

Association Between Sitting and Occupational Low Back Pain (LBP)

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ABSTRACT

*Low Back Pain (LBP) has been identified as one of the most costly disorders among the worldwide working population. Sitting has been associated with the risk for having LBP^{10,20,35,55}. The purpose of this literature review is to assemble and describe evidence of research about the association between sitting and the presence of LBP. The literature review was restricted to those occupations that require sitting for more than 50% of their working time and where the workers have physical co-exposure factors such as whole body vibration (WBV) and/or awkward postures. Fifteen studies were carefully selected and critically reviewed, and a model developed that describes the relationships between these factors. **Results:** The occupational group that showed the strongest association with LBP was Helicopter Pilots (OR = 9.0, 90% C.I = 4.9 -16.4). For all occupations, the odds ratio (OR) increased when WBV and/or awkward postures were analyzed as co-exposure factors. Exposure duration of vibration was associated with LBP to a greater extent than vibration magnitude. Awkward posture was also associated with the presence of LBP. The risk effect of prolonged sitting increased significantly when the factors of WBV and awkward postures were combined. **Conclusions:** Sitting by itself does not demonstrate an impressive risk association with LBP. However, sitting in combination with whole body vibration and/or awkward postures does increase the association with the presence of LBP.*

Key Words: *Sitting, LBP, sciatica, epidemiology, review*

Introduction

Low Back Pain (LBP) is an important public health problem in all industrialized nations. It remains the leading cause of disability in persons younger than 45 years old and comprises approximately 40% of all compensation claims in the United States.^{14,16,54} About one-third of American workers are in jobs that contribute to an increased risk of developing back disorders, although the causes of lumbar disorders are complex and difficult to identify.⁴⁰ Within the general population, the lifetime prevalence of LBP has been estimated at near 70% for industrialized countries.⁴¹ The average estimated year-prevalence derived from British population surveys is 38%.^{43,53}

Because of the potential economic and social benefits to be gained from reducing the magnitude of LBP in industry, many investigations have centered their attention on injury factors, particularly those activities and events associated with the onset of symptoms.⁴⁷ The major thrust of research about LBP has been to identify occupational risk factors associated with its presence and occurrence.

With the rapid development of modern technology, sitting has now become the most common posture in today's workplace. Reinecke *et al.*⁴⁶ reports that three-quarters of all workers in industrial countries have sedentary jobs that require sitting for a long period. However, in many activities, sitting can be a less straining posture than standing.²⁶ Both postures are commonly used, and have advantages and disadvantages depending on the task to be performed. In this review, "sitting" is discussed in the context of Western industrialized standards. Sitting is described as an erect posture in which the head and trunk are vertical, the lower legs are bent at about 90 degrees at the hips and knees, and the feet are firmly placed on the floor.¹³ The concept of sitting in non-western societies is very different. In India and Southeastern Asia, for example, it is still common to see workers sitting cross-legged on the ground, squatting, or in a kneeling position.²⁶ Although they are common, these variations of sitting are not discussed in this review.

The existence of the relationship between workplace factors and the occurrence of LBP has long been recognized.^{1,11,24} Among the occupational exposures identified, sitting is commonly cited as a risk factor in the literature, along with heavy physical work, heavy or frequent lifting, non-neutral postures (i.e., trunk rotation and forward bending), pushing and pulling, and exposure to whole body vibration (motor vehicle driving or other).^{10,20,35,55}

Many experimental investigations have focused on biomechanical hypotheses to explain the association between sitting and LBP. The literature on this subject is extensive, but the evidence is somewhat contradictory. It has been shown that intradiscal pressure is increased in the sitting posture.³⁹ In a more recent investigation, Wilke *et al.*⁵⁶ reevaluated the intradiscal pressure in sitting and found that, in fact, it can be less than in erect standing. Another hypothesis is that prolonged static sitting postures may have a deleterious effect on the nutrition of the intervertebral disc.³⁵ Thus a constantly changing position is important to promote the flow of fluid (nutrition) to the disc.⁵²

In general, however, epidemiological studies related to this topic have demonstrated little progress to date in the validation of those factors established in experimental biomechanical and pathoanatomical research. For this reason, the authors decided to systematically review the recent literature for further evidence. This review is restricted to a consideration of work-related physical risk factors to LBP while sitting. Although other factors such as physiological and psychosocial factors may also be important, they are not the focus of this study.

For this review, sitting is defined as a sustained upright trunk posture with limited possibilities to change posture or position. LBP is represented here by reported or examined ache, pain, stiffness, or discomfort in the lumbar spine.⁸ Many workers whose occupation requires sitting are also exposed to whole body vibration and/or awkward posture, and these exposures are often independently analyzed in the literature. Awkward posture represents a

non-neutral trunk posture (i.e., bending forward and/or twisting of the trunk).^{10,20,25} “Postural load”⁶ and “unfavorable posture”³⁶ are terms used in the literature that refer to awkward posture. Whole body vibration (WBV) is present when the body receives continuous vibration transmitted from the seat over a period of time.^{6,8}

This review seeks to empirically examine the association between the presence and/or occurrence of LBP among occupational groups in which the seated posture is the major physical requirement for the work. The following questions were considered: (1) Is there evidence in the recent epidemiological literature of an association between occupational groups exposed to sitting and reported LBP? (2) Is there evidence in the recent epidemiological literature of an association between exposure to WBV while sitting and reported LBP? (3) Is there evidence in the recent epidemiological literature of an association between awkward posture while sitting and reported LBP? (4) Is there evidence in the recent epidemiological literature of an association between the combined effect (both WBV and awkward posture) while sitting and reported LBP?

Methodology

Using MEDLINE (National Library of Medicine, USA), and Healthstar as the principal databases, studies published between 1990 and 2001 were retrieved. The primary keywords used were **LBP** and *sitting*. The secondary key words used were *whole body vibration*, *static posture*, *occupational back pain*, *awkward posture*, and *sedentary occupation*. Reference lists of studies retrieved were carefully screened in order to locate additional papers. Only articles written in English were included and a total of 108 studies were identified.

Those studies that described the presence and/or occurrence of reported or examined LBP in occupational groups in which the major physical requirement is sitting (calculated as sitting for more than half of work-time) were included. Job titles were also used as the selection criteria to identify those occupations in which the worker is required to sit for the major part of the day. Twenty-eight publications met this criterion and were reviewed using the Quebec Task Force appraisal form.⁴⁵

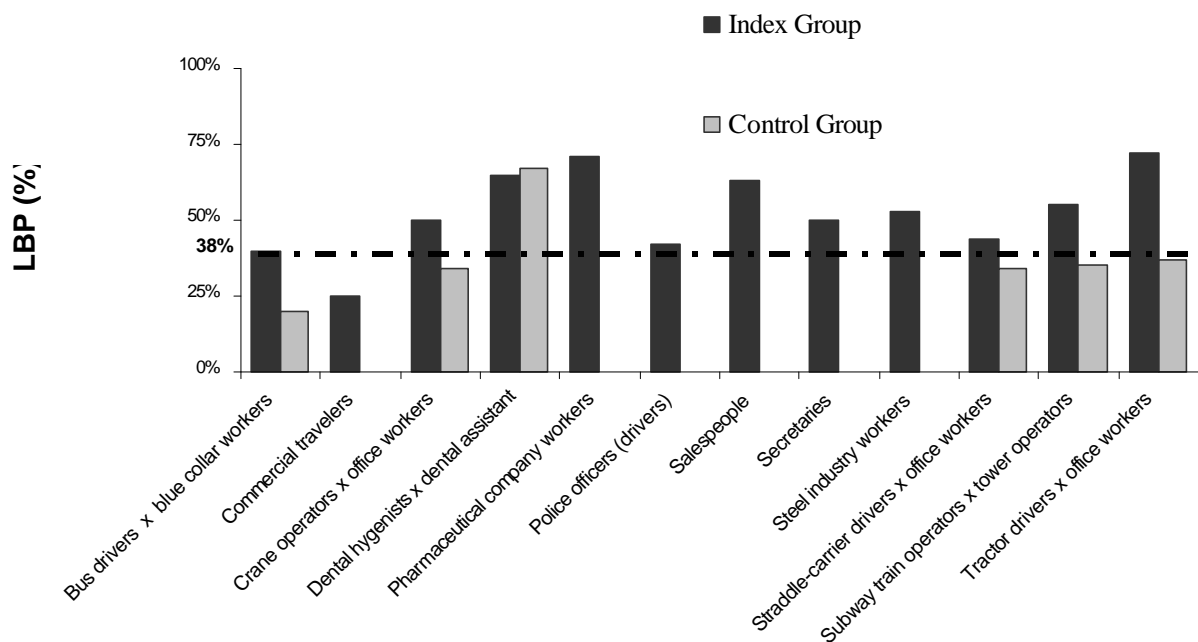
Quality criteria were established for inclusion and carefully analyzed by the authors. They were: a clear definition of LBP; a control group (if applicable) that is well described and relevant (consisting of similar or internal groups subjected to less exposure to sitting); a response rate reported if a questionnaire was used to gather data; exposure described or at least graded; and a statistical measure of association (Odds Ratio or Risk Ratio).

After applying the evaluation criteria, a total of thirteen articles were excluded from the final review. Five were experimental studies^{22,28,29,37,46} and eight were epidemiological studies. The main exclusion criteria pertained to the lack of a statistical measure of association. Six epidemiological studies were excluded for this reason.^{9,21,23,27,35,49} Two epidemiological studies were excluded, one because of small sample size¹⁰ and one because the focus was placed on psychosocial factors rather than physical work-related factors while sitting.⁵¹ Thus, the remaining fifteen publications were reviewed to evaluate the possible associations between sitting at work and reported LBP.

Results

Figure I depicts the results of studies undertaken from 1990 to 2000 that measured the annual prevalence rates of LBP among occupational groups that are required to sit for more than half of their work-time. The estimated annual prevalence rate of LBP in the general population of Europe was used for comparison.^{43,53} European population data was chosen as comparison group because 80% of the studies reviewed were conducted in Europe. The average age of the populations listed in Figure I was 30-50 and most of the workers were male. In general, the figure shows a higher annual prevalence rate for those occupational groups that spend more than half of a working day in a sitting position. Commercial travelers⁴⁴ and office workers (in control groups)^{6,12} showed a lower prevalence rate (25%) than the average of annual prevalence rate (38%) found in the compared European general population.^{43,53} Tractor drivers reported the highest annual prevalence rate, with almost two times the annual prevalence rate (72%) of the general population.¹²

FIGURE 1: ANNUAL PREVALENCE OF LBP FOUND IN STUDIES OF OCCUPATIONS WHERE SITTING IS REQUIRED FOR MORE THAN HALF OF WORK-TIME



Fifteen publications were selected according to specific criteria for a more detailed review regarding the association between presence and/or occurrence of LBP and occupational groups in which sitting is the major physical requirement. Twelve of these studies were conducted in Europe,^{3-6,8,12,17,32,33,36,38,44} one was conducted in Israel,⁴⁸ one in Canada,³¹ and one in North America.¹⁹ The studies yielded different types of prevalence estimates (i.e., point, period, lifetime); however, in the majority of studies the odds ratio (OR) for annual prevalence was provided. In general, the definition for LBP was consistent. Most authors described how data had been collected and attempted to categorize participants as exposed/non-exposed, or even to quantify their exposure. It should be noted that for all the studies analyzed, the maximum parameter was selected by the authors for each of the exposure factors described. For instance, Bovenzi and Betta⁶ provided the OR for three parameters of the exposure 'vibration duration' such as 5-15 years, 16-25 years, and greater than 25 years. The later parameter (>25 years) was selected for this review. LBP was self-reported in all the publications reviewed, with the exception of two that used a medical examination.^{17,48}

TABLE I – ASSOCIATION BETWEEN THE PRESENCE OF LBP AND OCCUPATIONS REQUIRING SITTING FOR > 1/2 WORK-TIME

First Author and year	Study Design	Study Group	Control Group	Outcome	Exposure	Risk Indicator (95% CI or pvalue)
Bongers 1990 ³	Cross-sectional Cohort	Helicopter pilots (n=133)	Non-flying officers (n=228)	LBP	Pilot a helicopter	OR= 9.0 (4.9-16.4)*
Boshuizen 1992 ⁵	Cross-sectional Cohort	Truck and tractor drivers (n=196)	Blue-collar workers (n=107)	LBP	Drive a tractor or a truck	OR= 1.39 (0.71-2.7)*
Bovenzi 1994 ⁶	Cross-sectional Cohort	Tractor drivers (n=1155)	Office workers (n=220)	LBP (previous 12 months)	Drive a tractor	OR= 2.39 (1.57-3.66)
Bovenzi 1992 ⁸	Cross-sectional Cohort	Bus drivers (n=234)	Maintenance workers (n=125)	LBP (previous 12 months)	Drive a bus	OR= 2.57 (1.52-4.35)
Burdorf 1993 ¹²	Cross-sectional	Crane operators (n=94) Straddle-carrier drivers (n= 95)	Office Workers (n=86)	LBP (previous 12 months)	Being a crane operator Being a straddle-carrier driver	OR= 3.29 (1.52-7.12) OR= 2.51 (1.17-5.38)
Heliövaara 1991 ¹⁷	Cross-sectional Cohort	Professional drivers (n= 310)	Non-professional drivers (n= 5363)	LBP	Occupational vehicle driving	OR= 1.83 (1.12-3.0)*

Liss 1995 ³¹	Cross-sectional	Dental hygienists (n=950)	Dental assistants (n=108)	LBP (previous 12 months)	Work as a dental hygienist	OR= 0.9 (0.6-1.4)
Macfarlane 1997 ³²	Longitudinal Cohort	Workforce population of Northwest England (n=1412)	N/A	LBP (I year follow-up)	Drive a car (>4 h/day)	OR= 1.1 (0.5-2.7)
Magnusson 1996 ³³	Cross-sectional Cohort	Bus drivers (n=111) Truck drivers (n=117)	Sedentary workers (n=137)	LBP (previous 12 months)	Drive a bus or truck	OR= 1.79 (1.16-2.75)
Masset 1994 ³⁶	Cross-sectional	Steel industry workers (n= 618)	N/A	LBP (previous 12 months)	Work in a seated position	OR= 1.46 (p = 0.09)
Moen 1995 ³⁸	Cross-sectional	Dentists (n=96) Dental auxiliaries (n=83)	Office workers (n=25)	LBP (employment period)	Being a dentist	OR= 1.0 (0.5-1.9)
Rotgoltz 1992 ⁴⁸	Cross-sectional	Pharmaceutical factory workers (n= 208)	N/A	LBP (previous 12 months)	Work in sitting position (packing, laboratories and offices)	OR= 1.97 (1.37-2.81)
Pietri 1992 ⁴⁴	Longitudinal cohort	Commercial travelers (n=1719)	N/A	LBP (previous 12 months)	Drive a car (>5 h/day)	OR= 2.1 (1.3-3.4)

* 90% Confidence Interval

Table II summarizes the studies that examine the association between the presence and/or occurrence of LBP and exposure to WBV among occupations that require sitting for more than half of work-time. All studies used vibration dose as the exposure measured; however, some studies also provided the OR for vibration magnitude^{4,6,8} and/or duration.^{3,4,6,8} To calculate vibration dose, the studies used the formula $\sum a_i^2 \cdot t_i$, where a_i is the estimated vector sum of accelerations measured on the vehicle and t_i the time in years (or hours in the case of helicopter pilots). In all studies, vibration measurements on the vehicles were performed according to the recommendations of the international standard ISO 2631-1.¹⁸ The occupation that shows the strongest association between LBP and vibration dose was helicopter pilots with OR = 39.5 (90% CI 10.8 - 15.6). It is noteworthy that this was the only group that used hours as a measurement for duration of exposure because pilots systematically document their flight hours in a flight log. Both the magnitude and duration show an average OR = 2.0 for increased risks of reported LBP. However, the duration of exposure to WBV shows a higher association than the magnitude of WBV in all studies in which both type of exposures were measured.

TABLE II – ASSOCIATION BETWEEN THE PRESENCE OF LBP AND EXPOSURE TO WHOLE BODY VIBRATION AMONG OCCUPATIONS THAT REQUIRE SITTING FOR >1/2 OF WORK-TIME

First Author and Year	Study Design	Study Group	Control Group	Outcome	Exposure / WBV	Risk Indicator OR (95% CI)
Bongers 1990 ³	Cross-sectional Cohort	Helicopter pilots (n=133)	Non-flying air force officers (n=228)	LBP	Duration: Total flight time/>4000 h	OR= 13.4 (5.7-32.0)*
					Dose: >1200 m ² h/s ⁴	OR= 39.5 (10.8-15.6)*
Boshuizen 1990 ⁴	Longitudinal Cohort	Tractor drivers (n=450)	Agricultural workers (n=110)	LBP	Magnitude: >0.7 m/s ²	OR= 2.10 (1.07-4.1)*
					Duration: > 10 years	OR= 3.6 (1.21-11)*
					Dose: >5 year m ² /s ⁴	OR= 2.8 (1.64-5.0)*
Boshuizen 1992 ⁵	Cross-sectional Cohort	Truck and tractor drivers (n=196)	Blue-collar workers (n=107)	LBP	Dose: 15 year m ² /s ⁴	OR= 1.96 (1.03-3.7)*
Bovenzi 1992 ⁸	Cross-sectional Cohort	Bus drivers (n=234)	Maintenance workers (n=125)	LBP (previous 12 months)	Magnitude: >0.60 m/s ²	OR= 1.76 (0.86-3.58)
					Duration: >15 years	OR= 2.90 (1.54-5.46)
					Dose: >4.5 years m ² /s ⁴	OR= 2.63 (1.35-5.12)
Bovenzi 1994 ⁶	Cross-sectional cohort	Tractor drivers (n=1155)	Office workers (n=220)	LBP (previous 12 months)	Magnitude: >1.25 m/s ²	OR= 2.29 (1.43-3.68)
					Duration: >25 years	OR= 2.74 (1.69-4.45)
					Dose: >30 years m ² /s ⁴	OR= 2.36 (1.48-3.74)
Magnusson 1996 ³³	Cross-sectional cohort	Bus drivers (n=111)	Sedentary workers (n=137)	LBP (previous 12 months)	Bus drivers Dose: 48.18 years m ² /s ⁴	OR= 2.0 (0.98-4.1)
		Truck drivers (n=117)			Truck drivers Dose: 79.97 years m ² /s ⁴	

* 90% Confidence Interval

Only two studies^{6,8} determined the risk of the association between reported LBP and postural load due to frequent bending and twisting of the trunk while sitting (Table III). Bovenzi and Zadini⁸ showed that the reporting of LBP increased when exposure to awkward postures increased (OR = 2.29, 95% CI 1.22 - 4.29) for bus drivers when compared with maintenance workers. With exposure to frequent awkward postures, Bovenzi and Betta⁶ found that tractor drivers are almost five times more likely to report LBP than office workers.

TABLE III – ASSOCIATION BETWEEN THE PRESENCE OF LBP AND AWKWARD POSTURE AMONG OCCUPATIONS THAT REQUIRE SITTING FOR >1/2 OF WORK-TIME

First Author and Year	Study Design	Study Group	Control Group	Outcome	Exposure	Risk Indicator OR (95%CI)
Bovenzi 1992 ⁸	Cross-sectional Cohort	Bus drivers (n=234)	Maintenance workers (n=125)	LBP (previous 12 months)	Awkward Posture	OR= 2.29 (1.22-4.29)
Bovenzi 1994 ⁶	Cross-sectional cohort	Tractor drivers (n=1155)	Office workers (n=220)	LBP (previous 12 months)	Awkward Posture	OR= 4.56 (2.59-8.03)

As indicated on Table IV, only one study measured associations for reported LBP and for the combined effect of exposure to WBV and awkward posture. This study was done by Bovenzi and Betta,⁶ who also looked at agricultural tractor drivers exposed to whole body vibration and the association of postural stress with the occurrence of chronic LBP. The tractor drivers were 4.56 (95% CI 2.59 - 8.03) more likely to report LBP compared with the unexposed subjects (office workers). Bovenzi and Betta⁶ categorized postural stress by rating the workers' perception of the frequency and duration of each posture. They calculated the frequency using a five-item index scale assigning a value from 0 (never) to 4 (very often). Following this step, a mean value was used to determine the duration by calculating the postural indices during a typical workday. Finally, they categorized the average postural load into the four grades described on the table (mild = 0-0.99, moderate = 1-1.99, hard = 2-2.99, and very hard= 3-4). The results of this study show that after combining the exposure factors, the risk of the occurrence of chronic LBP increases as vibration dose and postural load increase. In fact, the risk for chronic back pain increases more than threefold compared with the unexposed group (office workers).

TABLE IV- ASSOCIATION BETWEEN THE COMBINED EFFECT OF VIBRATION DOSE (years m²/s⁴) / POSTURAL LOAD AND THE OCCURRENCE OF CHRONIC LBP

Total vibration dose (years m ² /s ⁴)	Postural load (grades)*			
	1 (mild)	2 (moderate)	3 (hard)	4 (very hard)
5	OR=1.29	OR=1.79	OR=2.50	OR=3.48
10	OR=1.41	OR=1.96	OR=2.73	OR=3.79
20	OR=1.55	OR=2.15	OR=2.99	OR=4.16
30	OR=1.63	OR=2.27	OR=3.16	OR=4.39
40	OR=1.70	OR=2.36	OR=3.29	OR=4.58

Modified from Bovenzi M & Betta A A 1994 Low-Back Disorders in Agricultural Tractor Drivers Exposed to Whole-Body Vibration and Postural Stress. Applied Ergonomics 25(4): p237⁶

* Odds Ratio adjusted for age, BMI, education, sport activity, car driving, marital status, mental stress, climatic conditions and back trauma

Discussion

The prevalence rates of LBP have been affecting the economy of industrialized countries in many ways.^{14,16} As was described in Figure I, the prevalence rate of reported LBP in those occupations that require the worker to sit for the major portion of a working day is significantly higher than the prevalence rate of the general population.^{43,53} There are different factors such as physical, psychosocial, and individual characteristics that contribute to these findings.^{10,20,35,47,55} Only the physical factors will be discussed here.

Sitting

Sitting has been a complex topic for researchers of LBP. For many years, the sitting position has been identified as one of the major risk factors for having LBP.^{24,34} Nachemson and Elfström found that body position affects the magnitude of the loads on the lumbar spine, and that it increases markedly when sitting is compared with upright standing and well supported reclining.³⁹ This finding created much controversy, and while some subsequent lab studies supported it,^{2,28} others have found different results.^{35,56} For instance, the conclusions of Wilke *et al.*⁵⁶ re-evaluate the assumption that there is an increased presence of higher intradiscal pressure while sitting than erect standing. A definitive experimental conclusion has been yet to be confirmed. However, the literature reviewed for this paper has shown that sitting by itself does not imply a markedly increased association with the presence and/or occurrence of reported or examined LBP. In fact, it was found that the association became considerably stronger only when the occupational groups studied were exposed to WBV and/or awkward postures while sitting.

Sitting and exposure to whole body vibration

One of the major co-exposure factors for all the occupations analyzed was WBV. There is a clear indication of an increased risk for reported LBP in occupations with exposure to WBV while sitting, mostly in professional driving occupations.^{3,5,6,7,8,17} Many authors have carefully reviewed the risk effect expressed as increased associations from exposure to WBV. Although these authors concluded that there is indeed a risk of this physical factor, there is not yet a clear dose-response relationship. There are many confounding factors that interfere with the relationship between LBP and WBV exposure. Worker age, the duration of the exposure, history of LBP, previous exposure, and even posture while exposed to WBV seems to affect that relationship.^{3,5,8,42,50} Few studies control for some of these confounding factors. However, the association is still high.^{3,4,5,8} In fact, occupations such as helicopter pilots have shown very high OR (OR = 39.5, 90% CI 10.8 - 15.6) for a vibration-dose exposure greater than 1200 m²/s⁴ after adjusting for awkward postures.³

Two other vibration dimensions were described by the studies reviewed: the magnitude of the exposure and the duration of the exposure. The articles reviewed showed that duration of the exposure had a slightly stronger association with the presence of LBP than with magnitude of vibration.^{4,6,8} This finding suggests a cumulative effect. As the time of exposure increases, the risk of reporting LBP increases. Bovenzi and Betta⁶ found that prolonged tractor driving and exposure to WBV was the factor most associated with reporting chronic LBP and sick leave. They suggested an excessive accumulated vibration dose effect as the main reason, which is in agreement with the Boshuizen findings.⁵ It is important to

understand that in both cases either duration or magnitude were positively associated with the presence of reported LBP symptoms. It is also important to take into account that the recommended ISO standards did not reveal any preventive health effect. Even following ISO recommendations, the levels of vibration magnitude to which most drivers are exposed seems to be higher than the recommended maximum level of exposure. Many authors argue that these recommendations should be reviewed.^{3,5,6}

Sitting and Awkward Posture

Awkward postures have been described as possible risk factors for the presence of LBP.^{10,20,25} Many experimental studies^{2,25} have demonstrated that postural changes affect spinal loads. Keyserling et al.²⁵ used a computer-aided system to investigate trunk posture during work by measuring the time spent in neutral and non-neutral postures. Their results suggested that by controlling non-neutral trunk posture the risk of developing back pain on industrial jobs can be reduced. Non-industrial occupations such as professional drivers, dentists, and helicopter pilots are also potentially exposed to awkward postures. However, only two epidemiological studies showed the associated risk of being exposed to awkward posture and having LBP.^{6,8} The results of these two studies confirm that in the case of bus and tractor drivers, the risk of having LBP increases due to awkward posture while driving. The risk is even greater for tractor drivers (even after adjusting for vibration dose). The question to be asked in this case is if the observed adverse effects of driving in these studies should be attributed to the exposure to awkward posture alone or to a combination of prolonged sitting and twisted and bending posture, once sitting *per se* was not investigated.

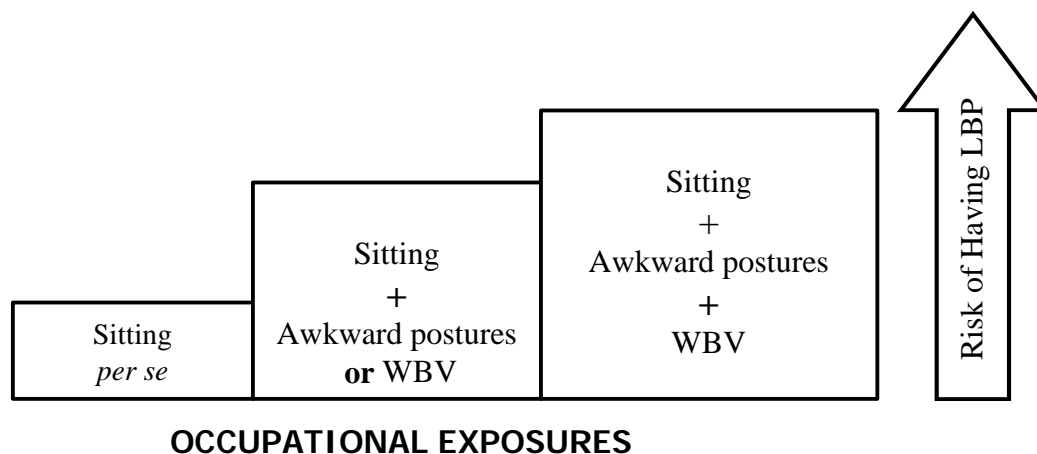
A Proposed Model

The literature reviewed has indicated an increased risk for LBP for individuals in those occupations that require prolonged sitting (defined as sitting for more than half of a working day). However, the risk increases after combining factors such as WBV and awkward postures. In fact, for all the occupations studied, these co-exposure factors were the variables that led to a significantly increased risk. The fact of being seated for an extended period does not significantly demonstrate an impressive risk of having LBP symptoms. Bovenzi and Betta⁶ compared a group of agricultural tractor drivers with a group of office workers. Both groups were exposed to static load due to prolonged sitting. However, only the tractor drivers' group was exposed to the combined factors of WBV and awkward posture. They found that tractor drivers were 2.39 times more likely to report LBP than office workers (OR = 2.39, 95% CI 1.57 - 3.66). The association was similar (OR = 2.36, 95% C.I 1.48 - 3.74) when they looked at WBV while sitting (adjusted for awkward posture). And it increased even more when postural load was analyzed adjusting for vibration dose (OR = 4.56, 95% C.I 2.59 - 8.03).

A model was constructed based on those factors (Figure 2). The model aims to describe how the risk effect of prolonged sitting increases significantly as other co-exposure factors (in this case WBV and awkward postures) play a role. As such, just the fact of sitting probably does not present a risk until the worker is exposed to either a certain level of WBV and/or an awkward posture. When those co-exposure factors are combined, the risk for reporting LBP increases even more (Figure 2). Bovenzi and Betta⁶ tried to demonstrate this finding after analyzing the combined effect of postural load and total vibration dose. They

found, as mentioned above (Table IV), that the combination of the vibration dose and postural load increases the risk of reporting LBP. In fact, there was a linear trend of increasing prevalence of LBP as the combined effect increases, perhaps demonstrating a dose-response relationship.

FIGURE 2: THE RISK OF HAVING LBP WHILE SITTING INCREASES SIGNIFICANTLY AS THE COMBINATION OF PHYSICAL FACTORS SUCH AS WBV AND AWKWARD POSTURE BEGIN TO HAVE AN ACTIVE EFFECT ON THE WORKER'S BACK.



It could be argued that this model has many limitations due to the fact that LBP is multifactorial in its origin. Through this literature review some physical (mechanical) factors were identified that are associated with the occupations performed while sitting (WBV, awkward posture, and a combination of both). However studies have shown that there are other risk factors for LBP to which workers are exposed during the time period when they are sitting or not sitting, such as manual material handling or lifting activities, or psychosocial factors.

Conclusion and implications

More epidemiological studies are needed to provide clear evidence of the association between sitting and occupational LBP. However, our review suggests the following conclusions:

- Sitting by itself does not show an increased association with the presence of reported LBP.
- Sitting in combination with other co-exposures such as WBV and awkward postures does increase the association with the presence of LBP.
- Occupational groups exposed to WBV while sitting are at an increased risk of having LBP. Also, the influence of the duration to the exposure seems more important than the magnitude of the exposure, suggesting a cumulative effect.
- Although awkward posture has not been as well investigated as WBV, the results of the preliminary research reveal a strong association with the presence of LBP. Further

research is needed on this question, as well as the development and testing of more valid and reliable instruments for its measurement.

- Sitting in combination with WBV and awkward posture seems to have the strongest association with the presence of LBP. More studies on this topic are needed to confirm this hypothesis.

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