Low back pain in bus drivers and fare collectors: study of association with exposure to whole-body vibration

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Abstract:
The bus driver and fare collector activities involve various risks to workers' health, including exposure to Whole-Body Vibration (WBV). This study aims quantify the exposure levels to the WBV, identify the significant variables associated with low back pain (LBP) and determine the prevalence of LBP in the last 12 months among these workers in the city of Itajubá, Brazil. Methods. A questionnaire was applied to 33 workers to get socio-demographic data, information related to the working environment and health. The WBV exposure assessment was conducted. The logistic regression was used to obtain the adjusted Odds Ratio (OR). The prevalence of low back pain was 18.2%. The highest values of the vibration acceleration referred to [A(8)z] value, for both groups of workers. For fare collectors, there are also relevant risk on the y direction [A(8)y]. In the multivariate analysis it were considered significant: weighted acceleration on the y axis - awy (OR = 1.18 95% CI 0.99-1.42) and occupation (bus driver) (OR = 0.013 95% CI 0.0003 to 0.61). These workers are exposed to important vibration levels. The fare collectors are subject to a greater low back pain risk. The results may contribute to the improvement in the workstation and the working process of the bus drivers and fare collectors.
Keywords: Vibration, low back pain, epidemiology.

Lombalgia em motoristas e cobradores de ônibus: estudo de associação com exposição à vibração de corpo inteiro

Resumo:
As atividades de motorista de ônibus e de cobrador envolvem vários riscos ocupacionais, incluindo a exposição à Vibração de Corpo-Inteiro (VCI). Este estudo busca quantificar os níveis de exposição ao VCI, identificar as variáveis significativas associadas à dor lombar (DL) e determinar a prevalência de lombalgia nos últimos 12 meses. A avaliação da exposição VCI foi realizada. Foi empregada a análise por regressão logística para se obter a Razão de Chances (RC) ajustada. A prevalência de lombalgia foi de 18,2%. Os valores mais altos da aceleração de vibração referem-se ao valor (A(8)z), para ambos os grupos de trabalhadores. Para os cobradores também há risco relevante na direção y (A(8)y). Na análise múltipla foram consideradas significativas: aceleração ponderada no eixo y - awy (RC = 1,18 IC95% 0,99-1,42) e ocupação (motorista de ônibus) (RC = 0,013 IC95% 0,0003 a 0,61). Há uma importante exposição à VCI entre esses trabalhadores. Os cobradores estão submetidos a um risco maior de

lombalgia. Os resultados encontrados podem contribuir para a melhoria das condições de trabalho de motoristas e cobradores de ônibus.
Palavras-Chaves: Vibração, lombalgia, epidemiologia.

Lumbalgia en conductores de autobuses y recolectores de tarifas: estudio de asociación con la exposición a vibraciones de todo el cuerpo

Resumen:
Las actividades del conductor del autobús y del cobrador de tarifas implican diversos riesgos para la salud de los trabajadores, incluida la exposición a vibraciones de cuerpo entero (VCE). Este stuby tiene como objetivo cuantificar los niveles de exposición al VCE, identificar las variables significativas asociadas al dolor lumbar (DL) y determinar la prevalencia de DL en los últimos 12 meses entre estos trabajadores en la ciudad de Itajubá, Brasil. Métodos. Se aplicó un cuestionario a 33 trabajadores para obtener datos sociodemográficos, información relacionada con el clima laboral y la salud. Se realizó la evaluación de la exposición a WBV. Se utilizó la regresión logística para obtener la Razón de Posibilidades ajustada (RP). La prevalencia de lumbalgia fue del 18,2%. Los valores más altos de la aceleración de vibraciones se refieren al valor [A (8) z], para ambos grupos de trabajadores. Para los recaudadores de tarifas, también existe un riesgo relevante en la dirección y [A (8) y]. En el análisis multivariado se consideró significativo: aceleración ponderada en el eje y - awy (RP = 1,18 IC 95% 0,99-1,42) y ocupación (conductor de autobús) (RP = 0,013 IC 95% 0,0003 a 0,61). Estos trabajadores están expuestos a importantes niveles de vibración. Los recaudadores de tarifas están sujetos a un mayor riesgo de dolor lumbar. Los resultados pueden contribuir a la mejora de la estación de trabajo y el proceso de trabajo de los conductores de autobuses y recaudadores de tarifas.
Palabras clave: Vibración. lumbalgia. epidemiología.

INTRODUCTION

Exposure to whole-body vibration (WBV) is present in various fields of activity, covering various operations and situations: the construction industry (motor graders, shovel loaders, bulldozers); the transportation industry (trucks, buses, motorcycles, vehicles in general); rail transport (trains, subway); industrial equipment (bridge-crane, forklift); agricultural machinery (tractors, harvesters); helicopters; vessels and vehicles off-road use in mining (SILVA e MENDES, 2005). The values of WBV levels in the machine operator workstation and vehicles have as key determinants the speed of vehicle, the type and the condition of suspension, the tires situation, the quality of sitting, the status and quality of the pavement and the experience of the driver.

Excessive exposure to WBV is associated with a number of health problems, with the low-back pain, the primary outcome studied in the literature (KRAJNAK, 2018; PARK *et al.*, 2013; HOY *et al.*, 2010; GRIFFIN *et al.*, 2008; PALMER *et al.*, 2000).

The environment and the organization work of bus drivers and fare collectors, involve health risks. Typically they are exposed to long hours and irregular working patterns, insufficient rest time and weekly rest. In specific relation to the workstation, it observes the adoption of a static position with frequent twisting of the trunk. Moreover, they are also exposed to noise, vibration and air pollutants (BERMUDES *et al.*, 2019; SILVA e MENDES, 2005; SANTOS JÚNIOR., 2003). Cohort studies, considered the most robust in epidemiology, have sustained the risk of low back pain among professional drivers exposed to whole body vibration (BOVENZI, 2010; BOVENZI, 2009). The relevance of exposure to whole body vibration among professional truck drivers for the occurrence of musculoskeletal disorders was elucidated in a systematic review of the literature (MORAES *et al.*, 2016).

Bus drivers and fare collectors, constitute a group of workers exposed daily to the WBV, in which the problem of lower back pain is representative (PALMER *et al.*, 2008; SEIDEL; 2008; OKUNRIBIDO *et al.*, 2007; SZETO e LAM, 2007; BOVENZI *et al.*, 2006; OKUNRIBIDO *et al.*, 2006; NISHIYAMA *et al.*, 2000; SEIDEL, 2005). There is, due to the peculiarity of the occupation, absence of specific studies for fare collectors. The fare collector works in the sitting position in a seat located transversely to the body of the vehicle. He supervises the payment of the passengers with magnetic card and receives the values of the tickets. He assists the driver in the conduct of the trip, e.g., verifying the safety of the passengers landing through the rear door of the vehicle. This task imposes the frequent need for trunk rotation since the workstation is on the same side face of the vehicle where the doors are installed. It is an occupation that is no longer found in countries classified as developed.

The vast majority of studies in this field take care not to assign only the WBV as risk of lower back pain, since there is a complexity of factors involved as poor posture and long time sitting (JOSEPH *et al.*, 2020). Therefore, it reinforces that there is no simple and direct relationship between the WBV exposure and risk to the health of the lumbar spine (SEIDEL, 2008).

The lower back pain is associated with inability to work, leading to a representative number of sickness absences, a loss of productivity, and impairment to quality of life (DAGENAIS *et al.*, 2008). About 37% of lower back pain cases worldwide are attributed to occupation, with a higher proportion among men due to greater participation in the workforce, and in activities where there are risks such as heavy lifting and exposure to whole-body vibration (PUNNET *et al.*, 2005).. The lower back pain is associated to smoking too (RAHMAN *et al.*, 2010).

This study aims quantify the exposure levels to the WBV, identify the significant variables associated with lower back pain and determine the prevalence of lower back pain among bus drivers and fare collectors were the aims of this study.

SUBJECTS AND METHODS

Study area

The research was conducted in the period between April and November 2014, in a public transport company, which has 168 employees, of whom 122 (72.6%) are bus drives and fare collectors. The fleet is equipped with 37 buses, with an average age of 4.3 ± 1.7 years, over 18 routes in the city of Itajuba, located in the southern state of Minas Gerais, with 90,658 inhabitants, in Brazil (IBGE, 2010).

Type of study

The methodological approach used in this study was the cross sectional type.

Sample design

The prevalence of lower back pain of bus drivers, found in the literature, reported in the previous 12 months was 58% (OKUNRIBIDO *et al.*, 2006). Using these data as reference for the calculation of the sample, with an error margin of 5%, and 95% confidence level, the value found was 52 workers. There was a 10% increase for losses or refusals and 20% to contemplate confounding variables, resulting in 69 workers.

Assessment of exposure

The assessment of exposure to WBV was performed in all 18 routes served by the company, in defining the sample population of workers. Measurements of vibration were carried out under actual operating conditions as established by the guideline ISO-2631-1 (ISO, 1997) and NHO-09 (FUNDACENTRO, 2013), considering the three orthogonal directions x (fore-and-aft), y (lateral) and z (vertical). For this employee was a set of equipment consists of a vibration meter, brand Larson & Davis, model HVM100 (Figure 1). The measuring time corresponded to round-trip total time of each route. The basic method or root mean square (r.m.s.) method was employed (ISO, 1997). To establish the value of daily exposure $A(8)$, relating to eight hours of exposure were used the equations 1 to 3. The meter employed in the evaluation procedure directly provides the weighted acceleration values on the three orthogonal axes ($a_{wx,}$ $a_{wy\,e}$ a_{wz}). Exposure time is informed by bus driver or fare collector assessed.

Figure 1. HVM100 Vibration Meter and Seat Accelerometer

Source: Authors.

$$A_{x\,(8)} = 1.4 \times a_{wx} \sqrt{\frac{T_{exp}}{T_0}} \; m/s^2 \quad (1)$$

$$A_{y\,(8)} = 1.4 \times a_{wy} \sqrt{\frac{T_{exp}}{T_0}}\ \ m/s^2 \qquad (2)$$

$$A_{z\,(8)} = 1.0 \times a_{wz} \sqrt{\frac{T_{exp}}{T_0}}\ \ m/s^2 \qquad (3)$$

Where:

$Ax_{(8)}$ = Daily vibration exposure on the *x* axis;

a_{wx} = Weighted acceleration on the *x* axis;

$Ay_{(8)}$ = Daily vibration exposure on the *y* axis;

a_{wy} = Weighted acceleration on the *y* axis;

$Az_{(8)}$ = Daily vibration exposure on the *z* axis;

a_{wz} = Weighted acceleration on the *z* axis;

T_{exp} = Exposure time to WBV in hours and

T_0 = Reference time of 8 h.

Considering the possibility of significant impact on driving the vehicle, mainly due to the quality of the pavement, was also employed the method of the fourth power by VDV parameter (Vibration Dose Value), which constitutes a more appropriate estimate of risk (ISO, 1997). Equations 4, 5 and 6 express the calculation of daily exposures for the three axes. The highest value was used as a reference to compare with the established limits, according to NHO-09 guidelines (FUNDACENTRO, 2013). The meter employed in the evaluation procedure directly provides the vibration dose values on the three orthogonal axes (*VDVx, VDVy* e *VDVz*) and the measurement time (*Tmeas*). Exposure time is informed by the bus driver or fare collector assessed.

$$VDV_{exp,x,i} = 1.4 \times VDV_x \left(\frac{T_{exp}}{T_{meas}}\right)^{1/4} m/s^{1.75} \qquad (4)$$

$$VDV_{exp,y,i} = 1.4 \times VDV_y \left(\frac{T_{exp}}{T_{meas}}\right)^{1/4} m/s^{1.75} \qquad (5)$$

$$VDV_{exp,z,i} = 1.0 \times VDV_z \left(\frac{T_{exp}}{T_{meas}}\right)^{1/4} m/s^{1.75} \qquad (6)$$

Where:

VDVexp, x,i = Vibration dose value daily exposure on the x-axis;

VDVx = Vibration dose value on the x-axis;

VDVexp, y,i = Vibration dose value daily exposure on the y-axis;

VDVy = Vibration dose value on the y-axis;

VDVexp, z,i = Vibration dose value daily exposure on the *z* axis;

VDVz = Vibration dose value on the *z* axis;

Texp = Exposure time to vibration in hours and

Tmeas = Exposure time measurement in hours.

The evaluation process was based on the following established limits[28]:

- Exposure Action Value (*EAV*): 0.5 m/s^2 *A*(8) or *VDV* of 9.1 $m/s^{1.75}$;
- Exposure Limit Value (*ELV*): 1.1 m/s^2*A*(8), or *VDV* of 21 $m/s^{1.75}$

The sum vector or the overall weighted total r.m.s. acceleration (Sum_{Aeq}) was calculated, and it was used like a explanatory variable too, by the Equation 7.

$$Sum_{A_{eq}} = \sqrt{1{,}4 \times a_{wx} + 1{,}4 \times a_{wy} + 1{,}0 \times a_{wz}}\ m/s^2 \qquad (7)$$

Where:

a_{wx} = Weighted acceleration on the *x* axis;

a_{wy} = Weighted acceleration on the *y* axis;

a_{wz} = Weighted acceleration on the *z* axis.

Questionnaire

A questionnaire was designed contemplating information about the occurrence of lower back pain and herniated disc diagnosis and other variables possibly associated with the occurrence of the disease. It was used approach to scaling responses, by the Likert scale, for the questions about usual weighting lifting, job satisfaction and to perform physical activity. The questionnaire was based from the elaborate review (GRIFFIN *et al.*, 2008; PALMER *et al.*, 2000). A pretest was conducted in 21 drivers to test and adjust the applied questionnaire. The questionnaire was conditioned upon signing of the Informed Consent Term (ICT). The study was approved by the Research Ethics Committee (REC) of the Faculty of Medicine of Itajuba, under number 400 744. The application of questionnaires to bus drivers and fare collectors was determined at random, seeking cover all bus models for the assessment of exposure to WBV. The questionnaire and the execution of measurements were performed by one of the author of this research. The questions based on the Likert scale were categorized later for analysis.

Only were included in the survey, bus drivers and fare collectors who were in active and were excluded workers with back orthopedic problems and those who met apart for any reason, be it illness, retirement, work accidents, among others.

Statistical analysis

To describe the association between the dependent variable (occurrence of lower back pain in the last 12 months, from the date of application of the questionnaire, and the set of explanatory or predictor variables that are significant to the occurrence of the injury, the unconditional logistic regression was used to control the confusion variables. In constructing the multivariate model, univariate analyzes were conducted with all variables, using as a criterion for entry into the modeling process, a p value < 0.20 based on the test of likelihood ratio. In order to find the adjusted model the progressive methodology step by step (stepwise forward) including the variables in descending order of significance (p < 0.05) was applied (HOSMER e LEMESHOW, 1989). Through this model, the dependent variable was the likelihood of a positive response in the model, or log odds (chance) of occurrence of responses. Thus, the logit called, or the log of the odds of the dependent variable, from the logistic regression model, is given by the following Equation 8 (HOSMER e LEMESHOW, 1989):

$$g(x) = \beta_0 + \sum_{i=1}^{n} \beta_i x_i \qquad (8)$$

Where:

β_0 is the coefficient for intercept, while the estimated coefficients "βi", for the independent variables, represent the rate of change of a dependent variable of the function by unit change (x_i) in the independent variable.

The explanatory variables used in the analysis refers to demographic data such as age (years); length of service (years); education (years of schooling); Body Mass Index (BMI); waist circumference (cm); smoking (*smoker/former smoker* or *never smoked*); perform physical activity (*always/often* or *sometimes/never*); job satisfaction (*satisfied/very satisfied* or *dissatisfied/very dissatisfied*); development extra-occupational activity with exposure to WBV (*yes* or *not*); prior exposure to WBV (*yes* or *not*) and manual lifting (*always/ often* or *sometimes/never*). The information was self-reported both by the bus drive and fare collectors, except for the value of waist circumference, where a tape measure in the field was used. The variables corresponding to exposure to vibration, expressed by Equations 4 to 6, were worked as continuous; whereas quantitative others, the median was used as the cutoff point.

. For the sample analyzed, the Shapiro-Wilk normality test was performed, which demonstrated the normal distribution of data, using Past™ software version 3.25. The statistical program used was the Epi-Info™ version7.0.2.1 (CDC, 2013).

RESULTS

The survey comprised 50 workers, less than 69 workers, calculated for sample size, of whom 17 (34%) were excluded because of orthopedic problems in the back. Thus, the study analyzed respondents 33 bus drivers and fare collectors, all male, including 25 bus drivers (75.8 %) and eight fare collectors (24.2%). Socio-demographic data and on the conditions and the work process, used as explanatory variables, are presented in Table 1.

Table 1 - Distribution of mean values and prevalence of socio-demographic data and the conditions and work process.

Variable	Driver	Fare collector	*p*
Age in years (Average ±SD)	42.9 ± 10.3	31.2 ± 5.9	< 0.01
Tenurein years (Average ± SD)	8.1 ± 8.5	2.6 ± 3.8	n.s.
BMI in $kg.m^{-2}$ (Average ± SD)	25.8 ± 4.4	26.5 ± 6.8	n.s.
Waist circumference in cm (Average ± SD)	94.4 ± 11.8	96.6 ± 22.7	n.s
Schooling in years (Average ± SD)	7.6 ± 2.7	10.0 ± 1.9	0.02
Workday in hours (Average ± SD)	8.9 ± 1.3	8.7 ± 1.8	n.s.
Occupational extra activity (%)	28.0	0.0	n.s
WBV previous exposure (%)	100.0	50.0	< 0.01
Smoking (%)	36.0	50.0	n.s.
Usual weight lifting (%)	8.0	25.0	n.s.
Job satisfaction (%)	76.0	100.0	n.s.
Perform physical activity (%)	24.0	75.0	< 0.01

n.s. = not significant.
Source: Authors.

Exposure assessment to WBV

Data from evaluation in the field of bus drivers and fare collectors exposure to WBV, according to the basic method and fourth power method were expressed in terms of means and percentile (P_{25} and P_{75}) shown in Table 2. The mean values on *z* axis considered to be the most relevant to the occurrence of disorders in the spine, had an average of 0.81 and 0.71 m/s^2, for drivers and fare collectors respectively. It's possible to observe by the mean values of *A*(8), both to bus drivers and fare collectors, on the y and z axes are above the exposure limit value (ELV), while the *A*(8)x mean values are above the exposure action value (EAV) for the two groups of workers. It was observed the mean values of *A*(8), on the y and z axes, to the fare collectors, were classified like relevant risk; while to the bus drivers this risk was found on the *A*(8) mean value on the *z* axis. All the values of VDV on the three axes, for the bus drivers and fare collectors, are above the exposure action level (EAV), but below the ELV.

Table 2 - Distribution of values, expressed in means (SD), 25th (P_{25}) and 75th (P_{75}) percentiles, registered in the exposure assessment of drivers to WBV, according to the basic and the fourth power methods. The exposure values above the exposure action value are in bold, while the exposure values above exposure limit are in bold and italic.

Drivers	a_{wx}	a_{wy}	a_{wz}	**A(8)$_x$**	**A(8)y**	**A(8)z**	**VDVx**	**VDVy**	**VDVz**	**VDV (8)x**	**VDV (8)y**	**VDV (8)z**
Means (SD)	0.29 (0.06)	0.34 (0.10)	0.81 (0.21)	**1.05** (0.42)	***1.16*** (0.43)	***1.97*** (0.69)	5.44 (2.20)	6.15 (2.39)	9.91 (3.03)	**10.79** (7.05)	**11.86** (7.08)	**16.32** (5.17)
Maximum	0.47	0.60	1.39	2.46	2.32	4.29	13.10	12.58	19.48	30.77	30.42	32.58
Minimum	0,21	0,20	0.58	0.49	0.54	0.73	3.20	4.80	5.39	5.43	5.39	8.58
P_{75}	0.31	0.35	0.85	1.10	1.22	2.05	5.92	6.63	11.04	11.43	14.60	18.50
P_{25}	0.26	0.28	0.70	0.86	0.94	1.67	3.99	4.80	7.96	6.66	7.49	12.95
Fare Collectors												
Means (SD)	0.30 (0.05)	0.42 (0.08)	0.71 (0.11)	**1.09** (0.21)	***1.46*** (0.42)	***1.82*** (0.39)	6.30 (1.28)	8.29 (1.93)	9.17 (1.37)	**11.95** (3.18)	**14.30** (3.07)	**14.79** (2.13)
Maximum	0.36	0.55	0.86	1.36	1.99	2.25	8.05	10.96	10.70	15.02	17.27	16.91
Minimum	0,22	0,31	0.57	0.80	0.86	1.21	4.51	5.26	6.71	7.76	8.16	10.54
P_{75}	0.34	0.49	0.79	1.27	1.87	2.13	7.35	9.77	10.24	14.63	16.70	16.37
P_{25}	0.26	0.35	0.60	0.86	1.12	1.50	5.31	6.85	8.31	8.50	12.85	12.95

Source: Authors.

The results of the univariate analysis, with the variables considered significant only, are exposed in the Table 3.

Table 3 - Univariate analysis for the explanatory variables in bus drivers and fare collectors (n = 33) presenting OR, CI (95%) and p values for the occurrence of low back pain in the last 12 months.

Explanatory variable	OR	$CI_{95\%}$	*p*
Job title			
Fare collector	1		
Driver	0.025	0.0021 - 0.2925	< 0.01
a_{wy}			
Continuous	1.13	1.02 - 1.24	< 0.01
Age			
Continuous	0.89	0.78 - 1.01	0.03
Physical activity			
No	1		
Yes	0.21	0,03 - 1.39	0.09
$A(8)_y$			
Continuous	1.01	1.00 - 1.03	0.13
Schooling (in years)			
Up to 8	1		
Above 8	3.40	0.52 - 22.0	0.18

Source: Authors.

The prevalence of back pain in the last 12 months, value obtained by the questionnaires applied, was 18.2%. The multivariate model more adjusted to the dependent variable "*have had lower back pain in the last 12 months*" is shown in Table 4.

Table 4 - Multivariate analysis for the explanatory variables in bus drivers and fare collectors (n = 33) presenting OR, CI (95%) and *p* values for the occurrence of low back pain in the last 12 months.

Explanatory variable	OR	$CI_{95\%}$	Coefficient (β)	*p*
a_{wy} (ms^{-2})				
Continuous	1.18	0.99-1.42	0.17	0.07
Job title (JT)				
Fare collector	1			
Driver	0.013	0.0003-0.62	-4.37	0.03
Constant (β)			-6.33	

Source: Authors.

As set multivariate model and by referring to equation 7, the log odds of a dependent variable (LBP) is expressed by Equation 10:

$$g(x) = -6.33 + 0.17(\mathrm{a_{wy}}) - 4.37(JT) \quad (9)$$

Where:

a_{wy}: Weighted acceleration on the *y* axis and *JT*: Job Title.

DISCUSSION

The value interpretation reveals that the occupation acts as a significant variable in relation to lower back pain. Work as a bus driver poses less risk when compared to fare collectors, since the chance of having back pain is 0.013 times that of fare collectors. The vibration expressed by equivalent acceleration on the *y* axis represents a factor of risk, i.e., the chance of pain tends to increase exponentially according to the product between the acceleration value and the coefficient found 0.17.

The prevalence of lower back pain registered in this study, 18.2%, was lower than that found in other studies that analyzed the bus driver's occupation, as 56% (SEIDEL, 2008) and 61% (OKUNRIBIDO *et al.*, 2007). It was found that the highest values of the vibration acceleration based on the magnitude of the mean acceleration, above the exposure threshold and classified as relevant, referred to the *z* axis, considering 8 h exposure [*A*(8)z] both for the fare collector as for the bus driver. In addition, the mean values found on the z direction [*A*(8)z], for both occupations were considered as relevant risk. For fare collectors, there are also relevant risk on the y direction [*A*(8)y].

This study revealed that the magnitude of the equivalent vibration acceleration on the *y* axis, adjusted by occupation, was significantly associated with back pain in the last 12 months, not in line with the results observed in literature, in which the *z* axis value was significant (SEIDEL, 2008). One of the possible limitations to this study is the bias of the healthy worker or survivor, as was the inclusion of only the workers in the workforce, not including workers, retirees, those who migrated to other activities and away or inactive for other reasons (SILVA e MENDES, 2005; KELSEY *et al.*, 1996).

A bias not infrequently found in epidemiological studies is the bias of the measurement. It occurs especially when the explanatory variables are sourced from reports of workers (KELSEY *et al.*, 1996). In order to reduce recall bias, it took into consideration the occurrence of pain in the last 12 months. However, it is wise to consider that lower back pain frames may have been overlooked by drivers.

The temporal ambiguity is one of the biases that affect more epidemiological studies (KELSEY *et al.*, 1996). However, its strength loses relevance in studies with retrospective approach like this.

With respect to accuracy, the survey involved 33 workers only, lower number to the sample size initially estimated at 69 workers. This limit was due to difficulties in the relationship with the company studied, that "closed the doors" during the research, revealing obstacles to unravel the reality of the relationship between health and work, a fact that does not reduce the value of this study.

This study aimed to evaluate the exposure levels of bus drivers and fare collectors to WBV and the association between this risk and lower back pain, adjusting for confounding variables. It was found that exposure to WBV is a risk to the health of drivers, as observed the values exceed the limits established levels for standardization, surpassing relevant levels established.

The value of acceleration on the *y* axis (a_{wy}) was significant in the final model, adjusted to occupation. It was observed that the acceleration values [$A(8)$] in this axis are above exposure limits to the two groups of workers, specially to the fare collectors who are submitted a relevant risk value, which encourages the adoption of preventive measures. The prevalence of lower back pain observed was lower than that found in the literature, probably due to the bias of precision.

CONCLUSION

This study aimed to investigate the association between exposure to whole body vibration and the occurrence of low back pain among drivers and bus drivers. It was observed that there is a significantly greater chance of injury among the fare collectors in relation to the drivers, thus revealing a category of workers at risk of this musculoskeletal disorder.

The results can contribute to the improvement of the working environment of these workers. It is recommended to adopt research with greater breadth and depth, considering the limitations exposed, in order to contribute to a public transportation with comfort and lower risk to the health of bus drivers and fare collectors.

REFERENCES

BERMUDES, W.L.; MINETTE, L.J.; CUNHA, J.R. Avaliação de riscos ocupacionais de motorista de ônibus intermunicipal: um estudo de caso no Estado do Pará. **Revista Sustinere**, v. 7, n. 1, p. 4 – 18, 2019. Available in: <https://www.e-publicacoes.uerj.br/index.php/sustinere/article/view/41782/30124>. Access in: 22 November 2021

BOVENZI, M. A longitudinal study of low back pain and daily vibration exposure in professional drivers. **Industrial Health**, v. 48, p. 584 – 595, 2010. Available in: <https://www.jstage.jst.go.jp/article/indhealth/48/5/48_MSWBVI-02/_pdf/-char/en>. Access in: 22 November 2021

BOVENZI, M. Metrics of whole-body vibration and exposure–response relationship for low back pain in professional drivers: a prospective cohort study. **International Archives of Occupational Environmental Health**, v. 82, p. 893 – 917, 2009. Available in: <https://web-s-ebscohost.ez38.periodicos.capes.gov.br/ehost/pdfviewer/pdfviewer?vid=1&sid=55396192-58f8-4f95-b9c3-5cbe8612c1d0%40redis>. Access in: 22 November 2021

BOVENZI, M.; RUI, F.; NEGRO, C.; D'AGOSTIN, F.; ANGOTZI, G.; BIANCHI, S. *et al.*. An epidemiological study of lower back pain in professional drivers. **Journal of Sound and Vibration**, v. 298, p. 514 -539, 2006. Available in: <https://www.sciencedirect.com/science/article/abs/pii/S0022460X06004585?via%3Dihub>. Access in: 22 November 2021

CDC - CENTERS FOR DISEASE CONTROL AND PREVENTION. **Epi Info 7**, 2013. Available in: <https://www.cdc.gov/epiinfo/support/downloads.html>. Access in: 22 November 2021 18 Nov.. 2021.

DAGENAIS, S.; CARO, J.; HALDEMAN, S. A systematic review of lower back pain cost of illness studies in the United States and internationally. **Spine Journal**, v. 8, p. 8 – 20, 2008. Available in: < https://doi.org/10.1016/j.spinee.2007.10.005 >.

FUNDACENTRO - FUNDAÇÃO JORGE DUPRAT FIGUEIREDO, DE SEGURANÇA E MEDICINA DO TRABALHO**. Norma de higiene ocupacional : NHO 09 : avaliação da exposição ocupacional a vibrações de corpo inteiro : procedimento técnico**. São Paulo: Fundacentro, 2013. 63 p. Available in: <http://www.gov.br/fundacentro/pt-br/arquivos/link/noticias/NHO_09_portal_20130919181959.pdf>. Access in: 22 November 2021

GRIFFIN, M;J.; HOWARTH, H.V.C.; PITTS, P.M.; FISCHER, S.; KAULBARS, U.; DONATI, P.M.; BERETON, P.F. **Non-binding guide to good practice with a view to implementation of directive 2002/44/EC on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibrations) – Part II Guide to good practice Whole-Body Vibration**. Luxembourg: Office for Official Publications of the European Communities, 2008, 2008. 118 p. Available in: <https://op.europa.eu/en/publication-detail/-/publication/3f9392ff-8975-4139-9ea2-5b168a334664/language-en>. Access in: 22 November 2021.

HAKALA, P.; RIMPELÄ, A.; SALMINEN, J.J.; VIRTANEN, S.M.; RIMPELÄ, M. Back, neck, and shoulder pain in Finnish adolescents: national cross sectional surveys. **British Medical Journal**, v. 325, n. 7367, p. 743 – 745, 2002. Available in: <https://www.bmj.com/content/325/7367/743.1.full.pdf>. Access in: 22 November 2021

HOSMER, D.W.; LEMESHOW, S. **Applied logistic regression**. New York: Jonhn Wiley, 1989, 307 p.
HOY, D.; BROOKS, P.; BLYTH, F.; BUCHBINDER, R.. The epidemiology of lower back pain. **Best Practice & Research Clinical Rheumatology**, v. 24, n. 6, p. 769 – 781, 2010. Available in: <https://www.sciencedirect.com/science/article/abs/pii/S1521694210000884?via%3Dihub>. Access in: 22 November 2021

IBGE – INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. **Cidades@**, **Itajubá**, 2010. Available in: <http://cidades.ibge.gov.br/xtras/perfil.php?lang=&codmun=313240&search=minas-gerais|itajuba>. Access in: 22 November 2021.

ISO - INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, **ISO 2631/1:1997 – Mechanical vibration and shock – evaluation of human exposure to whole-body vibration, Part 1: General requirements**, Geneva, Switzerland.

JOSEPH, L.; STANDEN, M.; PAUNGMALI, A.; KUISMA, R,; SITILERTPISAN, P.; PIRUNSAN, U. Prevalence of musculoskeletal pain among professional drivers: A systematic review. **Journal of Occupational Health**, v. 62, n. 1, e12150. Available in: < https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7434558/>. Access in: 03 June 2022.

KELSEY, J.L.; THOMPSON, W.D.; EVANS, A.S. **Methods in Observational epidemiology**. 2. ed. New York: Oxford University Press; 1996, 432 p.

KRAJNAK, K. Health effects associated with occupational exposure to hand-arm or whole body vibration. **Journal of Toxicology and Environmental Health. Part B, Critical Reviews**, v. 21, n. 5, p. 320-334, 2018. Available in: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6415671/pdf/nihms-1015266.pdf. Access in: 30 January 2022.

MORAES, G.F.S.; SAMPAIO, R.F.; SILVA, L.F.; SOUZA, M.A.P. Whole-body vibration and musculoskeletal diseases in professional truck drivers. **Fisioterapia em Movimento,** v. 29, n. 1, p. 159 - 172. 2016. Available in: <https://www.scielo.br/j/fm/a/Pq5v4tM9TQ3KpjpxZYwZk8q/?format=pdf&lang=en>. Access in: 22 November 2021

NISHIYAMA, S.; UESUGI, N.; TAKESHIMA, T.; KANO, Y.; TOGII, H. Research on vibration characteristics between human body and seat, steering wheel, and pedals (effects of seat position on ride comfort**). Journal of Sound and Vibration**, v. 236, p. 1 - 21. 2000. Available in: <https://www.sciencedirect.com/science/article/abs/pii/S0022460X00928621?via%3Dihub>. Access in: 22 November 2021

OKUNRIBIDO, O.O.; MAGNUSSON, M.; POPE, M.H. Low back pain in drivers: the relative role of whole-body vibration, posture and manual materials handling. **Journal of Sound and Vibration**, v. 298, p. 540 – 555, 2006. Available in: <https://www.sciencedirect.com/science/article/abs/pii/S0022460X06004779>. Access in: 22 November 2021

OKUNRIBIDO, O.O.; SHIMBLES, S.J., MAGNUSSON, M., POPE, M. City bus driving and lower back pain: a study of exposures to posture demands, manual materials handling and whole-body vibration. **Applied Ergonomics**, v. 38, p. 29 – 38, 2007. Available in: <https://www.sciencedirect.com/science/article/abs/pii/S0003687006000172?via%3Dihub>. Access in: 22 November 2021

PALMER, K.T.; GRIFFIN, M.J.; BENDALL, H.; PANNETT, B.; COGGON, D. Prevalence and pattern occupational exposure to whole body vibration in Great Britain: findings a national survey. **Occupational Environmental Medicine**, v. 57, p. 229-236, 2000. Available in: <https://oem.bmj.com/content/57/4/229.long>. Access in: 22 November 2021

PALMER, K.T.; HARRIS, C.E.; GRIFFIN, M.J.; BENNETT, J.; READING, I.; SAMPSON, M. *et al.* Case–control study of low-back pain referred for magnetic resonance imaging, with special focus on whole-body vibration. **Scandinavian Journal of Work Environment and Health**, v. 35, p. 364 – 373, 2008. Available in: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2875180/pdf/ukmss-27639.pdf>. Access in: 22 November 2021

PARK, M.S.; FUKUDA, T.; KIM, T.G.; MAEDA, S. Health risk evaluation of whole-body vibration by ISO 2631-5 and ISO 2631-1 for operators of agricultural tractors and recreational vehicles. **Industrial Health**, v. 51, p. 364-370, 2013. Available in: <https://www.jstage.jst.go.jp/article/indhealth/51/3/51_2012-0045/_pdf/-char/en>. Access in: 22 November 2021

PUNNETT, L.; PRÜSS-UTÜN, A.; NELSON, DI.;, FINGERHUT, M.A.; LEIGH, J.; TAK, S.; PHILLIPS, S. Estimating the global burden of low back pain attributable to combined occupational exposures. **American Journal of Industrial Medicine**, v. 48, n. 6, p. 459-69, 2005. doi: 10.1002/ajim.20232.

SANTOS JUNIOR, E. A. De que adoecem e morrem os motoristas de ônibus. **Revista Brasileira de Medicina do Trabalho**, v. 1, n.2, p. 138 – 147, 2003. Available in: <http://www.rbmt.org.br/export-pdf/244/v1n2a07.pdf>. Access in: 22 November 2021

SEIDEL H. Intraspinal forces and health risk caused by whole-body vibration – Predictions for European drivers and different field conditions. **International Journal of Industrial Ergonomics**, v. 38, p. 856–867, 2008. Available in: < https://www.academia.edu/52533201/Intraspinal_forces_and_health_risk_caused_by_whole_body_vibration_Predictions_for_European_drivers_and_different_field_conditions > Access in: 22 November 2021

SEIDEL H. On the relationship between Whole-body vibration exposure and spinal health risk. **Industrial Health**, v. 43, p. 361 – 377, 2005. Available in: <https://www.jstage.jst.go.jp/article/indhealth/43/3/43_3_361/_pdf/-char/en>. Access in: 22 November 2021

SHIRI, R.; KARPPINEN, J.; LEINO-ARJAS, P.; SOLOVIEVA, S.; VIIKARI-JUNTURA, E. The Association between Smoking and Lower back Pain: A Meta-analysis. **The American Journal of Medicine**, v. 123, n. 1, p. 87e7-87e35, 2010. Available in: <https://doi.org/10.1016/j.amjmed.2009.05.028>.

SILVA, L.F.; MENDES, R. Combined exposure to noise and vibration and its effects on worker's hearing. **Revista de Saúde Pública,** v. 39, p. 9-17, 2005. Available in: <https://www.revistas.usp.br/rsp/article/view/31827/33767>. Access in: 22 November 2021

SZETO, G.P.Y.; LAM, P. Work-related musculoskeletal disorders in urban bus drivers of Hong Kong. **Journal of Occupational Rehabilitation**, v. 17, p. 181–198, 2007. Available in: <https://doi.org/10.1007/s10926-007-9070-7>.