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Evaluation of Computer Workstation Ergonomics and its Effect on the Musculoskeletal Disorders

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Abstract:

Ergonomics, positioning and posture of body and design of workstations in offices are considered key research areas in recent times. There is a wide gap in practice and theory of ergonomics. The goal of this study is to evaluate the musculoskeletal health of the employees with relevance to ergonomics and workstation design in practical environment of software houses. A cross-sectional study was conducted among 96 computer users of software houses in Lahore, a metropolitan city of province Punjab, Pakistan. Inclusion criteria of the study were male and female software house employees, aged between 24–31 years, who use computer workstation for at least 03 hours a day and had at least 06 months working experience. Data on prevalence of employees' musculoskeletal disorders was collected through a specially designed questionnaire adapted from Nordic Musculoskeletal Questionnaire (NMQ). Computer workstations were evaluated by Occupational Safety and Health Administration (OSHA) computer workstation eTool. Our studies show that the lifetimes' prevalence of WMSDs in Females is highest in the neck (72.7%), followed by lower back (50%) and in Male, the lifetimes' prevalence of WMSDs was highest in neck (59.5%), followed by shoulder (54.1%), lower back (43.2%). The neck, shoulder upper back, and lower back are the most affected area.By using logistic regression it was analyzed that the significant ergonomic risk factors for WMSDs in neck region was poor design in Workstation (OR=0.951, 95% CI: 0.929-0.974, Overall Chi-Square: 38.22), followed by design flaws in seating (OR=0.952, 95% CI: 0.927-0.978, Overall Chi-Square: 38.22).

Keywords: Musculoskeletal Disorder, Ergonomics, Computer Workstation, Software House Employees

I. Introduction

In the third industrial revolution, computer has emerged as a major technological machine among various other machines that boosted the manufacturing process and created a new digitalized world. . With the increasing use of IT related services, this evolution has transformed the Manufacturing-Based Economies into Knowledge-Based Economies (KBE). All over the world people employ computers either at their place of work or at home to perform versatile tasks.The reliance on computers is ever growing in

all walks of life and this extensive usage has accompanied with certain health issues for its users. The work strain, repetitious chores, monotony, societal aspects, insecure postures and underprivileged workstation are some of the associative risks of excessive computer usage (Sorli & Stokic, 2009). Sitting on a computer for long hours is a well-known occupational hazard that results in Work-Related Musculoskeletal Disorder (WMSD)(Baig et al., 2019). The sickness and disorders that mostly affect the muscular tissues, human nervous system, joints, spinal discs, tendons and ligaments are known asMusculoskeletalDisorders (MSDs). The United States (US) Bureau of Labor Statistics states that the disordersincluding pinched nerve, herniated disc, meniscus tear, sprains, strains, tears, hernia (traumatic and non-traumatic), pain, swelling, numbness, carpal or tarsal tunnel syndrome, and Raynaud's syndrome are defined as MSDs. The exposure to the tasks and work environment such such as overexertion, bodily reaction, repetitive motion involving micro-tasks, and vibration leads to the injuries or illnesses regarding MSDs(Gasibat et al., 2017).

Among European Union members, the sickness caused by work-related musculoskeletal disorders is one of the major reason of absence from work.About a quarter of work population complained discomfort in shoulder, neck, and upper limbs according tothe 4th European Working Condition Survey (Bevan, 2015). Working on computers for long hours is associated with problems in upper-back, lower back and neck regions (Cho et al., 2012). Ergonomics is defined as the science of fitting the job to the worker. In the context of software house work, it refers to the computer user-workstation fit(Mani, 2018). Factors that make a worker prone to developing WMSDs are called ergonomic risk factors(Hossain et al., 2018). One such risk factor is ergonomically bad workstation(Chiasson et al., 2015). The process of identification of the hazards and assess the risk of the health and safety of the computer users is process known as workstation risk assessment(Pavlovic-Veselinovic et al., 2016).WMSD is caused by different ergonomic risk factorsat the workplace such as workstation design, poor posture, repetitive movements, static postures working for prolonged periods of time without breaks and psychological factors(Jaffar et al., 2011).

A lot of literature can be found for MSD in older people(MacKinnon et al., 2019), (Okunribido et al., 2011), but there is a lack of availability of researches targeting young individuals, who are in their full functional capacity and workability, particularly in Pakistan. The nature of labor forces, mainly in software houses is changing. Young individuals are more prevalent. We collected recent data about MSDs in older and young people from Dr. Waseem who is a physiotherapist in Al Razi Hospital, Lahore and teaches in Shalamar Hospital, Lahore. According to the data, the ratio of MSDs in young people is increasing recently. It is the need of the hour to study the existence and risk factors of MSDs in them. So, our study focuses on prevailing MSD in young employees of software houses in Lahore, Pakistan.

The objectives of this study are to evaluate the ergonomics features in the design of computer workstations in software houses of Lahore and to elicit a relationship between poor ergonomics features in workstation design and prevalence of work-related musculoskeletal disorders.

II. Literature Review

The deficiencies in workstation, duration of work, age and acute health issues are connected together and considered jointly for diagnosis of Work- Related Musculoskeletal Disorders (WMSDs). There are many computer users who are the victims of health disorders due to inadequately designed computer workstations, the prevalence of Work-related musculoskeletal disorders (WMSDs) among these users is frequently visible (Moharana et al., 2015).Previous studies have suggested that as a person ages, his functional capacity and workability decrease, particularly when he reaches later decades of his life. This also increases age-related MSDs in older people (Kenny et al., 2008). It is concluded that MSD was one of the main health concerns in workplaces and in 30% of the cases the workers were required to take time away from the work for rehabilitation.(Azaroff et al., 2002). It is also identified that most of the occupational illnesses were related to MSD in older people (Osborne et al., 2012). It is found out that MSD had a more distinct effect on older people as compared to young people. One of the reasons for this was that the recovery period for injuries as MSD lengthens with age (King et al., 2009).

In this work, a research is conducted based on sample collected from 03 software houses, with employees working on computer for at least 06-07 hours. The effects on the various body parts influenced by the poor workstation design are also analyzed using logistic regression.

III. Methodology

A self-administered questionnaire containing two standardized checklists (1) OSHA for computer workstation evaluation (2) Standard Nordic Questionnaire to assess the prevalence of Work-Related Musculoskeletal Disorder (WMSD) in the employees were distributed online to 03 software house of Lahore -Pakistan.The elements of the questionnaire were study introduction, volunteers consent form and hyperlink to Google Form for data collection. Total number of responses received by the scholar was 101, out of which 05 responses were dropped due to incomplete, unusable information. The remaining sample size was left with only 96 responses. The respondents' demographics and other personal attributes including their gender, age, education, Experience, total working hours, working hours with computer, smoking habits, and prior medical concerns were inquired to find out the effect of these controlled variables with the prevalence of work-related musculoskeletal disorders (WMSD). The majority of respondents (95%) were young as their age is below 35 years. Males were 77% of the sample which shows the general consistency of working pattern in Pakistan.

Most of the respondents (64%) have 16 years of formal education which is enough to understand the English questionnaire. Among the total respondents, only 87% were non-smokers and 92% had no prior medical concern. 88% of the respondents were working 06 to 09 hours. While analyzing the weights of employees, it was noticed that 86% of employees had weight between 51kg to 90kg which is considered a healthy weight as most of the respondents were male and 77% of respondents had height above 165.2 centimeters.

Table 1: Descriptive Statistics of Control Variables

Variable	Min	Max	Mean	SD
Age (Years)	21.00	41.00	27.40	3.94
Education (Years)	14.00	18.00	16.00	0.58
Height (cm)	152.40	187.96	171.53	9.09
Weight (Kg)	40.00	122.00	73.48	14.72
How long have you been working in this position? (Years)	1.00	6.00	2.96	1.56
How many days do you work per week? (Overtime not included)	2.00	7.00	5.13	0.73
How many hours do you work per day?	2.00	8.00	6.73	1.42
How many hours do you spend behind your workstation?	2.00	8.00	5.56	2.12

Notes: Min = Minimum, Max = Maximum, SD = Standard Deviation

The OSHA checklist contains 48 items to assess the goodness of computer workstation, the numbering of items were done by the scholar to facilitate the respondents and for better presentation of work. These items are related to six different but pertinent categories of workstation design as laid out in the Computer Workstation eTool, i.e., workstation, seating, keyboard/input devices, monitor, accessories, and general concept. There were 12 items related to Workstation, 10 for seating, 07 for Keyboard/ Input, 06 for Monitor, 07 for Accessories, and 06 related to general concepts evaluation. In the response, the employees were asked to tick "Yes" or "No" for each item.

A team of Nordic research scientists have made a standardized questionnaire Standard Nordic Questionnaire (SNQ) that is being used to collect the data for prevalence of musculoskeletal disorders (MSD). The questionnaire is used mostly in combination with various other occupational hazards to find out the cause of MSD. One such use of SNQ is to use it with Ergonomics assessment programs for epidemiological studies of WMSD (Kuorinka I, Jonsson B, Kilborn A, et al., 1987). The questionnaire focuses on 09 parts of the body where MSD is most common. The data of MSD in these parts are collected for a period of lifetime, 12-month, 01 month, last-week and today. In addition to the data on pain/ discomfort, the questionnaire is designed to collect data on consequence of WMSD in the respondents such as sick leave, visiting to the physiotherapist etc. In this study adjusted odds ratio (AOR) (CI: 95%) confidence interval and ($p < .0005$) was adopted to find out the degree of association between independent and dependent variables.

IV. Results and Discussions

After individual category analysis of OSHA checklist, the overall deficiencies at workstation were identified by summing up and ranking the "No" response to OSHA items, and a similar method is adopted by prior studies(Wang et al., 2020). The first main deficiency which is reported by 81.3%* of respondents is that their work surface has square or sharp edges that contact with wrist and hand cause discomfort. The second deficiency is that the respondents' telephone 77.1%* was not appropriately positioned to their workstation and individuals needed to bend their head upright while using the telephone. Third deficiency, reported by 71.9% respondents that their neck and head not in-line or balanced with their trunk/torso. In fourth deficiency, 60.4% employees complained about the glare from the windows or lights are mirrored in the screen that makes them to crook or takes difficult positions to see details clearly on the screen. The

fifth main problem is reported by 59.4% of respondents that their armrests were not adjustable and did not support forearms while performing computer tasks.

Table 2: Deficiencies identified with the OSHA VDT workstation checklist

Item No	Frequency (Percentage)	Deficiency Area	Item No	Frequency (Percentage)	Deficiency Area
1	**71.9***	Workstation	25	46.9	Keyboard/Input Device
2	37.5	Workstation	26	32.3	Keyboard/Input Device
3	38.5	Workstation	27	18.8	Keyboard/Input Device
4	27.1	Workstation	28	22.9	Keyboard/Input Device
5	49.0	Workstation	29	54.2	Keyboard/Input Device
6	54.2	Workstation	30	34.4	Monitor
7	43.8	Workstation	31	44.8	Monitor
8	40.6	Workstation	32	29.2	Monitor
9	28.1	Workstation	33	28.1	Monitor
10	24.0	Workstation	34	60.4	Monitor
11	32.3	Workstation	35	13.5	Monitor
12.	**81.3***	Workstation	36	46.9	Accessories
13	47.9	Seating	37	52.1	Accessories
14	42.7	Seating	38	52.1	Accessories
15	33.3	Seating	39	58.3	Accessories
16	44.8	Seating	40	**77.1***	Accessories
17	37.5	Seating	41	46.9	Accessories
18	20.8	Seating	42	50.0	Accessories
19	59.4	Seating	43	14.6	General Concepts
20	58.3	Seating	44	19.8	General Concepts
21	22.9	Seating	45	38.5	General Concepts
22	28.1	Seating	46	36.5	General Concepts
23	18.8	Keyboard/Input Device	47	36.5	General Concepts
24	57.3	Keyboard/Input Device	48	50.0	General Concepts

Note: *Item number in OSHA Computer Workstation eTool (https://www.osha.gov/)

The lifetimes' prevalence of WMSDs varied significantly by gender. For female (N=36), the lifetime prevalence of WMSDs were highest in the neck (72.7%), followed by lower back (50%), shoulder and upper back (36.4%), wrist/hands (31.8), hips/thighs (22.7%), and elbows and feet/ankles (13.6%). For male (N=57), the lifetimes' prevalence of WMSDs was highest in neck (59.5%), followed by shoulder (54.1%), lower back (43.2%), upper back (36.5%), hips/thighs (24.3%), knees (24.3%), wrist/hands (23.0%), elbows (21.6%) and feet/ankles (20.3%). The detail is given in Figure 1.

Table 3 provides a comparison of the results of our research with the results of some previous researches. It shows the rank of prevalence of WMSDs in different body parts with 1 having the highest prevalence and 9 having the lowest prevalence. For our study, we have included the average prevalence for males and females both. It can be seen that the top three body parts with highest prevalence of WMSDs in all the researches compared in Table 3 are neck, shoulder and lower back. However, the exact ranking differs in each research because the participants belonged to different occupations and had different working durations.

Figure 2 represents the consequence of WMSD in 09 body parts. These consequence create the economic, social and societal impacts. Due to neck pain, a substantial number of both male and female take sick leave (23.0%, 13.6%) followed by those who took medication (17.6%, 13.6%), visited health professional (12.2%, 13.6%)

and in the end suffered from normal work activities (10.8%, 4.5%). Due to shoulder pain, a substantial number of both male and female took medication (18.9%, 18.2%), followed by taking sick leave (16.2%, 18.2%), visited health professional (12.2%, 22.7%), and in the end suffered from normal work activities (9.5%, 4.5%).

Figure 1: Prevalence of WMSDs in different body regions by the respondents

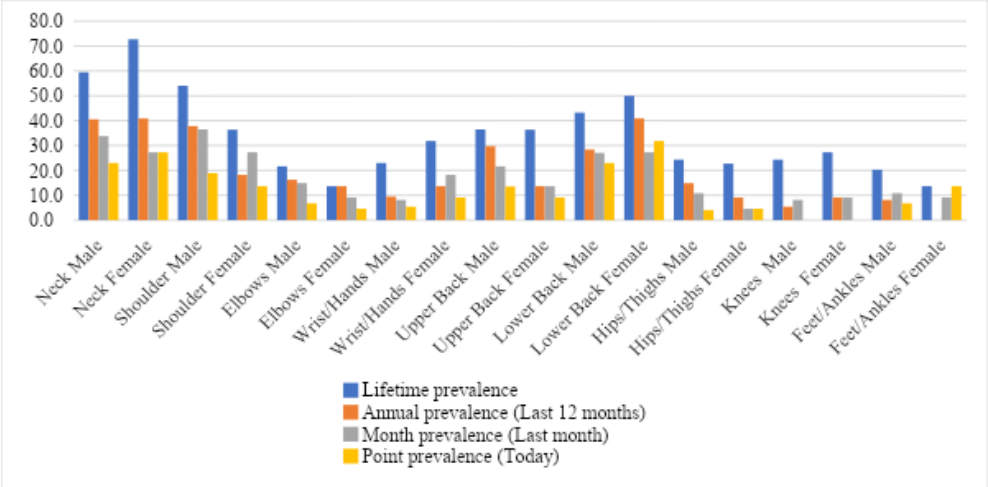


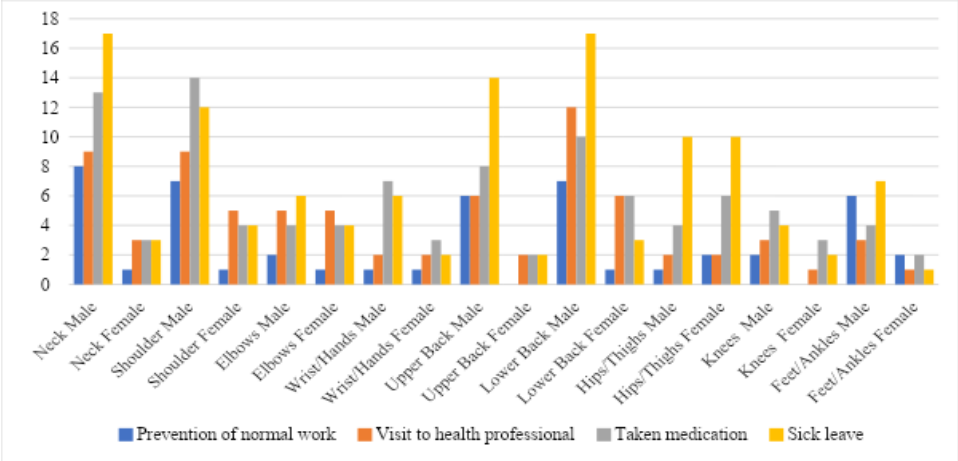
Table 3: Comparison of Rank of Prevalence of WMSDs in Different Body Parts - Results of Our Research with the Results of Some Previous Researches.

	(Umar et al., 2019)	(Mekhora et al., 2000)	(Mohammadipour et al., 2018)	Our Study
Neck	1	2	2	1
Shoulder	3	3	3	3
Elbow	6	-	9	8
Writs/ Hands	5	-	6	5
Upper Back	4	4	5	4
Lower Back	2	1	1	2
Hips/Thighs	-	-	7	7
Knees	-	-	4	6
Feet/ Ankles	-	-	8	9

The risk factors such as age, experience, BMI and daily working hour associated with the one-year prevalence of WMSD's in the different body region was studied, the same method adopted by prior studies (Hossain, M. D., Aftab, A., Al Imam, M. H., Mahmud, I., Chowdhury, I. A., Kabir, R. I., &Sarker, M., 2018), (Cheng, H. Y. K., Cheng, C. Y., & Ju, Y. Y., 2013). The relationship between age and one-year prevalence of WMSDs with neck, shoulder, elbows, upper back, lower back, hips, knees, and ankle are found statistically insignificant. The reason for this insignificance relationship might be because the age of all respondents is below 35, showing that the sample is quite young. Relationship between experience and WMSDs with wrist (χ^2 = 4.71*) and knees (χ^2 = 9.76*) is statistically significant but insignificant with other body parts. Further, the impact of BMI on WMSDs is insignificant for each body part, and this result may be because the weight of most of the respondents are between 51 to 90 which is considered a healthy weight as most of the respondents are male with the average height of 171.3

centimeters. Relationship between working hours and yearly prevalence of WMSDs is significant for wrist only ($\chi^2 = 3.13$*).

Figure 2: Consequences of WMSDs in different body regions by the respondents



The logistic regression model was statistically significant in neck region, $\chi 2 = 38.22$, $p < 0.0005$. The model explained 33.0% (Cox & Snell R2) to 44% (Nagelkerke R2) of the variance in WMSDs in neck. Further detail of each factor's regression results is provided in Table 4.

Table 4: Significance of Ergonomics of Workstation on different body parts (P <0.0005)

	χ^2	Sig.	Cox & Snell R^2	Nagelkerke R^2
Neck	38.22	0.00	0.33	0.44
Shoulder	41.53	0.00	0.35	0.49
Elbow	47.60	0.00	0.39	0.67
Writs/ Hands	25.81	0.00	0.24	0.48
Upper Back	56.37	0.00	0.44	0.65
Lower Back	44.61	0.00	0.37	0.52
Hips/Thighs	36.14	0.00	0.31	0.57
Knees	29.78	0.00	0.27	0.71
Feet/ Ankles	25.42	0.00	0.23	0.62

To examine the effect of ergonomic features on the prevalence of the musculoskeletal disorder, a logistic regression is conducted between six (06) ergonomic features. The features were (Workstation, Seating, Keyboard/Input Device, Monitor, Accessories, General concept) as laid out in the OSHA checklist.The prevalence of WMSDs against nine body parts neck, shoulder, elbows, wrist/hands, upper back, lower back, thighs, knees, and feet/ankles) were studied according to the OSHA checklist.

The Logistic regression explains significance in all nine body parts with respect to OSHA ergonomics features. The workstation deficiency is the first main cause of higher WMSDs in the neck region with the highest b coefficient (-0.050) and produced an odds ratio (OR) of 0.95 (95% confidence interval (CI): 0.93-0.97). This result indicate that these subjects were 0.97 times more likely to suffer from WMSDs in the neck region. Similarly, the model revealed that a seating deficiency is the second major cause of

higher WMSDs in the neck region (b = -0.049) and produced an odds ratio (OR) of 0.95 (95% confidence interval (CI): 0.93-0.98). The deficiencies in seatingmade these subjects0.91 times more likely to suffer from WMSDs in neck region.

The workstation and seating are two equally important deficiency to cause higher WMSDs in the shoulder region with the highest b coefficient (-0.059) and produced an odds ratio (OR) of 0.94 (95% confidence interval (CI): 0.92-0.97). These subjects were 0.97 times more likely to suffer from WMSDs in shoulder region.

The deficiencies in accessories is the first main cause of higher WMSDs in the elbow region with the highest b coefficient (-0.10) and produced an odds ratio (OR) of 0.90 (95% confidence interval (CI): 0.85-0.96). Resultantly, the subjects were 90 percent more likely to suffer from WMSDs in the elbow region. The workstation deficiency is the second major cause of higher WMSDs in the elbow region (b = -0.076) also produced an odds ratio (OR) of 0.93 (95% confidence interval (CI): 0.90-0.96). The subjects were 0.91 times more likely to suffer from WMSDs in the elbow region due to deficiency in workstation.

The b coefficients for all ergonomic features are significantly negative, indicating that the decrease in these ergonomic features is associated with increased odds of having WSMDs in the wrist/hand. The workstation deficiency is the first main cause of higher WMSDs in the wrist/hand region with the highest b coefficient (-0.055) and produced an odds ratio (OR) of 0.95 (95% confidence interval (CI): 0.92-0.98). The subjects were 0.95 times more likely to suffer from WMSDs in wrist/hands region.

The keyboard/input device deficiency is the first main cause of higher WMSDs in the upper back region with the highest b coefficient (-0.072) and produced an odds ratio (OR) of 0.93 (95% confidence interval (CI): 0.90-0.96). The subjects were 0.90 times more likely to suffer from WMSDs in the upper back region. The deficiencies in accessories is the first main cause of higher WMSDs in the lower back region with the highest b coefficient (-0.056) and produced an odds ratio (OR) of 0.95 (95% confidence interval (CI): 0.92-0.97). In result of the deficiency in accessories these subjects were 0.95 times more likely to suffer from WMSDs in the lower back region. Further detail is given in Tables 5 and 6.

Table 5: Relationship between Ergonomic features Score and Musculoskeletal Disorders (WMSDs)

Risk factors	Neck		Shoulders		Upper back		Elbows		Wrist/hand	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Ergonomics Features										
Workstation	0.951	0.929-0.974	0.942	0.917-0.968	0.94	0.92-0.97	0.93	0.89-0.96	0.95	0.92-0.98
Seating	0.952	0.927-0.978	0.943	0.916-0.971	0.94	0.91-0.97	0.93	0.91-0.96	0.96	0.93-0.98
Keyboard/ Input Device	0.969	0.954-0.984	0.955	0.936-0.973	0.93	0.90-0.96	0.95	0.92-0.97	0.97	0.95-0.99
Monitor	0.968	**0.953-0.983**	0.965	0.950-0.981	0.95	0.93-0.97	0.95	0.93-0.97	0.97	0.95-0.99
Accessories	0.964	**0.949-0.980**	0.965	**0.949-0.981**	0.95	0.92-0.97	0.90	0.85-0.96	0.96	0.93-0.99
General concept	0.972	0.958-0.987	0.961	0.944-0.978	0.95	0.93-0.97	0.95	0.92-0.97	0.97	0.96-0.99

In contemporary times, this study has its individuality in selection of sample size which is young and work in a demanding environment of Software Houses in Lahore Pakistan. The provision of furniture in the software houses and evaluation of setting of appropriate workstation for the prolonged sitting and its effect on WMSD is studied.

Major deficiencies were in all six categories of workstation evaluation i.e. Workstation, Seating, Keyboard/ Input devices, Monitor, Accessories and General concepts as laid out in the OSHA evaluation guidelines and given in Table2.

It is widely accepted in the literature that poor ergonomics risk factors can lead to WMSD(David et al., 2008). The lifetime prevalence, 12-month prevalence, last month prevalence, todays' prevalence of WMSD is observed due to poor ergonomic features in the workstation. The lifetimes' prevalence of WMSDs varied significantly by gender. For females (N=36), the lifetime prevalence of WMSDs is highest in the neck (72.7%) [Fig-1]. This study claims that poor ergonomics features in the workstation setting is one major cause of employee health.

Table 6: Relationship between ergonomic features score and musculoskeletal disorders (WMSDs)

Risk factors	Lower Back		Hips/ Thighs		Knees		Feet/ Ankles	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Ergonomics Features								
Workstation	0.95	0.93-0.98	0.94	0.91-0.97	0.94	0.91-0.98	0.96	0.92-0.99
Seating	0.95	0.93-0.98	0.95	0.93-0.97	0.97	0.94-0.99	0.96	0.93-0.98
Keyboard/ Input Device	0.97	0.95-0.98	0.94	0.92-0.97	0.96	0.94-0.99	0.95	0.92-0.99
Monitor	0.96	0.95-0.98	0.95	0.93-0.97	0.97	0.94-0.99	0.94	0.91-0.98
Accessories	0.95	0.92-0.97	0.90	0.85-0.97	0.89	0.78-1.01	0.96	0.93-0.99
General concept	0.97	0.95-0.98	0.95	0.93-0.97	0.97	0.94-0.99	0.95	0.93-0.98

The results show that gender as well as working hours and age are considered an important parameter while evaluating the increasing MSDs; this is not applicable in this case since the participants of study are young. Higher prevalence of the MSDs results in the body parts including neck, shoulder, upper body, lower body and knee which result in joint pains and discomfort. Previous work shows that the incorrect feature results in severe back pain and neck pain. The Logistic regression value calculated based on the OSHA checklist shows that all the body parts are affected by MSDs in case of poor ergonomic features of the seating, work-station and keyboard. However, the neck and lower back affect the most which is in accordance with the literature.

V. Conclusion

The excessive use of computers and prolonged sitting on the workstation results in multiple health issues in the employees, including work related musculoskeletal disorders (WMSDs). So, the excessive computer usage resulted in increased prevalence of WMSDs in the employees of software houses as studied for Lahore city of Punjab, Pakistan. The poor ergonomic features of the workstation, seating and placement of keyboard/ Input devices, Monitor, Accessories such as telephone and general concepts related to postural issues results in MSDs. The MSD affect various joints and cause discomfort in neck, shoulder, lower back, upper back, wrist/hand, knee and elbow. The poor ergonomic feature calculated by Logistic regression shows that the neck, upper body, lower body, shoulder and knee are largely affected. As the conclusion it is established that poor quality of ergonomics furniture in software houses results in WMSD.

VI. Limitations and Future Directions

This study has a few limitations. There are other potential risk-factors involved in the prevalence of WMSD such as employee's mental health and the environmental factors such as extreme temperature and/ or humidity etc. A more pertinent factor involved in WMSD is recall biasedness of the participants. The employees could have responded with biased information when they register their data of past 01 year in the checklist.

This study can be utilized in various policy making processes both at micro and macro scale in public and private sector equally. The effect of bad workstation on the employee's health can be used to compute the employee's performance decline. The same effect can also be used to design more robust and personalized furniture for the employees in the software houses. The scholar intends to pursue the latter scheme in the future.

References

Azaroff, L. S., Levenstein, C., & Wegman, D. H. (2002). Occupational injury and illness surveillance: conceptual filters explain underreporting. *American Journal of Public Health*, *92*(9), 1421–1429.

Baig, M. A., Munir, R., & Munir, W. (2019). Computer Vision Syndrome: A Rising Occupation Hazard. *Pakistan Journal of Medical Research*, *58*(1).

Bevan, S. (2015). Economic impact of musculoskeletal disorders (MSDs) on work in Europe. *Best Practice and Research: Clinical Rheumatology*, *29*(3), 356–373. https://doi.org/10.1016/j.berh.2015.08.002

Chiasson, M.-E., Imbeau, D., Major, J., Aubry, K., & Delisle, A. (2015). Influence of musculoskeletal pain on workers' ergonomic risk-factor assessments. *Applied Ergonomics*, *49*, 1–7.

Cho, C.-Y., Hwang, Y.-S., & Cherng, R.-J. (2012). Musculoskeletal symptoms and associated risk factors among office workers with high workload computer use. *Journal of Manipulative and Physiological Therapeutics*, *35*(7), 534–540.

David, G., Woods, V., Li, G., & Buckle, P. (2008). The development of the Quick Exposure Check (QEC) for assessing exposure to risk factors for work-related musculoskeletal disorders. *Applied Ergonomics*, *39*(1), 57–69.

Gasibat, Q., Simbak, N. Bin, Aziz, A. A., Petridis, L., & Tróznai, Z. (2017). Stretching exercises to prevent work-related musculoskeletal disorders: A review article. *AJSSM*, *5*(2), 27–37.

Hossain, M. D., Aftab, A., Al Imam, M. H., Mahmud, I., Chowdhury, I. A., Kabir, R. I., & Sarker, M. (2018). Prevalence of work related musculoskeletal disorders (WMSDs) and ergonomic risk assessment among readymade garment workers of Bangladesh: A cross sectional study. *PLoS ONE*, *13*(7), 1–18. https://doi.org/10.1371/journal.pone.0200122

Jaffar, N., Abdul-Tharim, A. H., Mohd-Kamar, I. F., & Lop, N. S. (2011). A literature review of ergonomics risk factors in construction industry. *Procedia Engineering*, *20*, 89–97.

Kenny, G. P., Yardley, J. E., Martineau, L., & Jay, O. (2008). Physical work capacity in older adults: implications for the aging worker. *American Journal of Industrial Medicine*, *51*(8), 610–625.

King, P., Huddleston, W., & Darragh, A. R. (2009). Work-related musculoskeletal disorders and injuries: differences among older and younger occupational and

physical therapists. *Journal of Occupational Rehabilitation*, *19*(3), 274–283.

MacKinnon, A. L., Jackson, K., Kuznik, K., Turner, A., Hill, J., Davies, M. A. M., Jones, M. E., Delmestri, A., Sanchez-Santos, M. T., & Newton, J. (2019). Increased Risk of Musculoskeletal Disorders and Mental Health Problems in Retired Professional Jockeys: A Cross-Sectional Study. *International Journal of Sports Medicine*, *40*(11), 732–738. https://doi.org/10.1055/a-0902-8601

Mani, K. (2018). Ergonomics education for office computer workers: An evidence-based strategy. *Anatomy, Posture, Prevalence, Pain, Treatment and Interventions of Musculoskeletal Disorders*.

Mekhora, K., Liston, C. B., Nanthavanij, S., & Cole, J. H. (2000). The effect of ergonomic intervention on discomfort in computer users with tension neck syndrome. *International Journal of Industrial Ergonomics*, *26*(3), 367–379. https://doi.org/10.1016/S0169-8141(00)00012-3

Mohammadipour, F., Pourranjbar, M., Naderi, S., & Rafie, F. (2018). Work-related Musculoskeletal Disorders in Iranian Office Workers: Prevalence and Risk Factors. *Journal of Medicine and Life*, *11*(4), 328–333. https://doi.org/10.25122/jml-2018-0054

Moharana, G., Nayak, J., Rout, P. K., & ICAR-CIWA, B. (2015). Postural Discomfort, Musculoskeletal Problems and Stress of Farm Women and Participatory Evaluation of Stress Index. *Promoting Occupational Safety and Drudgery Reduction among Farm Women*, 72.

Okunribido, O. O., Wynn, T., & Lewis, D. (2011). Are older workers at greater risk of musculoskeletal disorders in the workplace than young workers? - A literature review. *Occupational Ergonomics*, *10*(1–2), 53–68. https://doi.org/10.3233/OER-2011-0192

Osborne, A., Blake, C., Fullen, B. M., Meredith, D., Phelan, J., McNamara, J., & Cunningham, C. (2012). Prevalence of musculoskeletal disorders among farmers: a systematic review. *American Journal of Industrial Medicine*, *55*(2), 143–158.

Pavlovic-Veselinovic, S., Hedge, A., & Veselinovic, M. (2016). An ergonomic expert system for risk assessment of work-related musculo-skeletal disorders. *International Journal of Industrial Ergonomics*, *53*, 130–139.

Sorli, M., & Stokic, D. (2009). *Innovating in product/process development: Gaining pace in new product development*. Springer Science & Business Media.

Umar, A., Kashif, M., Zahid, N., Sohail, R., Arsh, A., Raqib, A., & Zada, P. (2019). The Prevalence of Musculoskeletal Disorders and Work-Station Evaluation in Bank Employees. *Physikalische Medizin, Rehabilitationsmedizin, Kurortmedizin*, *29*(02), 99–103. https://doi.org/10.1055/a-0756-9782

Wang, P., Wu, P., Wang, X., Chen, X., & Zhou, T. (2020). Developing optimal scaffolding erection through the integration of lean and work posture analysis. *Engineering, Construction and Architectural Management*.