the graphical interface designed.

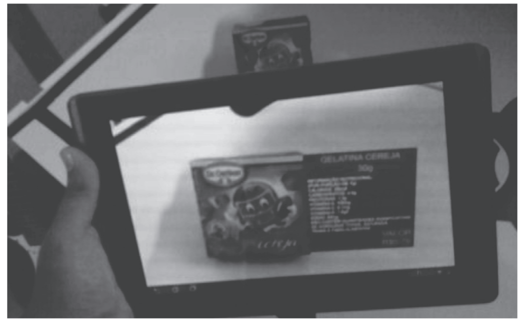

Figure 2. EyeBu, Example of graphical interface designed. (Forte *et al*., 2012).

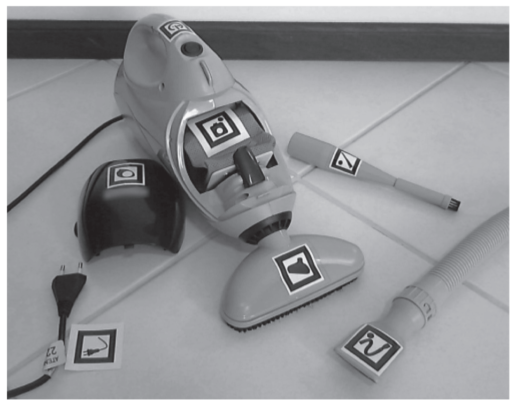

Figura 3. Vacuum cleaner with fiducial markers AR. (Gonçalves, 2012).

In the third research, Gonçalves (2012) proposed the use of Augmented Reality, through the use of "serious game", for the guidance of the use of a new product (electric appliance). For both, virtual objects and sound instructions were generated from fiducial markers (Figure 3).

Data from research demonstrated that participants who had direct contact with the product and were guided by interactive instruction through the game in AR showed a better performance, when assessed by some usability metrics, when compared to other participants that used conventional means like the instruction manual booklet, for example.

4 CONCLUSIONS

Augmented Reality applications in product design still require further study and applied to different categories of products, their effectiveness in different phases of the project and specific users.

Lucena (2012) states that some researchers, such as Tori, Azuma and others suggest that to improve what already exists in terms of AR, other areas need to be involved, such as design, more specifically, the informational design. The authors also suggest that one should better understand how virtual information is displayed to the user and how they interact with them.

Regarding the research on AR, Kirner (2008) states that there are some increasing trend, due to the reduction of costs, ease of access to resources, the use of touchscreens displays, and exploring the use of tangible interfaces. Besides the growth of collaborative applications with Virtual and Augmented Reality, mainly supporting areas such as education and training, with emphasis on distance learning, and virtual laboratories.

As there is a significant increase in research on applications of AR, it is also necessary to assess the effects of these applications through more in-depth, interdisciplinary and significant samples of actual users of the systems studies. In the case of AR in packs, front of potential use for user guidance, "increasing" the information necessary to the security of the user through graphical features (two and three-dimensional) and sound, the interaction between users and systems, usability aspects, as this relationship reflects the user learning about the product must be analyzed.

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Occupational Safety and Hygiene III – Arezes et al. (Eds)

Productivity and absence of workers with disabilities: Case study in the construction industry

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ABSTRACT: The purpose of this research was to evaluate productivity and absence of workers with and without disabilities in a construction work of a building. In the construction work where the research was applied there were four employees with physical disabilities. The methods used in the research were: direct observation of the activities and the environment; and a video and photographic record of the tasks, semi-structured interviews, application of socio-demographic questionnaire and data collection about absences and the productivity of employees with and without disabilities. In 75% of the cases, the company made some organizational adaptation, it was found an average of 2 and 2,5 absences of the workers with and without disabilities, respectively. In most cases, the production of workers with disabilities was smaller than the workers without it.

1 INTRODUCTION

People with disabilities (PD) represent about 15% of the world population, or one billion people (WHO, 2011). While in Brazil this figure is 23.9% of the population, i.e. there are 45.6 million PDs in Brazil (IBGE, 2011). The inclusion of this population in the social-labor environment has been discussed and encouraged in many countries through various laws, for example from quotas set for the employment of people with disabilities. In Brazil, laws establish a quota of 20% for public sector enterprises and 2% to 5% for private companies with over 100 employees.

Despite the attempts to include PD at work, the number of such people seeking employment and of those receiving job opportunities remains low. A recent study showed that in 27 countries, working-age persons with disabilities experienced significant labor market disadvantage and worse labor market outcomes than working-age persons without disabilities. On average, their employment rate, at 44%, was over half that for persons without disability (75%) (OECD, 2010). In the meantime, in Brazil, of 47.4 million people employed in 2012, only 330.296 were declared as people with disabilities, representing 0.7% of total (RAIS, 2012).

The construction industry is the fifth largest employer in Brazil between the sectors of economic activity, with about 2.5 million workers. However, between the years 2009 and 2010, it was the sector that had the biggest increase in workers (RAIS, 2012). Despite the importance of this economic sector in Brazil, there is a lack of publications on labor inclusion of PD in this sector in the country (Guimarães, 2011). This occurs not only in Brazil, because according to Newton and Ormerod (2005), there has been no previous research on construction industry employment and people with disabilities.

According to the survey results of Newton and Ormerod (2005), typically, workers with disabilities work in offices rather than on construction sites, in most construction companies. Furthermore, it is not known the types of impairment that they have, the relationship between environment and impairment and the impacts of that environment such as the type of work.

In this context, there is a need to determine which jobs can be performed by PDs and what adaptations are needed. Besides is also important to verify, in construction work industry, if the workers with disabilities present productivity similar to workers without any disability. Thus, the purpose of this research was to evaluate productivity of workers with and without disabilities in a construction work of a building.

2 METHODS

The survey was applied in August 2014 in a hotel construction site in the metropolitan region of *Recife*, in the state of *Pernambuco*, Brazil. The construction was in its finishing phase and there were 188 workers, in which four of them presented disabilities, being one handler and three hodmans.

The methods used in the field study were: direct observation of the activities and the environment; and a video and photographic record of the tasks. Following that, there were semi-structured interviews (elaborated by the authors) with the worker with disabilities and his supervisor, with the intent of identify the tasks performed. The employees with disabilities answered a socio-demographic questionnaire (elaborated by the authors) and data was collected from the company about absences and worker's productivity, with and without disabilities, that performed the same tasks in order to make a comparative analysis. The employees without disabilities that would have their data compared were determined randomly and according to tasks performed, because it would be necessary to compare the productivity of similar activities.

3 RESULTS

Worker 1, E.S.S., was 41 years old and had complete secondary school. He presented physical disability, due to consequence of poliomyelitis, with dissimilarity of length (3 centimeters) and monoplegia of the inferior right member; CID 10 B91; G83.1; M21.7; M41.9 and M21.5. He was in charge of construction for 1 year and 6 months, and previously, had worked with masonry for 6 years. The activities performed were: distribution of tasks to the workers, verification of tasks assigned to the workers, establishment of deadlines to the tasks and management of the workers in his team. The company didn't make any work adaptation for worker 1 perform his activities.

Worker 2, M.F.S., was 41 years old and had incomplete secondary school. He presented physical disability, the atrophy type and reduction of the inferior left member, his left feet was smaller than the right one; CID 10–Q72.8 and Q66.2. He reports pain in walking for a long period. He was a general hodman, for 3 months. His assignments were: cleaning the construction site, the lunch room and the bathrooms. The company had to make organizational adaptations, such as allowing that the employee performs lighter activities, without carrying weight or working in high places so that he can perform his tasks in masonry.

Worker 3, M.D.B.O.S., was 23 years old and had incomplete secondary school. He has physical disability, dyskinetic cerebral palsy, in which he presents difficulties in speaking and tremor in the

Table 1. Absence and productivity of workers with and without disabilities.

Worker	April 2014	May 2014	June 2014	July 2014
Worker 1*	A = 0 P = 0	A = 0 P = 0	A = 0 P = 0	A = 0 P = 350,00
Worker in charge 2	A = 0 P = 0	A = 0 P = 0	A = 0 P = 0	A = 1 P = 599,99
Worker in charge 3	A = 0 P = 0	A = 0 P = 0	A = 0 P = 0	A = 0 P = 906,88
Worker 2*	– –	– –	A = 0 P = 0	A = 3 P = 247,17
Worker 3*	A = 0 P = 72,80	A = 0 P = 160,00	A = 4 P = 160,00	A = 0 P = 100,00
Worker 4*	A = 0 P = 0	A = 0 P = 160,00	A = 0 P = 160,00	A = 1 P = 247,17
Hodman 1	A = 0 P = 560,00	A = 0 P = 352,40	A = 0 P = 323,10	A = 0 P = 313,34
Hodman 2	A = 0 P = 524,00	A = 4 P = 223,00	A = 7 P = 0	A = 0 P = 416,67
Hodman 3	A = 0 P = 0	A = 0 P = 0	A = 0 P = 0	A = 1 P = 218,82
Hodman 4	A = 0 P = 0	A = 0 P = 291,00	A = 0 P = 218,82	A = 0 P = 218,82

*Worker with disabilities. A = absence; P = value in *Reais* (R$) by productivity.

superior members during talk; CID 10–G80.3. He worked as a general hodman for about 5 months. His activities were: cleaning the construction site and the apartments after settlement of tilling and applying drywall. The company had to make organizational adaptations, such as allowing that the employee performs lighter activities, without carrying weight and working in high places so that he was able to perform his activities as a hodman.

Worker 4, M.S.N.S, was a 30 year old female and had complete secondary school. Her disability was absence of fingers in her left hand.; CID 10–Q71.3. She was a warehouse assistant for 5 months. Her tasks were: distribution of wares to the employees in the warehouse and register of that in a log book, organization of Personal Protection Equipment (PPE) in warehouse lockers, workers clothing separation, that needed to be cleaned or thrown away. The company had to make organizational adaptations, such as allowing that the employee performs lighter activities, without carrying weight and, when necessary, ask for help for another worker to get heavy objects so that she was able to perform her activities.

Comparing the absences of workers with and without disabilities is presented in table 1. It's important to highlight that hodmans 1, 2 and 3 perform the same activities that worker 3 and that hodman 4 does the same functions that worker 2. A comparison was made of absenteeism among workers who perform the same activity, given that different activities have different musculoskeletal overload which can lead to different results in absenteeism.

The Productivity is measured by the company in accordance with the amount of tasks performed for each function, that results in a value in *Reais*, Brazilian money, that is added to the employee's paycheck. Data was collected from the company about worker's productivity. The amount of productivity received by the workers, with and without disabilities, is presented in Table 1.

4 DISCUSSION

From the results analysis, it's possible to verify that most workers are male and all workers with disabilities have a predominant physical disability. That result supports the data of Brazil, once most of the workers with disabilities are males (65%) and with that kind of disabilities (66,10%) (RAIS, 2012).

In the field of schooling, it was found out that 50% of the sample presented incomplete secondary school and 50% completed secondary school. That result is different from the country data, once that only 42,27% of workers with disabilities presented completed secondary school and 39,55% incomplete secondary school in Brazil (RAIS, 2012). In concern of the Pernambuco state, in 2009, 31,3% of all construction workers had incomplete secondary school and 21,5% completed secondary school. The incompatibility of these data can be caused by the small sample studied in this paper. SINDUSCON/PE (2003), the building construction industry has an important role in employment generation, direct and indirect, especially for those with low professional training.

It was noted that in 75% of the cases, it was necessary some kind of adaptation in the job of the workers with disabilities. In those cases, all the adaptations were organizational, such as lighter tasks distribution, without handling weight and prohibition of working in high spaces. The results are similar to the ones of Stoddard (2006), in which 64% of employers that adjusted work stations to PD, confirmed that they reassigned non-essential tasks to other employees. It's noted that it wasn't invested money, *Real* (R$), with the adjustments, result that was similar to the results of Schartz, Hendricks and Blanck (2006), in which 259 of the companies that made adaptations of the work of PD, in the first year after inclusion, 49,4% of employers confirmed that didn't spent any amount of money with the adjustments.

In the matter of absence at work in the last 4 months, the average was 2 absences per worker with disabilities and 2,5 for workers without disabilities. Besides the small sample and that the fact that the research was done in one construction work of a single company, the results show that workers with disabilities have less absences than workers without disabilities.

Comparing the values of productivity, in *Reais,* paid for the company to the employees, it was verified that worker 1 didn't received productivity for 3 months, just like the other workers in charge without disabilities. In the fourth month, the worker 1 received an amount smaller than workers in charge 2 and 3.

It was noted that in the month (June) that Worker 2 begun work, he didn't receive productivity, but in the second month (July), he received a bigger amount than hodman 4, that performed similar function. Worker 3 received smaller amount of productivity in 4 months comparison to hodman 1, in 3 months in comparison to hodmand 2 and in 1 month in comparison to hodman 3. Worker 4 received smaller amount of productivity in 4 months in comparison to hodman 1, in 3 months in comparison to hodman 2 and in any month in comparison to hodman 3. However it's important to notice that there is no other worker that performs the activities similar to the worker 4, making it difficult to make a data comparing.

It's important to highlight that this research is a case study and it was applied in just one construction work and with a reduced sample. Therefore, due to the lack of publications in the building construction theme, it is necessary new researches, with bigger sample and in many different constructions of several companies to better understand the production environment and absences of workers with disabilities in the building construction environment.

5 CONCLUSION

The results of the research show that in 75% of the cases, the work environment was adapted, in organizational way, and it wasn't necessary financial investments. Besides that, it was noted that workers with disabilities presented a smaller absence average and production than the workers without disabilities.

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Occupational Safety and Hygiene III – Arezes et al. (Eds)

Way finding of blind people in the work environment: An ergonomic sight

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ABSTRACT: This paper relates to the importance of the systemic and ergonomic approach to conceive informational systems of way-finding to blind people in the working environment. The intent is to bring some contributions to models of systems operating from the analysis of the problems noticed during the execution of a planned route by blind people with the help of a tactile map. The results are three system's models that can subsidize the information designer to figure out "what", "how" and "where" to insert the informational content in each subsystem and supra system to future projects of way finding for blind people. This is the product of insights made from a research about ways to assist the navigation of blind pedestrians through the tactile map.

1 INTRODUCTION

The blind person has his work activities damaged if it is not possible to find an environment adapted to its needs of knowing where he is and where to go. He is willing to have insecurity and stress at his work position, not only because of attitudinal and instrumental barriers, but also because of architectonic and communicational hurdles.

The inclusion of people with disabilities in the work market depends not only on the individual qualification and work tasks facilities by assistive technology, but also on effective equalization of opportunities where it is required physical modifications on the working space to ensure the access and good performance in human activities from a adequate drawing, in equipments and also in spaces of constructed environment. (Bins Ely, 2003).

The tactile map is considered, in this context, an informational instrument that helps the decision-making process, the execution of the decision and the information processing of blind people to their orientation and mobility, provided in a systemic approach of Ergonomic.

Artur & Passini (2002) define way finding as a solution to space problems and comprehends three process interrelated: the "decision making" as a process of planning an action; the "execution of the decision" the act of transforming the plan of action in behavior and the "informational processing" that is the environment perception and cognition, where the base of information of the two process mentioned are based.

Dealing with way finding for blind people at the work space under the ergonomic sight, focusing in the relation between the blind person, the tactile map and the environment, refers to a creation of an informational system that protect the autonomy, security and satisfaction of the blind worker.

2 OBJECTIVE

The objective is to bring some contributions to models of systems operating from the analysis of the problems detected during the execution of a planned route by blind people with the help of the tactile map.

3 METHODOLOGY

The contributions to operating models of systems were achieved based on the systemic method proposed by Moraes & Mont'Alvão (2010)—Systematization of the System Human—Task—Machine—SHTM from the analysis of the problems noticed during the execution of a planned route by blind people with the help of the tactile map. The orientation decision and its execution were analyzed during a research experiment that resulted in a Master's degree dissertation. (Almeida, 2008). The techniques employed were observation, behavior register and inquests, as interviews and questionnaires, plus photographic and video recordings.

4 EXPERIMENTAL STUDY PROPOSED

The analysis of the executions of orientation decisions by blind people was performed during one of the steps of the proposed experiment by Almeida

(2008) at the Educational Center of the University of Pernambuco (UFPE), a place unknown by the participants.

It was selected twelve people: four with congenital blindness, four with low vision and four that became blind at an adult age, considered adventitious blindness. They were supposed to have waling-stick, cane, experience, adapted to its use; have the habit of walking frequently in a variety of places; a similar level of knowledge, and some professional experience.

Each one of them had the incumbency of 1) plan a route, from a tactile map, 2) execute the planned route and 3) describe the route after the reproduction of it with magnetized tape under metallic plates. The analysis of the problems relating the execution of the orientation decision was performed during the execution of the planned route, incumbency 2.

The fact that there were blind people with visual memory and some with residual vision made necessary to blindfold the participants, in order to neutralize them, and to not interfere or influence the studied phenomena.

The tactile map was 0,305 m by 0,47 m in the scale 1:100 made under a wood structure, covered by cardboard and then acetate. Different textures were placed on it to refer to the meaning of the route they would perform, as doors, bathrooms, extinguishers, garbage cans fixed in the wall, columns, rooms, garden, sidewalk and stairs. To the fully understanding of the symbology, a Braille legend was designed. Figure 1 show the tactile map and Figure 2 exemplify its use.

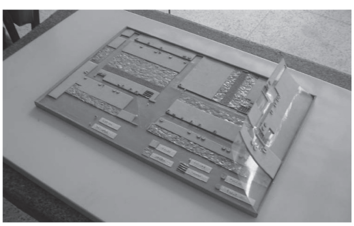

Figure 1. Tactile map designed for the research. Source: collection of the author (2008).

Figure 2. Planning of the route. Source: collection of the author (2008).

5 PRESENTATION OF RESULTS

5.1 *Questioning of the human—task—machine system*

According to Moraes & Mont'Alvão (2003) the way to identify the problem opens the possibility to decide what should be considered or ignored and what elements selected or reject in systems of models. This work considers the relation between the blind person, the tactile map and the environment.

The act of divert or hesitate during the route were considered orientation problems in the execution of the planned route with help of the tactile map. The performance was evaluated according to the mistake frequency associated to the number of times that the person requested help of the map during the execution of the route.

The sample studied in the experiment cannot reach to generalization, however, congenital blind people had a performance similar to the people with adventitious blindness. In this way, it was concluded that the first ones used different strategies to the problem solving of space orientation, excluding experience or visual memory.

The hesitation and mistakes during the route occurred with higher frequency in broad spaces, in corners of the hallways, after climbing and coming down the stairs, in the stairs platform of two stiles and in front of obstacles. It's possible to conclude that even if the blind person has an anticipated correct idea of the space with the help of the tactile map, if the environment has an adequate informational system, connected to the tactile map that helps the decision making, it tend to continue with hesitation, making mistakes in the route.

The referential marks detected in the tactile map such as stairs, end of hallways, intern garden, bathroom, drinking fountains, phone booths, when not founded in the route, make blind people feel disoriented. It's noted the need of information during the route that confirms if they are in the right path to find the referential marks.

It was observed that the reading strategies of the map implied in the quality of the comprehension of the environment and the route. The participants that planned the route from the panoramic view of the space or relates general aspects of space configuration, not focusing only on local aspects of elements in high-relief, had a better performance than those who planned the course only from the knowledge of the route.

If a blind person cannot understand the spatial configuration through the tactile map and didn't plan a strategy that facilitate the execution of the decision, especially in corners or pen spaces, probably that person will be disoriented, even having a tangible map with specific and necessary space information.

5.2 *Contributions to operating system models construction*

In the following it's presented contributions to the construction of three system models. 1) Characterization and serial position of the system 2) hierarchic system position and 3) expansion of the system. It is intended to apply the conditions of the Human-Task-Machine System (SHTM) into a concrete way finding situation for blind people from the recognition of the problem between the blind person, the tactile map and the environment.

The model 01. The blind person realizes the environment in an egocentric way that requires a detailed development, step by step, of their plan of action. Because of that, the target of the "characterization and serial position of the system" must display information in the map according to the limitations and sensorial abilities of the user in order to facilitate the process of planning the route. In order to achieve that, it's required to create a complementary informational system that is parallel and integrated to the tactile map that helps the decision making process and the execution of the route for any work position.

The requirements to achieve the target of the system deal with the efficiency in the choice of the referential elements that helps the navigation of the environment that must be represented in the tactile map in an adequate way, such as: material, texture and scale that must be applied in the tactile graphic, pictographic and schematic representation of the map; knowing how, where and when to put information according to the mental model constructed by the user from his experiences and interactions in the target system.

Blind workers need orientation information when getting to work. So it is suggested to make available, in a strategic place in the company, a tactile map that make the process of planning the route for any job post easier. This is the exit of the system. The obstacles during the route in the work environment are considered restrictions of the system. They are physical, architectonic, informational and communicational barriers.

The failures that can occur during the process are considered the unreasonable results of the system, such as: accidents, fall of the blind users, route detour, stress and spatial disorientation. In this way, the model "characterization and serial position of the system" can visualize the goal of the target system from the interaction of the blind person with the tactile map and environment, with requirements to its efficiency.

The model 2. The "hierarchic ordination of the system" puts the tactile map in other systems hierarchically superiors when the blind worker can make the orientation decision not only in his work positions, but also between departments, or between other buildings existent in the company or even between other offices, in the urban context.

In the same way, the target system, tactile map, presents hierarchic inferior levels, at the moment that the blind worker interacts with the tactile map and can make an orientation decision towards the tactile graphic communication in the map as also in the tactile verbal graphic language (Braille words) and in tactile pictographic language (symbols) or in the schematic tactile graphic language (diagrams) and, if it's possible, in the audible language in the map and also from the person that teach the user how to use the map.

Due to the great advance in technology there's a universe of support equipment, assistive technology to help blind people, however this target system is restricted to be integrated to sub-systems and supra-systems mentioned above. This way, it's observed the importance of the presence of the supra-systems and sub-subsystems to give support to the target system.

Model 3: The "expansion of the system" shows the general functioning vision of the whole informational system through the target system. There's an anterior system from the map, called serial 1, that relates to the process of finding the tactile map, and a posterior one called serial 2, that relates to the process of perform the route.

It is suggested, from the target system, the creation of parallel and integrated systems: sound information, informational anchor services; tactile graphic signalization provided by permanent or temporary physics supports located in a space (signs and tactile maps) or for individual use; horizontal floor signalization through colors and textures; information through assistive technology; redundant systems that reproduces the target system; architectonic information from helping referential elements for navigation that works as clues to orientation. In this manner, there's a hierarchic order and a serial position that give a notion of the expansiveness of the system improving the relation between blind person, tactile map and environment.

6 DISCUSSION

Even with the existence of laws with the social inclusion goal, as the decree-law n° 8213, article 93, (Brazil, 1991), wrote to cover reservation employment quotas in the private market, the blind worker will have his work activities damaged if he does not find an environment adapted to his needs of knowing where he is and where to go.

Projecting orientation information for blind people in the work place does not mean necessarily the conversion of data in tactile maps. The map role is to be an instrument for decision-making, so there is a need to provide additional information in the work environment so that the blind worker can perform his route with autonomy, security and satisfaction.

Even though the contributions of this work were based on the experiment proposed by Almeida (2008) the result is corroborated by the studies of Bins Ely et al (2012) when they affirmed that "the orientation conditions depend on the architectonic configurations and the existing informative supports (signs, posters, etc.) such as the conditions of the individuals perception, spatial information processing, decision making and acting".

Due to the complexity of the way-finding task for blind people, the presented work suggests that the companies adapt their spaces to the needs and limitations of blind users through an informational system in which the target, the tactile map, is conceived in the systemic vision of Ergonomics, searching to anticipate the way-finding activities and environment information accessibility needs though the construction of three models whose target system contemplate the satisfactory relation between the blind worker and his work environment.

7 CONCLUSION

If the systemic approach puts the tactile map as a component of an informational system, it cannot be analyzed in an isolated way. It is suggested the creation of projects that must be added up in order to accomplish the goal of the purposed system: to afford environmental information that fits blind people through the tactile map. It is incited that society deny the disabilities theory of cognitive rightness of space of blind population, in favor of the difference disabilities theory and consider that the blind person is capable to understand the space and that employers are able to include them in corporate market in environments adapted to their needs.

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Safety handling, rigging and lifting

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ABSTRACT: The present article identify important aspects for a safety technician activity to minimize potential incidents and accidents at the handling, rigging and lifting cargos whether they are simple or complex. This activity does not only concern with cargo by itself but also with all the machines and equipment selected and used in the entire procedure. At last but not least, it is extremely important verify the competence, credentials and capacity of proactivity teamwork of the human resources.

1 INTRODUCTION

Cargo movements have always been fundamental to man, as a matter fact it is an activity in which may occur many accidents and occupational illnesses.

Nowadays the risk of workers who handle or participate closely in the handling of loads can be very high and unlike what happened in the past, even people that are far from the places where these operations occur may in fact be subject to significant or even fatal risks.

Safety must be increasingly important and powerful towards the concern of countless lives of workers and remaining people. Due to negligence or willful misconduct in the handling activities, lashing or handling it can cause irreversible damage that can reach from a few employees to hundreds of thousands or millions of human beings and animals, also may affect infrastructures where they are and vicinity, as well as contaminate soils and aquatic environments, that would take quite a significant time to recover when it is even possible.

Currently, manufacturers started to create new machines, equipment and accessories, increasingly powerful according to international standards that require certification guarantee proper functioning, safety and ergonomic concepts (Official Journal of the European Communities 1989, Council Directive; Official Journal of the European Communities 2006, EC of the European Parliament and of the Council).

The obligation to make preliminary risk analysis from construction to running machines or tasks that lead to design preventive and corrective measures, as well as create effective individual and collective protective equipment, could significantly reduce the number and severity of accidents that are still high, especially when taken into account the value of human life, which is priceless (Official Journal of the European Communities 1989, Council Directive; Official Journal of the European Communities 2006, EC of the European Parliament and of the Council).

Safety technicians or engineers who have began to previously perform risk analyzes to the tasks, since the substance or product to move, until the final positioning of the load in question, through all the intermediate stages, namely, packaging, form handling, accessories lashing and handling, machinery and equipment as well as training and health conditions of the people involved in the activities, now also have to investigate accidents due to related work, including the acts and unsafe conditions as well as the organizational methods.

Briefly it is on all these safety aspects that this article is focus on.

2 PACKING OF LOADS

Depending on the physical state of the substance or product to carry and store, industry has developed packages to load that range from bulk (i.e.: oil, gas, cement, minerals, ...), the standard box was settled in order to be packed with the best use of space allied to the means of transport.

Thus, for correct safe transportation and economic viability various means of securing loads, depending on the needs imposed by the industry and commerce previously mentioned were created. Boxes of different types/materials, such as cardboard, plastic or wood are in common use. However the wooden pallets were of vital importance for the safe and rapid movement of cargo it saves much time spent in loading and unloading wagons during the second great world war (http://pt.wikibooks.org/wiki/Log%C3%ADstica/Embalagem/Paletes_e_contentores_paletiz%C3%A1veis, 2013).

Currently it is constructed in various materials and are of standard dimensions. The Euro Pallet, for example, has standard measures (800 mm × 1200 mm), in order to better move inside the vehicle for cargo transportation (wagons of goods in trains and trucks), and can be manipulated in both width in length by door electric pallet truck or other equipment with appropriate accessories (http://packagingrevolution.net/history-of-pallets-home-page/, 2011).

Packaging for loads of higher dimensions, or groups of several loads exist wire baskets, containers, frames, and sometimes the load itself has, since the manufacturer, appropriate boxes for their handling and transportation as loose lifting points.

These packagers loads are structurally designed to be used either onshore or offshore, meeting international standards and can only be used after certification to the effect, which must be periodically inspected and recertified by accredited companies for this purpose.

In several countries such as in Africa, apart from the document certification it is used a color code to quickly identify the lifting points packagers of loads as well as the accessories which are connected to them. Annually the color is changed (eg, 2012-green; 2013-yellow; 2014-light blue), the cargo is inspected in the year that is concerned (BVA/TOTAL, 2012–2014). All participants in handling know the safety precautions they should have with these packagers, it must be properly marked and identified as to their dangerousness care, handling and storage.

At European level its attempted to harmonize internationally recognized warnings like road and such symbols as defined in Annex II of Directive 57/548/EEC be replaced until June 1st, 2015 for new signs as defined in Regulation (EC) No 1272/2008 the European Parliament and of the Council of 16th December 2008 on classification, labeling and packaging of substances and mixtures, amending Regulation (EC) No 1907/2006.

When storing loads workers are exposed to ergonomic risks that should be taken into consideration to avoid Musculoskeletal Injuries Related to Work or occupational diseases.

The manual execution of storing loads has common risks that sometimes are maximized by unsafe acts and awkward postures. Begins with the employee often not using the adequate PPE, especially for hands, based on countless excuses, not only when the entity does not provide free appropriate gloves for tasks to do, but it also often happens whether the worker removes the protections of machines, tools and utensils that worker handles increasing the probability of contact with dangers which had been the target of reducing risk interventions.

Depending on the substances or products also use, the breath and the view can be significantly affected by not using CPE or adequate PPE and there may be workers who legally can not perform this activity (eg.: allergic, pregnant, postpartum, breastfeeding women and children).

The securing loads can not be regarded as a minor activity in lifting and moving loads. A poorly secured cargo could jeopardize the entire operation to perform.

Procedures and instructions for safe packaging for the typology of substances or products, as well as specific characteristics packagers, must receive theoretical and on-job training, to ensure that workers have a real sense of hazard and proper execute activity with the security measures set for them and for the packaging of cargo (BVA/TOTAL, 2012–2014).

3 LASHING OF LOADS

Ropes are the most usual means of lashing or tie for anyone who wants to carry a load. However, nowadays the straps are gaining ground for general cargo due to its resistance capacity of the facility and intends. Though it appears to be increasingly packagers for such loads or with specific characteristics that are moved by mechanical means and as such their structure must include space for carriage of the forklift or crane to the lifting points. In this case the lift kits consist of shackles, slings and rings, or even bars appropriate to the type of packer or locations of hoisting the load to be lifted. (Dickie, D.E. 2013. Rigging Manual Construction).

Tying loads correctly can be a relatively simple or complex task, but it can never be neglected since the load will be suspended due to multiple factors and may fall or drop loose objects that jeopardize the integrity of people who are nearby.

In case of lifts of standard packaging structures where the technical safety seeks to take into account the load to be lifted, the frame type and frequency of handling that type of packer, as well as other conditions exist, whether such will be transported to the offshore or onshore in order to verify if the packer is adequate and properly choosing the type of sling more advisable to their movement (synthetic, steel cables or chains) as well as their tension capacity (Working Load Limit—WLL, or Safe Working Load—SWL) or even shackle (dee/bow shackles or other) and the use or master links (DNV, 2006, 2.7–1 and 2.7–3; Gunnebo Industrier, 2001).

There is also to consider that there are many loads that by its configuration, structural dimension or weight are not transported in standardized packagers but as loose cargo.

In these cases, must be taken special care in performing lashing plans which need more or less deep analysis to analyze load balancing, correctly determine where the center of gravity is, to thereafter determine the accessory kit appropriate lashing for a future balanced and safe lifting and handling of cargo (DNV, 2006, 2.7–1 and 2.7–3; Gunnebo Industrier, 2001).

It is not an obligation of safety technician preparing the calculations of this plan, unless it has proper training for the effect, since in some cases they even have to be performed by specific software finite elements (BVA/TOTAL, 2012–2014).

However the safety technician must be aware of the means of executing and have critical capacity to analyze and define or verify compliance of various accessories to use in each lifting point and confirm that the equipment to be used are appropriate and are certified to the end expected, the target level, capacity and dimensions as well as condition and way of lashing the load to move (Lowe, A. 2013. Lifting Gera Examination).

The technician must analyze the plan and define the characteristics of accessories first in the office, but has to go to the field to verify the correct application of them or studying adaptations to the existing equipment, ensuring regulatory compliance and security conditions necessary at all stages of lashing load, ensuring a future handling safely. Should be confirmed or obtain real guarantees that the equipment to be used is properly pre-inspected before being applied and for guidance on whom performs these tasks specific checklists for the components of lifting accessories and the structure should be designed to lift as loose or as standardized filler.

In fact these checklists assist riggers and supervisors, beyond the technical itself, not to forget the details sometimes not analyzed, such as in particular the specific dimensions and positions of the lashing point to face flanges and lugs of the lifting slings, certifications and confirmation of the same to be those relating to equipment applied, the condition of the entire accessory kit lashing, contemplating wear, alignments, corrosion, mechanical damage, among several specific aspects of this kit, but without forgetting the certification of the structure or packer loads to use, or the mitigating or aggravating factors of tensions such as the angles formed by the slings, which should be avoided exceed the 90th degrees, the implications of these same angles either in tension or in slings resilience of shackles, or to loads with future handling in onshore or offshore (BVA/TOTAL 2012–2014; DNV, 2.7–1 and 2.7–3, 2006; Gunnebo Industrier, 2001).

There are also additional not directly belonging to lashing load but essential for its future lifting and whole team should analyze carefully, as are appropriate to certain types of spreader bars and hooks used for lifting. In short although the safety technician may not have to do the exact calculations of a lashing plan, especially in structures of great structural complexity transported as looses, has a significant number of things to check for himself or using the third-party support which will confirm, by first examining the results of these calculations and before authorizing the transport, testing its stability with lifting the load test according to the calculations in question confirming the stability and strength.

It is noteworthy that heavy lift should be particularly monitored because although it may be properly designed with adequate and proper position lashing points, their moorings may, as in other loads, need additional resources for the realization of safe moorings as eg the use of stairs or lifting platforms with risks of falling from heights. Also, it should confirm the technical safety conditions of lashing loads, the adequacy of the packer used, how the loads are placed, tied and placed protectors for workers, ensuring regulatory compliance in terms of equipment and safety aspects related to the destination of the loads, in addition to potential dropped objects that could fall and cause injury. All phases must have a maximum care in positioning, attitude and effort of workers in performing the tasks in order to prevent the occurrence of futures accidents or professionals illnesses (NSL. 1991. Manual Internacional de Manuseio e Içamento de Cargas).

4 HANDLING OF LOADS

A good operator can try to make a perfect lifting loads, but if it has no proper packaged and tied it might be the collapse of the load or lifting equipment, otherwise, if the weight is excessive for the packer itself it cannot resist. There must exist all caution in the tasks of objects that are able to rise with the potential to fall and cause damage.

Therefore, the operator that makes the lift, must have more than basic knowledge about how they are performed correctly, the operator must know all the steps preceding the survey.

Nowadays, most of the loads to be transported are high in volume and moved using mechanical means, by far exceeding the weight legally admitted for manual lifting.

The use of machinery and equipment to lift/move loads does not mean that there is no effort or risk to workers. There are risks of serious injury, even death when the operator, namely: is not trained or qualified to operate the requested equipment; overload machines outside the limits of capacity or traffic rules in the workplace; operates poorly maintained equipment; not respect speeds advised, i.e., have wrong attitudes through ignorance, incompetence or negligence.

Because of these situations there are duties and responsibilities of various entities and people that should always be safeguarded so as to prevent accidents, including manufacturer, employer, safety technicians, supervisors and operators.

The lifting plan begins in office analyzing all the information about the payload, rigging plan, location, and route to the destination where it will be placed in final position.

Thereafter the lifting means and unloading must be analyzed, as well as the handling of loads. Taking into account the multiple existing conditions, such as specifics of the load congested spaces, floor type, distances to be overcome by mechanical, location of operations (onshore or offshore) resources, starts the definition of methods to be used to perform these operations.

The choose of the mechanical means that should be used must take into account the existing equipment in locations where it will be perform the operation, or in the latter case, using tools, obtained in useful time, that fit the constraints analyzed above. Major reference to forklifts, cranes, platform lifts, trucks with adequate or specific trailers, among others.

Later on this article it is indicate in plant spaces to be used with the exact locations of the loads and their centers of gravity at all times when the load is placed on a surface (in which it should also be labeled the center of gravity), the places where lifting machinery of cargo and people should be put to perform operations safely.

Plants concerned must be considered limitations in the yard, the paths through which the loads are moved, without forgetting that these graphic information must be accompanied by additional information by dimensioning or labeling so that, for example, a crane operator knows which is the radius and proper length of the boom.

On the ground no machine should be able to operate without first being confirmed their certification at least an acceptable state of repair. Their operators must also be certified to meet the operating in a good physical and mental health. These before operating the machines should always do a pre-inspection to it and verify that it is in proper condition to be able to work at its fullest in secure conditions, involving also the space where it will perform the operations.

Also before starting work, a test for safe lifting of the same kind should be done if it has not been done during the lashing, or if it has already occurred for some time and is convenient to carry out confirmations. Only after this guarantee is that you can proceed to completion or continuation of the operation in question.

This operation is sometimes performed on very congested spaces and must be done carefully in advance on the machine that will raise ensuring safe lifting and consequent handling performed continuously and without hitting anything, as well as any placement of a lifting platform for supporting the link from the master link or flange which ensures the connection of the load to the hook of the crane lashing kit, so that will not exist any conflict between the machines during operation to perform, which may include traveling crane with a suspended load.

In case the lift is performed by means of a specific crane there must be careful that the hook has to be exactly positioned on the center of gravity of the load. This is to make sure that the load at the moment is highest will not suffer lateral moves avoiding collision with objects in their vicinity. Unfortunately this is a detail often overlooked or neglected that has caused and continues to cause significant problems.

It is because of situations like this and to ensure that all staff who will perform the work, that not always have real awareness of the dangers and risks involved, that should be performed a tool box meeting so that all this can be explained, as well as taken care to avoid it or ensure that it all may be properly controlled to acceptable level or even lower.

Thus, stakeholders of the team know exactly what they do, who report information and whom is accepting orders for the operation, although any element of this team has authorization to send interruption the operation if it finds high risk situations during the course of the operation.

There are actually loads of sizes and complex structures in which no one can simultaneously verify its entirety, so only a trained and cohesive team is able to ensure the realization of these tasks efficiently and safely. Note also that the lifting tables and calculations also show flat apart as intended execution of the existence of security clearances and limits that somehow can be exceeded in order to be able to perform some adjustments if necessary but without ever going over safety conditions. However this information should not be generalized, but kept in a small number of intermediate managers, usually the safety technician and the supervisor of the whole operation, which are at the venue of the operations.

5 CONCLUSION

In the handling, lashing and cargo handling operations, commonly referred by lifting operations, each year often occurs many accidents.

The entire procedure has to be analyzed and planned carefully before performing operations.

Professionals who perform it must be properly qualified and trained for the purpose and ensure that the safety measures established are met.

If we all fulfill strictly the mission entrusted to do, than it will be an acceptable job risk in which only rare times an accident may occur.

It is up to each of us accomplish what often is written, but not fulfilled: SAFETY FIRST.

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