WHOLE-BODY VIBRATION EXPOSURES IN BUS DRIVERS – AN EVALUATION ACCORDING TO BRAZILIAN REGULATORY STANDARD Nº15

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Abstract. *Whole-body vibration (WBV) is one of the main risk factors for bus drivers. WBV can degrade many systems in the body hampering the function of the musculoskeletal, cardiovascular, cardiopulmonary, metabolic, endocrine, nervous and gastrointestinal systems. All these disorders can result in substantial direct and indirect cost to the employer and employee. In 2014, the Brazilian Ministry of Labor updated the Regulatory Standard Nº15 (RS15), specifically the Annex8, in which the occupational exposure limits to WBV are listed. Nowadays, due to many lawsuits from bus drivers requesting insalubrious condition, a partnership between university and private bus company was established in order to investigate the levels of vibration for intercity bus drivers on-the-job using the actual recommendations of RS15. This paper presents the experimental results which consist in measuring the WBV exposure of 16 bus drivers in different roads (private and public) located in different states of Brazil. Tri-axial accelerations of WBV were obtained by using a seat pad and a portable data logger. The daily vibration exposure normalized to an 8 hours reference period (aren) and the vibration dose total value (VDVR) were estimated and compared with respect to the actual RS15(Annex 8) limits. The same parameters were compared with ISO2631-1 just for analyzing which standard is more conservative. Experimental results indicate that 19% of monitored drivers are in acceptable condition and 81% are in the action limit range, but none of them are in insalubrious condition according to RS15.*

Keywords: *whole-body vibration, bus driver, regulatory standard nº15, ISO 2631-1:1997.*

1. INTRODUCTION

Researches show that activities related to the road transport sector are at high risk of physical and mental health for the worker. Considering the great importance of this sector in providing to the society the right to come and go, and it meaningful participation in the deaths, diseases, accidents at work and path which occurred in the country, all these facts point to urgent commitments in the creation of better job and health conditions for these professionals. According to statistics from the Brazilian Ministry of Labor, bus drivers, in general, have higher rates of mortality, morbidity and absenteeism due to illness, compared to workers in other professions (Neri *et al*, 2005).

Numerous studies investigate the cause-effect relationships between their working conditions and the incidence of chronic diseases. Several research papers result in a long list of health problems that originate from work activities in the road transport area (Camara *et al*, 1996; Gallais and Griffin, 2006; Siu *et al*, 2012; Hirata *et al*, 2012; Burström *et al*, 2015; Arora *et al*, 2015).

Diseases related to the musculoskeletal system, mainly low back pain (LBP), are considered as the main cause of morbidity in the trucking industry workers (Roffey *et al*, 2010). Some of the common causes of LBP may be classified as: structural, neoplastic, infection, inflammation, and metabolic. For drivers, the etiology is mechanical (or structural) due to vibrations, poor posture and long time sitting (Jensen, 2008).

The physical and mental health of bus drivers is undoubtedly a reflection of their working and living conditions. Such conditions generate consequences not only for drivers (physical and emotional disturbances), but also cause negative impacts for the company (financial loss) and society (poor quality service).

As cited before, one of the main complaints of road bus drivers is the pain in the lumbar region (or LBP), which has become a major socioeconomic problem of modern times (Queiroga, 1999). Long term exposure to high amplitude whole-body vibration (WBV) is strongly associated with the subsequent development of back pain (Bovenzi and Hulshof, 1998). Other health effects associated with WBV include adverse consequences for cardiovascular, respiratory, digestive, reproductive, endocrine and metabolic systems.

In general, the road bus drivers are exposed to significant WBV for relatively long periods due to long routes. Vibration transmitted from the road to the bus driver through the seat pan and seat backrest might affect ride comfort and in some cases have a detrimental health effect (Griffin, 1990). Many studies have been performed in laboratory or *in situ* in which responses of bus drivers to vibration were investigated. Most of the studies, the independent variables studied were related to the characteristics of the vibration as direction, frequency, magnitude, waveform and duration (Schwarze and Notbohm, 1998; Blood *et al*, 2010; Thamsuwan *et al*, 2013).

In order to guide the evaluation of occupational exposure to WBV the international standard ISO 2631-1 (ISO, 1997, 2010) is recommended. Two vibration evaluation methods are described: (i) basic evaluation method using weighted root-mean-square (r.m.s.) acceleration; and (ii) the fourth power vibration dose method (or Vibration Dose Value - VDV) which is more sensitive to mechanical shocks (jars or jolts).

ISO2631-1 (ISO, 1997, 2010) also provides guidance regarding the evaluation of health effects, defining a “health guidance caution zone - HGCZ”. For exposures below the HGCZ it is suggested that no health effects have been clearly documented. For exposures within the HGCZ “caution with respect to potential health risks is indicated” and for acceleration exposures greater than the HGCZ it is suggested that “health risks are likely”. For an eight hour daily exposure, the upper and lower bounds of the HGCZ are 0.43 m/s^2 and 0.86 m/s^2 r.m.s. respectively. The corresponding values for the VDV measure are 8.5 $m/s^{1.75}$ and 17 $m/s^{1.75}$ (McPhee et al., 2009).

In European countries is adopted the Directive 2002/44/EC: vibration published by European Agency for Safety and Health at Work in 2002. According to this standard, the assessment of the level of exposure to vibration is based on the calculation of daily exposure A(8) expressed as equivalent continuous acceleration over an eight-hour period, calculated as the highest (rms) value, or the highest vibration dose value (VDV) of the frequency-weighted accelerations, determined on three orthogonal axes (x-, y- and z-directions for a seated or standing worker) in accordance with chapters 5, 6 and 7, annex A and annex B to ISO standard 2631-1(1997, 2010). The action value for hand-arm vibration (HAV) is 2.5 m/s^2 and the exposure limit value is 5 m/s^2. For WBV the daily exposure limit value standardized to an eight-hour reference period shall be 1.15 m/s^2 or a VDV of 21 $m/s^{1.75}$. Although the daily exposure action value standardized to an eight-hour reference period shall be 0.5 m/s^2 or a VDV of 9.1 $m/s^{1.75}$.

In Brazil, was approved on August, 2014, the ordinance 1,297 of the Ministry of Labor and Employment, which introduces a specific annex in Regulatory Standard N^o 9 (RS9) and amending Annex 8 (vibrations) of RS15. This latter address unhealthy due to insalubrity conditions in the work environment. Until this date, there was no Brazilian standard dealing with the assessment of vibration, neither WBV nor HAV. The older RS15, for example, in its Annex 8 referred to international standards as ISO 2631 (for WBV) and the ISO5349 (ISO, 2011) for HAV evaluations.

For currently RS9 was added on September 2014 an annex (Nº1) which set criteria for prevention of diseases and disorders resulting from occupational exposure to vibrations (both HAV and WBV), under the program of environmental risk prevention. The quantitative evaluation procedures for WBV and HAV shall be in accordance with the Occupational Hygiene Standards (OHS09 and OHS10, respectively) published by FUNDACENTRO (“Jorge Duprat Figueiredo” Brazilian Foundation of Safety and Occupational Medicine of the Ministry of Labor and Employment).

The RS15 (updated in August 2014) refers to the text of RS9 in order to guide the work safety professional on how the vibration exposure evaluating should be done. Both RS9 and RS15 establish quantitative limits for vibration level. RS9 sets the action value and the daily limit of occupational exposure to vibration for both WBV and HAV. So the RS15 sets the limits values of occupational exposure to vibration which characterize unhealthy condition (insalubrity) for WBV and HAV.

According to the current RS15, the unhealthiness due to WBV is characterized when the daily exposure limit value is 1.1 m/s^2 and the vibration dose value is 21.0 $m/s^{1.75}$. These parameters must be estimated using the resulting three axes (tri-axial method). In the same standard, the value limit for HAV is established by only the daily vibration exposure normalized equal 5 m/s^2. It is important to note that RS15 addresses to RS09 and this latter addresses to OHS09 and OHS10.

The differences among the values established by the standards listed above are shown in Tab.1. It is possible to note that the daily exposure limit value of Brazilian standard (RS15) are below that established by European Directive 2002/44/EC, but above the value recommended by ISO2631-1.

Table 1. Recommended exposure limit for occupational vibration exposure.

	Brazilian Standards	European Directive 2002/44/EC	ISO2631-1
Daily exposure action value	0.5 m/s^2 **	0.5 m/s^2	0.43 m/s^2
VDV action value	9.1 $m/s^{1.75}$ **	9.1 $m/s^{1.75}$	8.5 $m/s^{1.75}$
Daily exposure limit value	1.10 m/s^2 *	1.15 m/s^2	0.86 m/s^2
VDV exposure limit	21 $m/s^{1.75}$ *	21 $m/s^{1.75}$	17.0 $m/s^{1.75}$

* Regulatory Standard Nº15
** Regulatory Standard Nº9.

In this context, the aim of this paper is to show the experimental results obtained from measurements of the vibration levels in intercity bus drivers, on-the-job, using the actual recommendations of RS15. The experiments considered the occupational WBV exposure of 16 bus drivers in different roads (private and public) located in different states of Brazil. The daily vibration exposure normalized to a reference period of 8 hours and vibration dose total value were estimated and compared with respect to the actual RS15 (Annex 8) limits.

2. METHODS

2.1 Data acquisition equipment

The data acquisition equipment is a human vibration meter (HVM100 – Larson Davis) which includes a tri-axial seat pad accelerometer (PCB PIEZOTRONICS ICP SEN027) with cable and a handheld vibration analyzer (provides the signal filtering complied with ISO 2631-1:1997, integration and data storage).

The seat pad accelerometer was fixed on the seat cushion surface between driver and seat (at the seat/operator interface), as shown in Fig. 1(a). It measures accelerations in three directions (the x-, y- and z-direction) ranging from 0.5 Hz to 1000 Hz. As specified in OHS09 (which refers to ISO 2631-1:1997), the x-direction is defined as the longitudinal direction from the back to the front, the y-direction is defined as the lateral direction from the right side to the left side of the human being, and the z-direction is defined as the vertical direction from the buttock to the head.

Mechanical configuration of this seat pad accelerometer satisfies the requirement in ISO 2631-1:1997. The seat pad accelerometer was connected to the handheld vibration analyzer (Fig. 1(b)), which converted the analog signals to the digital signals, estimated and stored r.m.s, minimum, maximum and peak level data as the main metrics such as crest factor, vibration total value (*av*) and vibration dose value (*VDV*).

The operation mode selected was "whole body" with the following parameters: averaging time (the amount of time data which is collected and averaged before a new average is started) is "slow" response (1 second exponential detector); time history buffer is 120 samples for each two minutes. After the data is stored, the instrument is reset automatically and a new set of data is collected. The limitation on the memory is 100 files. So, the data files were downloaded to notebook using Blaze® software. A new acquisition process was started with the empty memory. The sensor calibration was performed before each measurement using Cal21-Type 1-94 dB at 1000 Hz from 01dB-Stell®.

Figure 1(a). Location of the seat pad accelerometer at the seat/operator interface

Figure 1(b). Location of the handheld vibration analyzer at the bus (behind the driver seat).

The Blaze® software in the laptop was used to display the data stored and to control the acquisition options. The battery of the HVM100 provided power for the whole equipment. After the measurement, acceleration signals were post-processed in Matlab® software. The data acquisition equipment and the post-processing fulfill the requirement in ISO 8041:2005.

2.2 Experimental design

The sampling for this work was constituted of 16 participants, all males. They were recruited from the staff population of a private road buses company (partner in this research). The criteria for recruitment were that each participant held a full Brazilian driving license, had at least 1 full year of driving experience and was between the ages of 18-65. The age range that was recruited was 32-53 years. The University of Brasilia Ethical Advisory Committee (CEP-FS/UnB) approved the study (protocol number 547.814).

The male subjects were anthropometrically evaluated using a bio-impedance instrument (OMRON Model HBF-306C) combined weighing machine and height meter. The average mass is 82.3 kg (range 60.0-120.0 kg), stature 1.70 m (range 1.60-1.79 m) and body mass index (BMI) is 28.7 kg/m^2 (range 19.4-37.5 kg/m^2).

During the work 15 different buses were used. The bus model was that available in the road bus company shown in Fig. 2. It is Mercedes-Bens 500RS Chassis, Marcopolo G7 1200 body model. The older bus used was manufactured in 2007 and the newest in 2011. The mean mileage of this fleet is 126,710 km (range 36,040-461,246 km). Predictive maintenance is performed every 20,000 km. Corrective maintenance is performed for each journey end.

The routes were defined by researches together with the road bus company manager. Same criteria were adopted in order to attend the research goals and do not interven in the company's logistics:

- All routes began in Brasilia to facilitate technical boarding responsible for the measurements, and due to the need to measure the anthropometric information of the driver before the trip.
- The trip should be completed during one day, for the safety of the technician and handling equipment inside the vehicle. This criterion was sufficient to limit the routes in the item distance. So the round trip could not exceed more than two days, mainly due to the technical availability.

Figure 2(a). Front view of the bus model used.


Figure 2(b). Side view of the bus model used.

- The routes should be performed exclusively by the partner company which already exists in the itinerary of the company. No extra route was created to this work.
- Routes should cover as many Brazilian states within the supply partner company, including privatized and public roads. In order to attend this latter criterion, the routes available and adopted in this work are described in Tab. 2, which are defined by two cities located in different states. Note in Tab. 2 that the last route has an intermediate city (525 km) (there is a change of driver in this city due to the long distance), so this route will be considered in two parts: BSB to URA (525 km) and URA to RIB (173 km). The abbreviation between parentheses will be used from now in the texts bellow.

Table 2. Defined routes and distance.

Routes	Distance
Brasília/DF (BSB) - Alvorada do Norte/GO (AVN)	256 km
Brasília/DF - Catalão/GO (CTL)	315 km
Brasília/DF - Unaí/MG (UNAÌ)	167 km
Brasília/DF - Arraias/TO (ARR)	431 km
Brasília/DF - Barreiras/GO (BES)	648 km
Brasília/DF - Uberaba/MG (URA) - Ribeirão Preto/SP (RIB)	698 km

Figure 3 helps the reader to localize the cities listed in tab. 2 in Brazil map.

Figure 3(a). Evaluated region in the Brazil map.

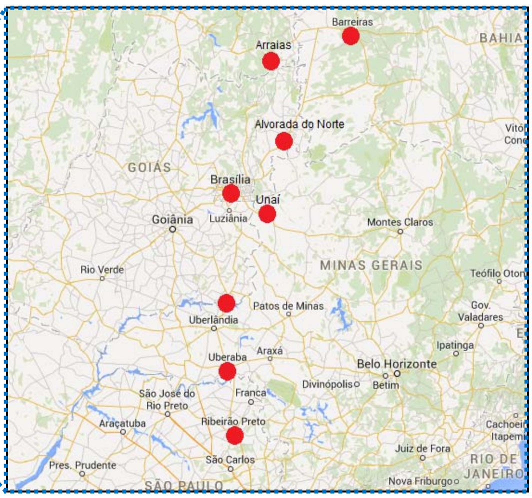

Figure 3(b). Location of the cities in the highlighted region.

Given the routes provided by the company (Tab. 2) which fulfilled the criteria of the previous items, the Tab.3 was defined as the design experiment of this work. Note that this table does not follow neither design experimental methodology just the better convenience for the road company and the drives that do not need change your work routine. The measurements were carried out from 08/16/2014 to 09/30/2014.

Analyzing Tab. 3 is possible to note that the routes evaluated in measurements 1 to 7 have been re-evaluated in number 8 to 14, so the drivers and bus were not the same. The grey highlighted cells are used to indicate repetition of driver and buses. The measurements 15 to 18 refer to route BSB-RIB and 19 to 20 refer to route BSB-BES, which did not have repetition due to the long distance.

Table 3. Experimental design.

Number	Date	Driver Identification	Bus Identification	Route	Measurement start (hr:min)	Measurement end (hr:min)
1	08/16/14	Driver #1	Bus #1	BSB - AVN	07:48	12:16
2	08/16/14	Driver #2	Bus #2	AVN - BSB	17:01	20:56
3	08/20/14	Driver #3	Bus #3	BSB – CTL	08:02	13:32
4	08/20/14	Driver #4	Bus #4	CTL - BSB	15:57	20:36
5	08/24/14	Driver #5	Bus #5	BSB – UNAI	09:27	11:50
6	08/24/14	Driver #5	Bus #6	UNAÍ - BSB	15:01	17:24
7	08/27/14	Driver #6	Bus #7	BSB - ARR	10:07	16:57
8	08/30/14	Driver #7	Bus #8	BSB - AVN	07:46	12:11
9	08/30/14	Driver #8	Bus #9	AVN - BSB	14:28	18:30
10	09/03/14	Driver #9	Bus #10	BSB – CTL	08:00	11:57
11	09/03/14	Driver #10	Bus #9	CTL - BSB	15:57	20:16
12	09/07/14	Driver #11	Bus #11	BSB – UNAÍ	08:42	11:00
13	09/07/14	Driver #11	Bus #11	UNAÍ - BSB	15:02	17:27
14	09/10/14	Driver #12	Bus #12	BSB - ARR	10:02	17:19
15	09/22/14	Driver #13	Bus #13	BSB - URA	07:59	16:13
16	09/22/14	Driver #14	Bus #13	URA - RIB	16:32	18:47
17	09/23/14	Driver #15	Bus #13	RIB - URA	13:07	15:37
18	09/23/14	Driver #9	Bus #13	URA - BSB	15:54	23:12
19	09/29/14	Driver #16	Bus #14	BSB - BES	09:03	18:47
20	09/30/14	Driver #16	Bus #15	BES - BSB	09:03	19:27

2.3 Evaluation of WBV effect on health

As mentioned before, the main objective of this work is to estimate the parameters required by RS15 and defined in this standard: the daily vibration exposure normalized to a reference period of 8 hours (*aren* in m/s^2) and vibration dose total value (*VDVR* in m/s$^{1.75}$). The first parameter is defined by Eq. (1):

$$aren = are\sqrt{\frac{T_{jorn}}{T_o}} \tag{1}$$

where T_o is 480 minutes (8 hours); T_{jorn} is the duration of the working day (in minutes), which in this case is considered as the total time of the analyzed route, including breaks and stops; *are* (in m/s^2) is defined by Eq. (2):

$$are = \sqrt{\frac{1}{T_{jorn}} arep^2 T_{\exp}} \tag{2}$$

where T_{exp} is the exposure time to the vibration (in minutes), which corresponds to the duration of the measurement since the acquisition equipment was paused when the driver was not exposure to vibration; *arep* (in m/s^2) is defined by Eq. (3):

$$arep = \frac{1}{s}\sum_{k=1}^{s} amr_k \tag{3}$$

where *s* is the number of data files (samples) stored for the entire route; *amr* (in m/s^2) is the vibration total value which is an output data of the measurement equipment for each two minutes of experimental acquisition.

The vibration dose total value (*VDVR* in m/s$^{1.75}$) is defined by Eq. (4):

$$VDVR = \left[\sum_j (VDV_{\exp j})^4 \right]^{1/4} \tag{4}$$

where j corresponds to x, y and z-direction; and VDV_{expj} (in m/s$^{1.75}$) is defined by Eq. (5):

$$VDV_{\exp j} = f_j \times VDV_j \times \left(\frac{T_{\exp}}{T_{med}} \right)^{1/4} \tag{5}$$

where T_{med} is the total duration of the measurement (in minutes), in this work is equal to T_{exp}; f_j are multiplying factors (1.4, 1.4 and 1 for x, y, z-directions respectively); and VDV_j is defined by Eq. (6):

$$VDV_j = \left[\sum_{k=1}^{s} VDV_{meas\ j}^{\ 4} \right]^{1/4} \tag{6}$$

where $VDV_{meas\ j}$ is the vibration dose value for x, y, z-direction in m/s$^{1.75}$ stored in the measurement equipment for each two minutes of experimental acquisition.

The results obtained from Eq. (1) and (4) are shown in the next topic.

3. RESULTS AND DISCUSSION

The Tab. 4 shows (in the last two columns) the daily vibration exposure normalized to a reference period of 8 hours (*aren*) and vibration dose total value (*VDVR*) estimated from experimental data for each route considered, which are required for RS15. The fourth column is the exposure time to the vibration in hours. The fifth column is the sample numbers of vibration total value stored during the considered route. The sixth column is the vibration partial exposure (*arep*) evaluated during the T_{exp}. Note that the parameters *aren* and *VDVR* are used in order to attend the RS15 (Brazilian standard), although the parameters *arep* and *VDVR* are required for ISO2631-1.

Table 4. Vibration exposure estimated.

Number	Route	Driver	T_{exp} (hr)	*Sample nº.*	*arep* (m/s^2)	*aren* (m/s^2)	*VDVR* (m/s$^{1.75}$)
1	BSB - AVN	Driver #1	3.93	14,160	0.580	0.407	8.903
2	AVN - BSB	Driver #2	3.73	13,440	0.557	0.381	7.866
3	BSB – CTL	Driver #3	4.57	16,440	0.691	0.522	15.117
4	CTL - BSB	Driver #4	4.30	15,480	0.568	0.417	10.002
5	BSB – UNAI	Driver #5	2.43	8,760	0.676	0.373	9.815
6	UNAÍ - BSB	Driver #5	2.40	8,640	0.695	0.381	10.018
7	BSB - ARR	Driver #6	6.10	21,960	0.494	0.431	12.170
8	BSB - AVN	Driver #7	3.83	13,800	0.662	0.458	10.921
9	AVN - BSB	Driver #8	3.60	12,960	0.680	0.456	12.044
10	BSB – CTL	Driver #9	3.63	13,080	0.551	0.372	8.226
11	CTL - BSB	Driver #10	4.07	14,640	0.760	0.542	11.893
12	BSB – UNAÍ	Driver #11	2.27	8,160	0.724	0.386	8.976
13	UNAÍ - BSB	Driver #11	2.40	8,640	0.730	0.400	10.074
14	BSB - ARR	Driver #12	5.87	21,120	0.860	0.736	14.125
15	BSB - URA	Driver #13	7.10	25,560	0.561	0.528	10.892
16	URA - RIB	Driver #14	2.23	8,040	0.552	0.292	7.889
17	RIB - URA	Driver #15	2.40	8,640	0.481	0.263	9.388
18	URA - BSB	Driver #9	6.47	23,280	0.562	0.505	9.737
19	BSB - BES	Driver #16	8.70	31,320	0.754	0.786	14.901
20	BES - BSB	Driver #16	8.97	32,280	0.645	0.683	12.493

In Tab. 4, yellow highlight cells means “action value” and red texts means “limit values”. Analyzing Tab. 4, specifically the parameters *arep* (required in ISO2631-1) and *aren* (required in Brazilian RS15), we can see that no driver are submitted to insalubrity conditions (all *aren* values are smaller than 1.10 m/s^2) neither there´re *arep* values above the HGCZ-health guidance caution zone (ISO2631-1). So, the drivers #3, 9, 10, 12, 13 and 16 are exposure to vibration above the action value (*aren* values upper than 0.5 m/s^2) or inside the HGCZ, which means caution with respect to potential health risks.

The last column of Tab. 4 shows the VDVR parameter (common to RS15 and ISO2631-1). According to Tab. 1, all yellow highlight cells indicate that the drivers are exposed to "action values" as specificity in RS15 (above to 9.1 m/s$^{1.75}$) and ISO2631-1 (above to 8.5 m/s$^{1.75}$).

The RS15 characterizes unhealthy condition if any of the limits of daily occupational exposure (*aren* or *VDVR*) exceed the limits defined in Tab. 1. Considering VDVR values, 81% of the evaluated drivers are exposure to potential health risks, but neither are exposures to insalubrity conditions. It is important to note that de fourth power vibration dose method is more sensitive to peaks than the evaluation of the second power of the acceleration time history. So, the high values of VDV may be an indicative of irregularities in the Brazilian roads.

Since the previous analyses were conducted for each driver, the next analysis will be done considering each route listed in Tab. 2. In order to easy the analysis the mean *VDVR* were estimated for each route and it is shown in Fig. 4.

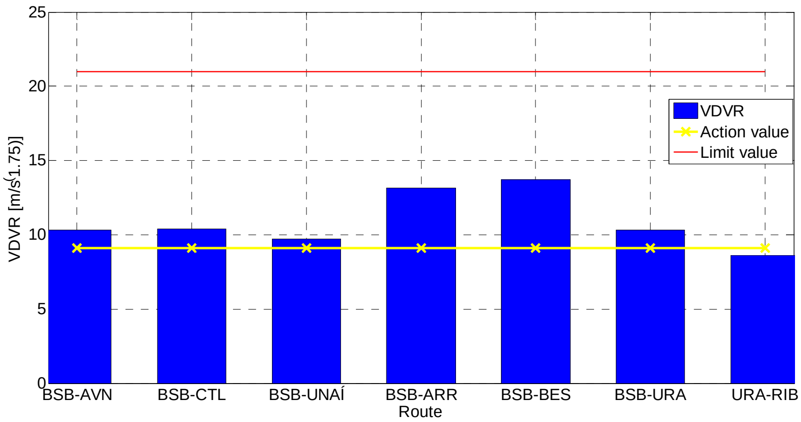

Figure 4. Mean VDVR estimated for each route evaluated.

As we can see in Fig. 4 the higher VDVR values were estimated to routes between BSB-BES and BSB-ARR respectively. This result was expected due to the claims of drivers about discomfort and pains when they drive when they drive in north, midwest and northeastern Brazil. The lower VDVR value corresponds to route between URA and RIB. This was another expected result due to this route have private roads, where the pavement irregularities are much smaller than those of public roads.

Many other aspects will be study in this research, like the anthropometric parameters of the drivers and it correlation with the vibration exposure; the analysis of the acceleration time history using signal processing, and others aspects.

4. CONCLUSIONS

The results shown in this paper are purely experimental and their meanly contribution is the amount of samples data collected. In general, during evaluation for labor expertise in order to assess working conditions, the measurements are done in a short stretch and time of working day of the driver.

Whole body vibration exposures of 16 bus drivers in 7 different routes were evaluated. The daily vibration exposure normalized to a reference period of 8 hours (*aren*) and vibration dose total value (*VDVR*) were estimated according to RS15(Annex 8) recommendations. The parameter *aren* indicates that 6 drivers are exposure to vibration above the action value. Although the *VDVR* parameter shows that 81% of the evaluated drivers are exposure to potential health risks but neither is exposures to insalubrity conditions.

Another interesting result was obtained when the mean VDVR were estimated to each route in order to know the vibration exposure which the driver experiments when he travels in it. The largest mean VDVR were estimated for the routes in the midwest (BSB-ARR) and northeast (BSB-BES) direction in Brazil. The lowest value of VDVR was found in privatized road (URA-RIB).

5. ACKNOWLEDGEMENTS

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7. RESPONSIBILITY NOTICE

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