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THE TRANSMISSION OF VIBRATION THROUGH CAR SEATS

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Abstract: Because is no industry that does not use cars, they arrived today indispensable. Drivers are subjected to whole body vibration. Vibrations are caused by road and vehicle type, and type of vehicle seat suspension, running speed and load. For these reasons, drivers suffer from various diseases of the skeletal, digestive, circulatory, etc. The most common adverse effects occur at resonance frequencies of 1-2Hz (the x and y axes) and 4-8Hz (z-axis). We conducted a study of WBV on company 6 cars. The transport was made on the different roads type. We measured accelerations in axes x, y and z for theses cars, for 1h/zi, for a period of 3 months (no weekends). It was observed that carefully limit has not exceeded and also the limit of discomfort, according to the guidelines of health care areas (Health Guidance Caution Zones of ISO 2631-1/1997).
Key words: vibration dose, car seat

1. INTRODUCTION

The purpose of this study is to measure the whole body vibrations for drivers.

Whole body vibrations refer to the vibration exposures found in many occupational settings such as heavy construction, forklift operation, vehicle operation, and farming and to the drivers. WBV exposure, especially when chronic, is suspected to cause adverse health effects such as fatigue, lower back pain, vision problems, interference with or irritation to the lungs, abdomen, or bladder, and adverse effects to the digestive, genital/urinary, and female reproductive systems.

Lumbar pains which appear at drivers were investigated in several studies [1, 2, 3].

A predominant adverse health effect is low-back pain (LBP) [4].

The following studies support the LBP relationship with WBV in specific industry studies: heavy construction [5]; forklift operation [6]; vehicle operators [7]; professional drivers [8]; farmers [9].

-spinal column disease and complaints are perhaps the most common diseases associated with the long-term exposure to whole-body vibration, where the back is especially sensitive to the 4-12Hz vibration range [10]

-digestive system diseases are often observed in persons exposed to whole-body vibration over a long period of time. This is associated with the resonance movement of the stomach at frequencies between 4 and 5Hz

-cardiovascular system effects resulting from prolonged exposure to whole-body vibration at frequencies below 20Hz. These result in hyperventilation, increased heart rate, oxygen intake, pulmonary ventilation and respiratory rate

Every part of the human body has its own resonant frequency (Fig. 1).

2. METHODS

The ISO/ANSI standards provide information on WBV monitoring. WBV is measured in a three-axis coordinate system. When seated, the axes represent vibrations as fore and aft (x-axis), side to side (y-axis), and vertical (z-axis) (Fig. 2).

Vibration is measured with a triaxial accele-rometer placed at the interface between the vibrating surface and the human body. For seated measu-rement, the accelerometer is placed between the seat and ischial tuberosities (ISO, 1997; ANSI, 2002).

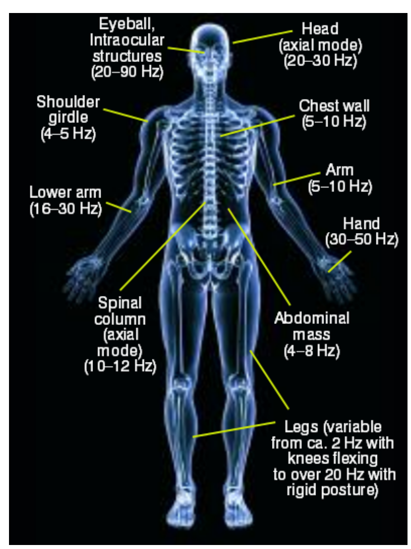

Fig. 1. Resonance frequencies of the human body

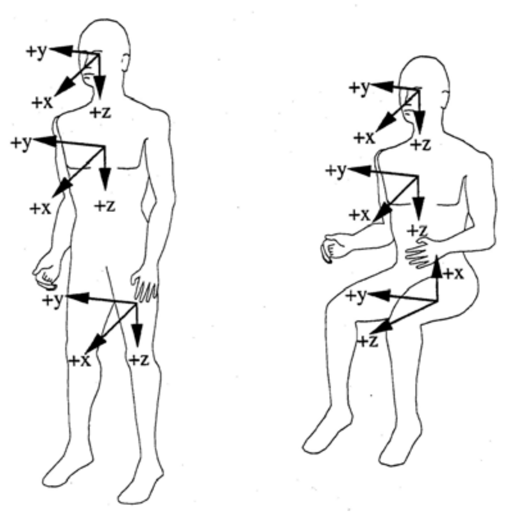

Fig. 2. Accelerations directions [11]

Vibration is measured as the variation with time of the magnitude of a quantity (e.g., distance) about a point that describes the motion or position of a mechanical system. With simple addition, the positive and negative distances traveled from the reference point would cancel each other and equal zero. For this reason, vibration is expressed as the root-mean-square (RMS) of the vibration accelerations (m/s2) and is calculated by finding the square root of the arithmetic mean of the squares of individual vibration wave values.

To determine whether WBV exposures present potential health risks to workers, weighted RMS and VDV values can be checked and compared with the health guidance caution zones graphically displayed in the ISO (1997)/ANSI (2002) standards or the specified values of EAV (weighted RMS = 0.50 m/s^2; VDV = 9.1 $m/s^{1.75}$) and ELV (weighted RMS = 1.15 m/s^2; VDV = 21 $m/s^{1.75}$) in the European Directive 2002/44/EC.

In order to characterise the vibrations produced by different cars (same type, but different productions years) measurements were made on 6 vehicles. To obtain information which covers a great variety of regnant intensities, frequencies and directions 3 different routes were monitored (2 in the city and 1 outside the city). The velocity during the tests was normal. At this study, participated 6 medium built drivers of 28-54 years of age.

The vibrations were measured in normal working conditions, according to International Standard ISO 2631/1. The whole body vibration, in different conditions, was measured at the driver/seat interface (on the 3 axes x, y and z from the centre of the human body). The whole body vibrations were measured using a MAESTRO vibro-meter, produced by 01dB-Metravib and a triaxial accelerometer, also produced by 01dB-Metravib, fixed inside a seat-pad [1, 3]. Accelerometers were placed on the floor and under the driver's body.

The accelerations generated by vibrations were calculated using the weight factors set by ISO 2631.

3. EXPERIMENTAL DATA PROCESSING

Data analysis was done with dBFA Suite - Software control data acquisition and post-processing. Data collected during the experiments were processed using calculations indicated ISO 2631-1-1997 and 2631-5-2004. Parameters given in ISO 2631-1 include:

The vibration total value A_{WT} or weighted acceleration sum (WAS) and it is defined as the root-mean-square of the three component values:

$$a_{WT} = [(1.4a_{hwx})^2 + (1.4a_{hwy})^2 + (a_{hwz})^2]^{1/2} \quad (1)$$

where a_{hwx}, a_{hwy}, a_{hwz} are frequency-weighted acceleration values for the single axes.

The 1.4 factor is the ratio of the longitudinal and transversal curves values, of equal answer in human answers, the most sensible.

VDV method uses the fourth power of vibration, which is more sensitive to shocks than using the power of two of calculating rms acceleration. VDV is given by:

$$VDV = \sqrt[4]{\int^{T} a^4(t)dt} \quad (2)$$

where $a_w(n)$ is the current weighted acceleration, ν_s frequency and N total number of measurements.

The time period needed to reach the value of the exposure which triggers the action (EAV) and the limit exposure value (ELV):

$$T_{EAV_{A(8)}} = 8\left(\frac{0,5}{A_w}\right)^2 \quad (h) \quad (3)$$

$$T_{ELV_{A(8)}} = 8\left(\frac{1,15}{A_w}\right)^2 \quad (h) \quad (4)$$

4. RESULTS AND DISCUSSIONS

We determined the following physical quantities characterizing vibration drivers (D):

1. Root mean square acceleration (a_W) calculated from the floor, seat, back, and forehead in the 6 cases (Fig. 3).
2. Vibration dose (VDV) calculated from the floor, seat, back, and forehead in the 6 cases (Fig. 4).

3. The time period needed to reach the value of the exposure which triggers the action (EAV) (Fig. 5) and the limit exposure value (ELV) (Fig. 6).

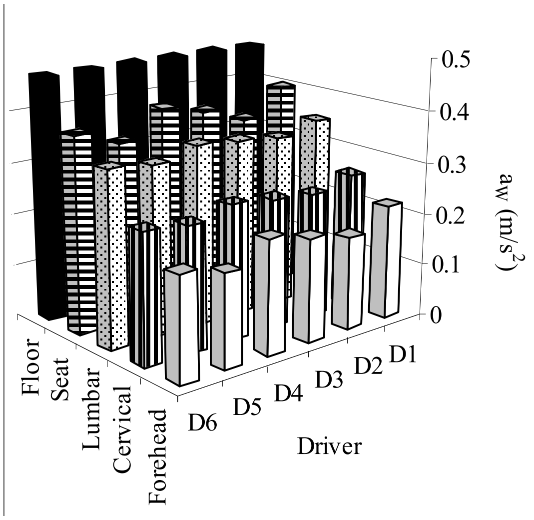

Fig. 3 Root mean square acceleration variation for 6 drivers (■) – floor, (≡) – seat, (▒) – lumbar, (|||)– cervical, (□) – forehead

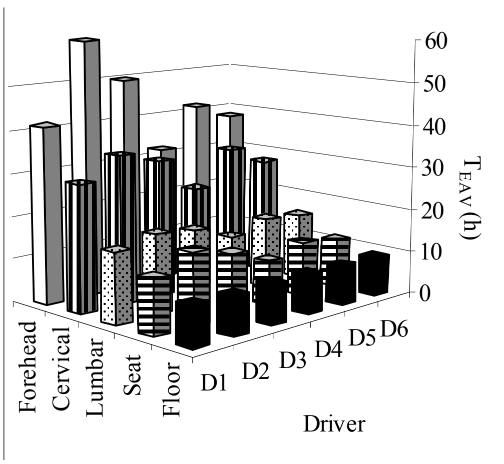

Fig. 5 Time exposure action value variation for 6 drivers (■) – floor, (≡) – seat, (▒) – lumbar, (|||)– cervical, (□) – forehead

Figure 7 shows that the average for root mean square acceleration values are between minimum and maximum values of the European Directive 2002/44/EC. These average values are aligned by curve:

$$a_W = 0.0004x^3 - 0.0145x^2 + 0.1371x + 0.489 \quad (R^2 = 0.9058) \quad [x \in (1, 6)] \qquad (5)$$

Figure 8 shows that the average for vibration dose values are between minimum and maximum values of the European Directive 2002/44/EC. These average values are aligned by curve:

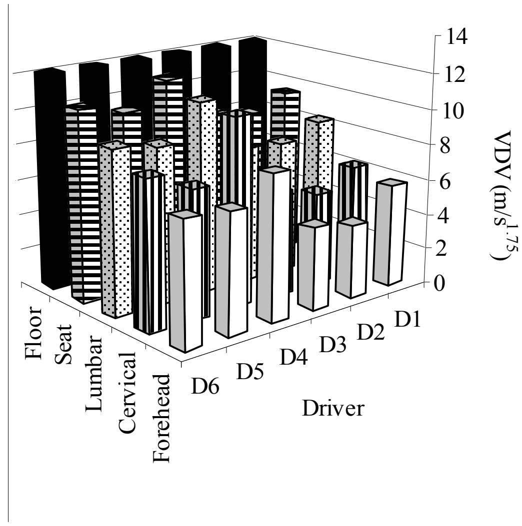

Fig. 4 Vibration dose variation for 6 drivers (■) – floor, (≡) – seat, (▒) – lumbar, (|||)– cervical, (□) – forehead

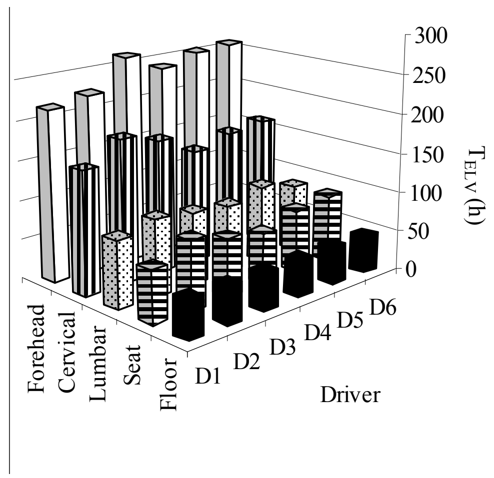

Fig. 6 Time exposure limit value variation for 6 drivers (■) – floor, (≡) – seat, (▒) – lumbar, (|||)– cervical, (□) – forehead

$$VDV = -0.0099x^3 + 0.3923x^2 - 4.1401x + 25.033 \quad (R^2 = 0.9142) \quad [x \in (1, 6)] \qquad (6)$$

It is found that the transmitted vibrations values of all cars are between legal limits. There are differences between these values due to the age of the car, driver, etc.

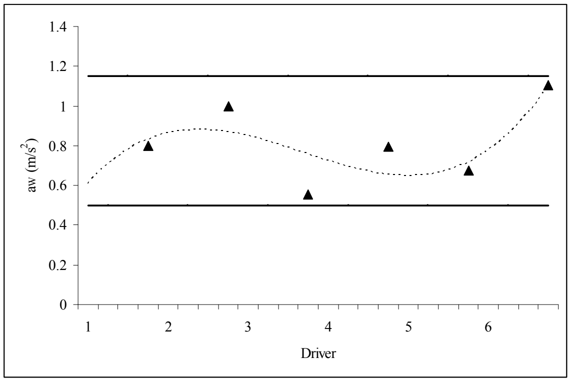

Fig. 7 $a_{r.m.s}$. average (▲) for 6 drivers (minimum value = 0.50 m/s^2), (maximum value = 1.15 m/s^2)

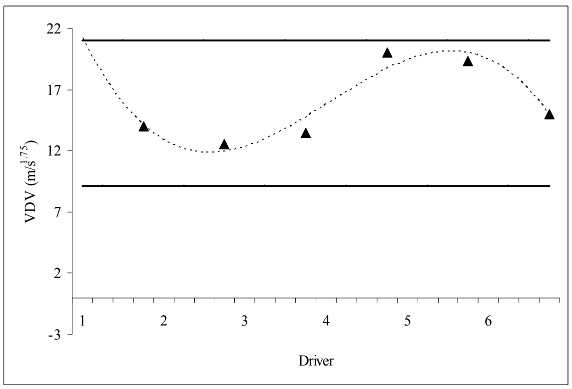

Fig. 8 VDV average (▲) for 6 drivers (minimum value = 9.1 m/s$^{1.75}$), (maximum value = 21 m/s$^{1.75}$)

5. CONCLUSIONS

Driver weight did not show a significant effect in this study, this may be a result of small sample size and the need for more measurements in the exploration of the relationship between driver weight and WBV exposure. High VDV z-axis exposures were also present in the older freeway segment and above the action limit. This study also found significant differences in vibration exposure across at different seat pressures; therefore driver selected seat suspension pressure appears to be an important determinant of exposure as measured in the z-axis a_w and VDV.

If a driver or worker has a genuine complaint then something should be done to try and rectify this. Seats with arm rests, lumbar support, an adjustable seat back and an adjustable seat pan are also useful for correcting driving surfaces to reduce vibration at the source. All it takes is a true holistic approach using occupational health and safety principles.

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