Whole-Body Vibration in Bus Drivers: Association with Physical Fitness and Low Back Pain

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Abstract

The aim of the study was to investigate the relationship between exposure to whole body vibration, prevalence of low back pain and level of physical fitness in bus drivers. The measurement of whole body vibration was in 100 city buses with different characteristics and the prevalence of low back pain was assessed in 200 drivers with a measurement of physical fitness level. Descriptive statistics with mean and standard deviation and inferential statistics were used with the Kurskal-Wallis test, Dunn's multiple comparisons test, Poisson regression and significance level of p <0.05. The results demonstrate significant differences between the vehicle models, characterizing the conventional and articulated buses on the y and z axes with higher levels of vibration. Drivers working with conventional and articulated vehicles had a higher prevalence of low back pain with 57.5 and 60%, respectively. The level of physical fitness was low in most of the sample, however, the drivers of bi-articulated and micro bus had higher levels. Poisson regression with the outcome of low back pain, showed the factors that showed a significant prediction: age, working time, abdominal muscle resistance, lumbar strength, RMSy and RMSz.

Keywords: Whole body vibration, bus drivers, low back pain and physical fitness

1. Introduction

Bus drivers are essential professionals in today's society, as conduct thousands of passengers to their destination. Occupational exposure to whole-body vibration from the operation of buses has long been acknowledged as one risk factor for musculoskeletal disorders, more specifically, low back pain (SARSWAT et al., 2016). Various factors which can be the causes of such musculoskeletal disorders are vibrations produced in the vehicles, prolonged sitting, position of the driver's seat in the bus, differences in the anthropometric sizes of the drivers, environment in which they are working (like automatic or manual transmission, brake travel etc.), awkward postures and various physiological factors such as age, height, weight, sex, health issues, body mass index etc. (MAGNUSSON et al., 1996; KUMAR et al., 2005; YASOBANT et al., 2015).

The social consequences of low back pain, including its severity, may be assessed in terms of the extent to which people are prevented from carrying out their normal activities (reduced activities) and absenteeism (WIDANARKO et al., 2012). In a study conducted in Norway, it was found that the annual absenteeism, in the case of back pain lasting more than two weeks is 2.27% participants with a median of 43 days. After one month, the return to work is 35%, after three months 76%, and after six months 85%. 42% of those on sick leave after six months do not return to work even after a year and retire due to disability (HAGEN; THUNE, 1998). In France, for chronic back pain, sick leave is prescribed in 23% of cases, with an average duration of 11 days (DREISER et al., 1997).

An exponential dose–response relationship between hours of weekly driving and injury risk has been found (KRAUSE et al., 2004). Additionally, was identified back disorders as one of the largest sources for medical impairment and early permanent disability among mass transit operators (JOHANNING, 1998). Currently, there is limited data available on whole body vibration levels experienced by workers on transit systems, but much of the data that have been published suggests that these worker's exposures exceed recommended standards (PADDAN; GRIFFIN, 2001). In addition, studies have identified road conditions as a major contributor to levels of whole body vibration exposure [TESCHKE et al., 1999; MALCHAIRE et al., 1996). However, most of these studies have focused on short-term exposures for vehicle operators traveling along a fixed route or a test track, or equivalent average exposure for vehicle operators traveling a variable route.

Previous studies have demonstrated that individuals with low back pain show a decreased muscular strength and endurance in trunk muscles, lower levels of abdominal muscle strength than subjects without pain, reduced flexibility of back muscles and hamstrings when compared to those of normal subjects (ALPEROVITCH-NAJENSON et al, 2010; CASSIDY et al., 2005; JACKSON et al., 1998; MARSHALL et al., 2009; TAKEMASA et al., 1995; EBRAHIMI et al., 2014, DEL POZO-CRUZ et al., 2014, PORTELA et al., 2015). The literature has also reported that obesity or a high body mass index (BMI >30 $kg.m^{-2}$) is associated with low back pain and disability in general workers (RUBIN, 2007; PORTELA et al. 2015). The aim of this study was to determine the levels of vibration exposure for bus drivers, using the ISO 2631-1 and 2631-5 standards, measure the physical fitness and low back pain prevalence.

2. Material and methods

The study included subjects who specifically drove each of the types of buses that the company owned: conventional buses, direct line "ligeirinhos", minibuses, articulated buses and bi-articulated buses. The sample of drivers consisted of a total of 40 subjects who worked specifically with one of the five types of buses, making a total of 200 individuals evaluated. At the time of the company's assessment, the total number of driver employees was 361 men.

The evaluation of the whole body vibration was performed by the researcher, using a triaxial accelerometer "*Triaxial DeltaTron Seat Pad Accelerometer Type 4515-B-002 - Bruel & Kjaer*" connected to the vibration analyzer "*Human Vibration Analizer Type 4447 - Bruel & Kjaer*". The accelerometer was installed on the seat and the analyzer was placed on a solid surface behind the driver's seat. Vibration measurements were carried out in accordance with the ISO 2631-1 (1997) standard. All vibration measurements were carried out in the driver's usual working situation, reproducing the route on which the bus travels. The time period for each measurement was approximately 30 minutes, reproducing a complete route of the itinerary that the driver takes.

Subsequently, the measurements made were analyzed using the Vibration Explorer Software BZ-5623 by *Bruel & Kjaer*, which presented all the results obtained by measuring the equipment for subsequent statistical analysis. The ISO 2631-5 (2004) standard was also used, which covers the assessment of occupational exposure to vibrations with multiple shocks and effects on health. The parameters analyzed were: frequency-weighted RMS acceleration (A_w), vibration dose value (VDV), crest factor, acceleration dose value (D_k), Static Spinal Compression Dose (S_{ed}) and Seat Effective Amplitude Transmissibility (SEAT). The parameters were normalized to reflect 8h of driving exposure (e.g. A_w (8), VDV (8), D_k (8) and S_{ed} (8)).

All the bus drivers were asked to complete the Pain Questionnaire of Corlett and Manenica (1980). This evaluation method for the prevalence of low back pain has been used in previous studies (PORTELA et al., 2015; ALPEROVITCH-NAJENSON et al., 2010). Participants were asked if they had work-related low back pain during the last 12 months (ache, pain or discomfort) for a day or more. Those who answered “yes” were included in the low back pain group and were asked to indicate in a body chart all of the pain sites and discomfort they had experienced. The participants who answered “no” were assigned to the group without low back pain. This study aimed to identify the prevalence of self-reported low back pain.

Height was recorded without shoes as stretch stature to 0.1 cm using a wall-mounted stadiometer. Body mass was measured to 0.01 kg on a calibrated electronic scale. Body mass index (BMI) was calculated from the ratio of body weight to body height in $kg.m^{-2}$.

The hamstring flexibility test was performed with a wooden box measuring 30.5 cm x 30.5 cm x 30.5 cm, and at the top, where the scale is located, there was an extension of 26.0 cm and the 23º cm of the scale coincided with the point where the subject touches the soles of his feet. The subject sat with his knees extended, touching his bare feet on the box under the scale, then placed his hands on each other on the scale, with his elbows extended, and performed a trunk flexion in front of him, registering the maximum point, in centimeters, reached by the hands.

To perform the abdominal test, the subject was positioned in the supine position on a foam mat. With hips and knees flexed, soles supported on the ground, arms were crossed in the anterior region of the chest holding the opposite shoulders. The appraiser immobilized the feet of the appraised, who received prior instruction to perform the greatest number of trunk flexions during the time of 1 minute. Only the flexions were recorded where the subject raised the trunk until contact between the anterior aspect of the forearms and the thighs occurred, and returned to the initial position, touching at least the anterior half of the scapula on the mat.

In the sample of drivers, strength assessment of the lumbar region was performed using a dynamometer. To assess lumbar strength, a dorsal dynamometer served as an assessment tool. The protocol consisted of the device being calibrated and zeroed, then asking the subject to position himself on the base of the device with the knees in extension, elbows in extension and the trunk erect. Soon after, the subject was asked to do the trunk extension, thus executing the movement force with the lumbar region. The result was the maximum force exerted by the tester, computing the best result of two attempts, measured in Kgf (kilogramforce).

Descriptive statistics with mean and standard deviation were used to characterize the data. Next, the assumptions of normality and homogeneity were tested with the Shapiro Wilk and Levene test, respectively. After this stage, inferential statistics tests were chosen according to the parametric or non-parametric approach. Data comparison was performed using the Kruskall-Wallis analysis of variance test followed by Dunn's multiple comparison test. Categorical data were compared using Pearson's chi-square test. To verify the relationship between the level of whole body vibration, physical fitness variables in the outcome of low back pain, a Poisson Regression was performed. The data were tabulated in the Excel 2013 Software, while the inferential statistics occurred in the SPSS Software version 21.

3. Results and Discussion

The results for the evaluation of the whole body vibration in 100 urban buses in the city of Curitiba - PR are described in Table 1, in addition to the comparison between the five types of buses studied. The values presented for the vibrational evaluation are in accordance with the ISO 2631-1 (1997) standard, which establishes the instructions for measuring human exposure to whole body vibration. The result of the data normality test made from the Shapiro Wilk test and presented significance levels of less than 5% ($p < 0.05$) for the whole body vibration data. Therefore, the analysis of the results was made using non-parametric inferential statistics.

Table 1. Descriptive statistics, analysis of variance and multiple comparison test of whole body vibration values in city buses, according to ISO 2631-1.

Parameter	Axis	CON	MIC	LIG	ART	BIA	p
RMS (m.s^{-2})	x	$0,383^{d}$ ±0,167	$0,421^{e, g}$ ±0,036	$0,253^{b}$ ±0,060	$0,396^{h, j}$ ±0,107	0,174 ±0,040	0,001
	y	$0,524^{b, d}$ ±0,304	$0,620^{e}$ ±0,055	0,287 ±0,100	$0,821^{c, h, f, j}$ ±0,5	0,247 ±0,102	0,001
	z	$0,587^{b, c, d}$ ±0,100	$0,560^{e, f, g}$ ±0,083	0,411 ±0,04	$0,499^{h, j}$ ±0,08	0,430 ±0,108	0,001
Crest Factor (m.s^{-2})	x	10,390 ±2,3	9,939 ±3,0	12,387 ±4,756	22,782 ±20,9	13,381 ±3,7	0,001
	y	15,411 ±3,6	12,738 ±4,1	19,277 ±11,2	26,540 ±19,7	17,354 ±5,8	0,001
	z	14,903 ±11,8	11,167 ±2,1	12,716 ± 1,6	12,240 ±1,3	13,874 ±2,3	0,029
VDV (m.s$^{-1,75}$)	x	4,118 ±1,7	4,005 ±1,1	2,844 ±0,1	$8,791^{c, h, e, j}$ ±8,6	2,116 ±0,8	0,001
	y	7,243	7,739	5,001	$20,595^{c, h, e, j}$	3,973	0,001

		±4,5	±2,0	±3,1	±20,7	±2,4	
	z	6,390$^{a, b, c, d}$ ±1,4	5,377$^{e, h, g}$ ±1,2	4,582 ±0,5	5,290 ±0,4	5,050 ±0,6	0,001
RMS VTV (m.s^{-2})		1,119$^{b, d}$ ±0,4	1,192$^{e, g}$ ± 0,09	0,684 ±0,1	1,409$^{c, h, j}$ ±0,6	0,611 ±0,1	0,001
VDV VTV (m.s$^{-1,75}$)		13,717 ±6,0	13,398 ±3,1	9,573 ±3,8	32,506$^{c, h, e, j}$ ±30,5	8,329 ±2,9	0,001
A(8)		0,833$^{b, d}$ ±0,4	0,867^{e} ±0,08	0,457 ±0,08	1,189$^{c, h, e, j}$ ±0,6	0,446 ±0,1	0,001

CON: Conventional bus; MIC: Minibus; LIG: Ligeirinho; ART: Articulated bus; BIA: Bi-articulated bus.
Kruskall-Wallis analysis of variance test;

Dunn's multiple comparison test: the statistical difference between CON and MIC; b difference between CON and LIG; c difference between CON and ART; d difference between CON and BIA; and difference between MIC and LIG; f difference between MIC and ART; g statistical difference between MIC and BIA; h statistical difference between LIG and ART; i statistical difference between LIG and BIA; j difference between ART and BIA.
Significance level: $p < 0.05$.

According to ISO 2631-1 (1997), the acceleration value that represents the magnitude of the whole body vibration is the RMS value between the three axes (x, y and z). When comparing the exposure between the types of vehicles, a significant difference is found between them ($p < 0.05$), with the highest values found in articulated, minibus and conventional buses. The characteristics that can contribute to lower vibration magnitudes in light and bi-articulated vehicles are the location of the engine, in light vehicles the engines are distant from the drivers and use of streets with adequate pavement, bi-articulated vehicles travel on exclusive roads called “channels”, the which are exclusive to this type of bus.

The RMS values presented by the average of conventional vehicles, minibus, light, articulated and bi-articulated are above the values recommended by the European Union Directive, which establishes that at RMS acceleration levels above 0.5 m.s^{-2}, actions must be taken in order to reduce the magnitude of whole body vibration transmitted to the worker.

To assess the relationship between exposure to whole body vibration, the measurement of the parameter S_{ed} (daily dose of static compression on the lumbar spine) and R factor (ratio between S_{ed} and maximum static compression force) was measured, in accordance with to ISO 2631-5 (2004). The values were found for each driver, adding up to a total of 200 measurements. Each bus gave rise to two measurements, as two drivers who worked on the same itinerary and with the same vehicle were evaluated. The results of this assessment are described in Table 2.

Table 2. Descriptive statistics, analysis of variance and multiple comparison test of whole body vibration values in city buses, according to ISO 2631-5

Parameter	CON	MIC	LIG	ART	BIA	p
S_{ed} (MPa)	0,625 $^{a, d}$ ± 0,1	0,580 ^{e} ±0,09	0,463^{i} ±0,2	0,746 $^{c, g, h, j}$ ± 0,3	0,402 ±0,06	0,001
Factor R	0,634$^{a, d}$ ±0,2	0,588^{e} ± 0,2	0,454^{i} ±0,1	0,765$^{c, f, h, j}$ ± 0,3	0,385 ±0,1	0,001

CON: Conventional bus; MIC: Minibus; LIG: Ligeirinho; ART: Articulated bus; BIA: Bi-articulated bus.

Kruskall-Wallis analysis of variance test;

Dunn's multiple comparison test: the statistical difference between CON and MIC; b difference between CON and LIG; c difference between CON and ART; d difference between CON and BIA; and difference between MIC and LIG; f difference between MIC and ART; g statistical difference between MIC and BIA; h statistical difference between LIG and ART; i statistical difference between LIG and BIA; j difference between ART and BIA.

Significance level: $p < 0.05$.

The verification of the compressor stress on the spine (S_{ed}) was performed on two types of buses in the city of Seattle, in the United States. It was identified that low-floor buses had 0.32 S_{ed} (MPa), while high-floor buses had 0.33 (MPa) running on city streets (THAMSUWAN et al., 2013). It is noteworthy that the low floor bus is very similar to the conventional model analyzed in the present study. In another study with buses in the city of Seattle, it was found that the buses had S_{ed} values of 0.71 ± 0.21 in MPa, (LEWIS; JOHNSON, 2012). With that, it is noticed that Curitiba vehicles have exposure values similar to the North American ones.

Other factors that can contribute to mitigate the exposure to whole body vibration are the characteristics of the seats used in the vehicle. In an American survey of forklift drivers, it was found that the transmission of vibration from the floor (S_{ed} = 1.05 MPa) to the seat (S_{ed} = 0.43 MPa) in vehicles with mechanical seats was greater than in pneumatic seats (S_{ed} floor = 0.88 MPa, S_{ed} seat = 0.48 MPa), (BLOOD et al., 2010). For Curitiba drivers, one of the major limiting factors for exercising the task of driving vehicles is the inadequacy of the seats on buses. The surveyed subjects reported that the bus seats have few ways of regulating the structure of each individual. As a result, the seats may have an inverse function in relation to their objective of attenuating the vibration transmitted to the driver, thereby increasing the vibration that reaches the driver.

Regarding Factor R, no study with bus drivers is found in the current literature. One of the few surveys that presents the R Factor calculation for workers exposed to full-body vibration, was developed with New Zealand farmers who drive boxes used in the agricultural environment. The study shows that the group of farmers is exposed to an average S_{ed} of 0.26 ± 0.1 MPa and Factor R of 0.31 ± 0.12 (MILOSAVLJEVIC et al., 2010). Thus, the individuals studied do not present a risk factor for the development of lesions in the lumbar spine, as they are below the recommended values of $S_{ed} < 0.5$ and Factor R < 0.8.

The diagram by Corlett and Manenica (1980), was used for subjective evaluation of the symptoms of pain or discomfort in the subjects of the sample. For the present study, the data of those drivers who reported pain only in the region of the lumbar spine are computed, thus, the sample of drivers was divided into subjects who had low back pain and subjects who did not. Furthermore, the results for age (years) and working time (years) are presented as a way to characterize the sample, according to Table 3.

Table 3. Descriptive statistics, analysis of variance and multiple comparison test of identification data and low back pain indexes in urban bus drivers.

Parameter	CON	MIC	LIG	ART	BIA	p
Age (Years)	46,9 ±9,7	46,5 ± 8,3	48,6 ± 9,3	47,3 ± 10,0	44,8 ± 9,5	0,489*
Working Time (Years)	9,7 ± 4,9	11,3 ± 4,9	11,5 ± 7,4	9,9 ± 5,8	10,1 7,6	0,561*
With Low Back Pain	23 (57,5%)	22 (55%)	19 (47,5%)	24 (60%)	18 (44%)	0,842**
Without Low Back Pain	17 (42,5%)	18 (45%)	21 (52,5%)	16 (40%)	22 (56%)	

CON: conventional bus; MIC: minibus; LIG: Ligeirinho; ART: articulated bus; BIA: bi-articulated bus.

* Kruskall-Wallis analysis of variance test.

** Pearson's Chi-square test.

Significance level of $p < 0.05$.

In the study with Israeli bus drivers, out of a total of 361, 164 (45.4%) reported feeling pain in the lumbar spine (ALPEROVITSCH-NAJENSON et al., 2010). The authors emphasize that age was the factor that presented an inversely significant correlation with the prevalence of low back pain. As a result, it is evident that at a younger age and with consequent working time for the driver, the probability of developing pain on the coast increases substantially. Another factor that receives attention in the research was that the prevalence of drivers who are engaged in regular physical activity programs is higher in drivers without pain (67.3%) compared to those who have pain (48.5%). A survey of 164 bus drivers in the city of Kolkata in India revealed a 45.4% prevalence of pain in the lumbar spine (GANGOPADHYAY; DEV, 2012). The authors point out that ergonomic factors such as uncomfortable seats and without support for the coast contributed to the increase in the prevalence of low back pain, in addition to the long working hours and lack of breaks during occupational hours. Thus, the prevalence of low back pain in drivers has been related to several factors related to the exercise of the task of bus driver.

In order to investigate the level of physical fitness of the 200 urban bus drivers, a physical evaluation was conducted with the following measures and motor tests: body mass index in $kg.m^{-2}$, abdominal muscle endurance test (quantified in repetitions), dynamometric test of the lumbar spine in kgf, flexibility test and hamstring in centimeters. The results of the physical fitness assessment are shown in Table 4, segmented by the type of vehicle the driver was driving.

Table 4. Descriptive statistics, analysis of variance and multiple comparison test of values related to the physical fitness variables of urban bus drivers.

Variables	CON	MIC	LIG	ART	BIA	p
BMI (kg.m^{-2})	28,2^{a} ± 3,7	25,1 ± 3,6	26,3 ± 2,5	27,1 ± 4,3	26,4 ± 4,8	0,008*
Abdominal Endurance (rep)	18, 9 ± 8,2	20,3 ±6,3	25,6^{b} ± 7,3	22,2 ± 9,2	22,6$^{d, g}$ ± 8,0	0,001*
Lumbar Strength (Kgf)	82,3 ± 23,6	94,0 ± 24,3	136,1$^{b, e, h}$ ± 35,6	100,9^{c} ± 15,8	132,2$^{d, g, j}$ ± 29,3	0,001*
Isquiotibial Flexibility (cm)	18,6 ± 6,0	20,9 ± 7,3	21,7 ± 7,5	19,8 ± 6,8	19,9 ± 7,2	0,204

CON: conventional bus; MIC: minibus; LIG: Ligeirinho; ART: articulated bus; BIA: bi-articulated bus.

* Kruskall-Wallis analysis of variance test.

Dunn's multiple comparison test: the statistical difference between CON and MIC; b difference between CON and LIG; c difference between CON and ART; d difference between CON and BIA; and difference between MIC and LIG; f difference between MIC and ART; g statistical difference between MIC and BIA; h statistical difference between LIG and ART; i statistical difference between LIG and BIA; j difference between ART and BIA.

** Pearson's Chi-Square test.

Significance level: $p < 0.05$.

In the evaluation carried out with 481 bus drivers from the Hong Kong region, overweight was found in male subjects, but not in female subjects, 25.2 ± 3.4 kg.m^{-2} and 23.6 ± 2.7 kg.m^{-2}, respectively (SZETO; LAM, 2007). Changes in hip flexibility in the sit and reach test were not found in subjects who had pain in the lower back. However, the positive association was seen with the tests of manual dynamometry and pain in the region of the cervical spine and in the region of the shoulders, therefore, lower rates of manual strength are related to higher rates of pain in these parts of the body.

The results of the association between the level of exposure to whole body vibration, prevalence of low back pain and physical fitness variables were obtained from the use of Poisson Regression. In cross-sectional studies with binary categorical outcomes, the association between exposure and outcome is estimated by the prevalence ratio (PR), which is obtained by Poisson Regression (COUTINHO et al., 2008). When it is necessary to adjust for potential confounding variables, logistic regression models are usually used. This type of model produces odds ratio estimates, often interpreted as an estimate of the prevalence ratio. However, the odds ratio does not come very close to the prevalence ratio when the initial risk is high, and in these situations, interpreting the odds ratio as a prevalence ratio is inappropriate. It is noteworthy that the logistic regression can overestimate the odds ratio compared to the prevalence ratio, thus, being able to influence the observed interactions (BARROS; HIRAKATA, 2003).

In order to estimate the relationship between the identification variables (age in years and working time in years), physical fitness variables (body mass index in kg.m^{-2}, abdominal muscle resistance measured in repetitions, lumbar strength in kgf, hamstring flexibility measured in centimeters, whole body vibration variables (RMS_x in $m.s^{-2}$, RMS_y in $m.s^{-2}$ and RMS_z in $m.s^{-2}$) on the pain outcome low back. Table 5 shows the results of the Poisson Regression with the prediction coefficients (B), level of significance between the variables and the outcome of low back pain (p), prevalence ratio for the predictor variables (Exp (B)) and interval confidence level greater than and 95%.

Table 5. Results for binary Poisson regression between drivers with and without low back pain.

	B	p	Exp (B)	I.C. de 95% For Exp (B)	
				Minimum	Maximum
Age (Years)	-0,156	0,000	0,856	0,799	0,917
Working Time (Years)	0,520	0,000	1,682	1,448	1,954
Body Mass Index ($kg.m^{-2}$)	0,092	0,111	1,096	0,979	1,227
Abdominal Resistance (rep)	-0,064	0,021	0,938	0,888	0,990
Lumbar Strength (kgf)	-0,024	0,022	0,976	0,956	0,997
Isquiotibial Flexibility (cm)	0,035	0,260	1,036	0,974	1,102
RMS_X ($m.s^{-2}$)	-4,599	0,115	1,110	1,000	3,048
RMS_Y ($m.s^{-2}$)	2,514	0,030	1,060	1,000	1,757
RMS_Z ($m.s^{-2}$)	-5,143	0,038	2,360	2,077	9,664
Constant	5,648	0,054	283,837		

Level of Significance: $p<0,05$.

The result of the binary Poisson Regression shows that the variables that presented significance considered to be excellent ($p < 0.05$), were: age, working time, abdominal muscle resistance, lumbar strength, RMS_y and RMS_z. The scores resulting from the regression are not analyzed in the form of a formula presentation, as the Poisson method demonstrates only the relationship that exists for the prevalence of a certain characteristic in a sample.

Regarding the prevalence ratio, the variables working time and RMS_z stood out, indicating a relationship of increased probability in the outcome, increasing the chances of low back pain occurring by 1.4 times and 2.4 times, respectively. The fact that the constant showed a positive value means that, based on the group of drivers under study, the work environment and individual variables provide a high probability of low back pain.

The variables of age, abdominal muscle resistance and lumbar strength showed a characteristic of decreasing the probability of low back pain, according to the established prevalence ratios. Thus, it is shown that subjects with increasing age decrease the prevalence of pain by 14.4%, while abdominal muscle resistance decreases by 6.2% and lumbar strength by 2.4%.

Other studies have used logistic regression to identify the probabilities of pain occurring in subjects exposed to vibrations. The influence of body mass index on the increase in the prevalence of low back pain in subjects exposed to whole body vibration was tested in a sample of 467 drivers of different vehicles in the Netherlands (NOORLOOS et al., 2008). The authors found that there was no significant association between high values of body mass index and low back pain in environments with full body vibration (odds ratio 0.97; 95% I.C.: 0.92–1.01). Thus, the data are similar to the present study, in which there was also no significant relationship between the prevalence of low back pain and BMI ($p = 0.111$, odds ratio 1.09; I.C. 0.979-1.227).

4. Conclusion

It has been demonstrated that most urban bus drivers are exposed to vibrational levels that require the initiation of control actions, and some of them can exceed the daily exposure limit established by the European Directive 44/2002 / EC, of 25 June 2002. Thus, such exposure can trigger disorders related to the health of workers who act as bus drivers. It was determined that there was a high percentage of low back pain in the sample of drivers studied. The subjects who worked with models of articulated vehicles, conventional vehicles and minibuses were the ones who presented more low back pain, compared to drivers of bi-articulate and light vehicles.

Regarding the level of physical fitness of the drivers, it was shown that most subjects were within limits below the recommended for health, having as an example the high body mass indexes, low abdominal muscle resistance, low hamstring flexibility, low strength low back and high level of physical inactivity. It is noteworthy that the drivers of light and bi-articulated buses showed better levels of physical fitness compared to drivers of conventional vehicles, minibuses and articulated vehicles. The association between the level of whole body vibration, prevalence of low back pain and physical fitness revealed that the factors that most influenced the pain dependent variable were abdominal muscle resistance, lumbar strength and the level of RMS vibration transmitted vertically on the z axis. It is noteworthy that the physical fitness variables were considered to be mitigating factors and the level of vibration of the whole body was considered aggravating the prevalence of low back pain in urban bus drivers.

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