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WHOLE-BODY VIBRATION EXPOSURE OF MALAYSIAN TAXI DRIVERS

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ABSTRACT

During their whole working time, taxi drivers are usually seated. Additionally, long-term exposure to whole-body vibration while driving may lead to diseases and adverse health conditions such as lower-back pain. The objective of this study is to investigate the relationship between measurable whole-body vibration and lower-back pain. This study was conducted on two highways: Kuala Lumpur–Karak Highway and the North–South Highway. A tri-axial seat accelerometer was placed at the point of contact between the driver and the seat pad. The assessment of whole-body vibration measurement is according to ISO 2631-1. Excessive whole-body vibration has been evidenced as leading to lower-back pain. Taxi drivers are recommended to drive no more than the allowable exposure limit. In this study, the whole-body vibration does not exceed the allowable exposure limit. Therefore, the taxi drivers in this study do not have lower back pain.

Keywords: Whole-body vibration; lower back pain; musculoskeletal disorder; vibration dose value.

INTRODUCTION

Whole-body vibration (WBV) is a mechanical energy oscillation which is transferred to the human body as a whole and it occurs usually through a supporting system, such as a seat or platform [1, 2]. Whole-body vibration is used to describe a situation when the whole environment is undergoing motion and the effect of interest is not local to any particular point of contact between the body and the environment [3]. It occurs when the body is supported by a vibrating surface. There are three main possibilities of whole-body vibration: sitting on a vibrating seat, standing on a vibrating floor, or lying on a vibrating bed. Taxi drivers are highly exposed to vibration, but awareness of the phenomena is still low. Driving for a long period of time will result in lower-back pain. The other risk factor for developing lower-back pain, other than whole-body vibration and static posture, is awkward movement. Long-term occupational exposure to whole-body vibration is associated with an increased risk of disorders of the lumbar spine and the connected nervous system [4-6]. The permissible frequency weighted acceleration exposure and the approximation indications of acceptability based on the root mean square acceleration values are shown in Table 1 and Table 2, respectively.

Table 1. Permissible frequency weighted acceleration exposure [7].

Exposure Limit	RMS Acceleration (m sec^{-2})
8 h	2.8
4 h	4.0
2.5 h	5.6
1 h	11.2
30 min	16.8
5 min	27.4
1 min	61.3

Table 2. Approximation indications of acceptability based on the RMS acceleration values [7].

Exposure limit (m sec^{-2})	Condition
< 0.315	Not uncomfortable
0.315 to 0.630	A little uncomfortable
0.500 to 1.000	Fairy uncomfortable
0.800 to 1.600	Uncomfortable
1.250 to 2.500	Very uncomfortable
> 2.000	Extremely uncomfortable

The possible effects of whole-body vibration exposure include herniated and degenerative lumbar disc diseases, lower-back pain, and other musculoskeletal disorders . This makes it clear that the exposure to whole-body vibration of occupational drivers is a risk factor in developing lower-back pain and other medical problems. Accordingly, the relationship between measurable whole-body vibration and lower-back pain for taxi drivers in Malaysia is investigated.

METHODOLOGY

This study was conducted on two highways: the Kuala Lumpur–Karak Highway and the North–South Highway. The measurement started early in the morning at 7.00 am. The tri-axial seat accelerometer was placed at the point of contact between the driver and seat pad. The assessment of whole-body vibration measurement is according to ISO 2631-1. The tri-axial accelerometer was placed at the contact point between the driver and the vibration source.

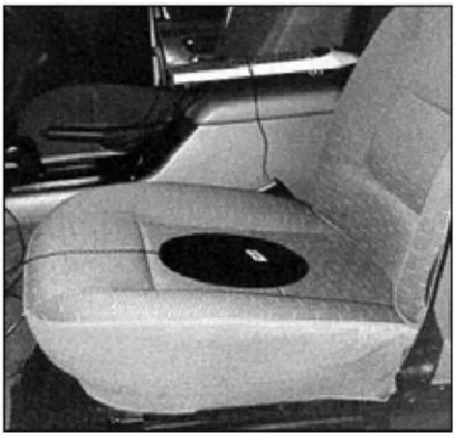


Figure 1. Tri-axial accelerometer sensor used for WBV measurement.

Figure 1 illustrates the accelerometer sensor. Two devices were used in the study: a dosimeter and an IEPE (ICP^{TM}) based accelerometer sensor. The IEPE (ICP^{TM}) accelerometer sensor, known as the tri-axial seat accelerometer, used in this study was a VI-400Pro real time vibration analyzer. This sensor was utilized to access the vibration level. The accelerometer consists of a piezoelectric element connected to a known mass. When the accelerometer vibrates, the mass applied force to the piezoelectric element generating an electrical charge that is proportional to the applied force. Most accelerometers require a current source of 4 mA and a compliance voltage at least 18 V to drive their internal circuitry. Other accelerometers require a 2 mA current source, but have limitations in cable length and bandwidth. The VI-400Pro has three input channels which can be configured for sound or vibration, uses RMS as the unit of the measurement, VDV (vibration dose value), peak, peak-peak, min, max transient vibration (MTVV), vector sum, daily vibration value A, exposure action value (EAV) time, exposure limit value (ELV) time, and time history. The Edge eg3 instrument has a one-quarter inch repolarized condenser field replaceable thread microphone measuring 70–140 dB. This instrument displays L-avg or L-eq run time data values.

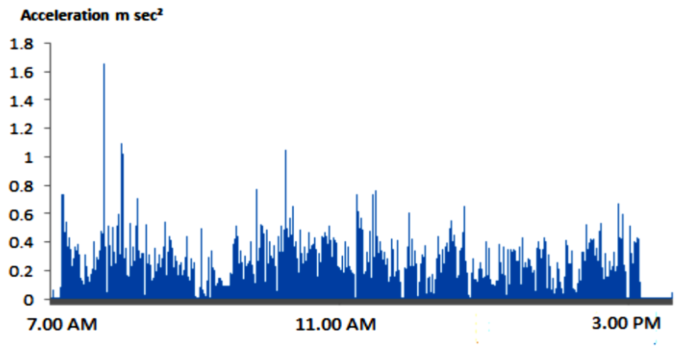
RESULTS AND DISCUSSION

The results of this study indicated that measurements of daily exposure to vibration A and VDV on the Kuala Lumpur–Karak Highway were much higher compared to the measurement on the North–South Highway. Table 3 shows the measurement values.

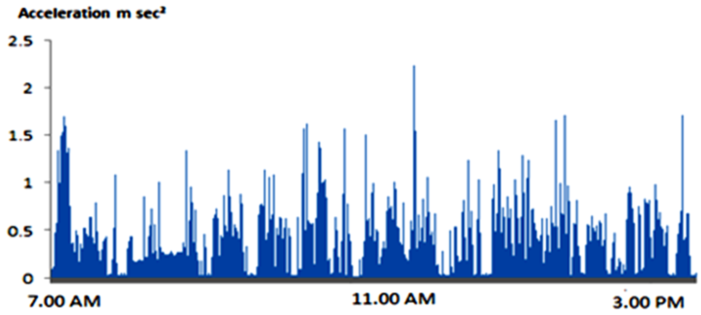
Table 3. Whole-body vibration measurement data collected in taxis.

	North–South Highway	Kuala Lumpur–Karak Highway
Daily exposure to vibration A	0.3917 m sec^{-2}	0.4166 m sec^{-2}
Vibration dose value (VDV)	7.1438 m sec$^{-1.75}$	7.5871 m sec$^{-1.75}$
Daily exposure action value time (0.5 m sec^{-2})	13 h 02 min	11 h 33 min
Daily exposure limit value time (1.15 m sec^{-2})	>24 h	>24 h

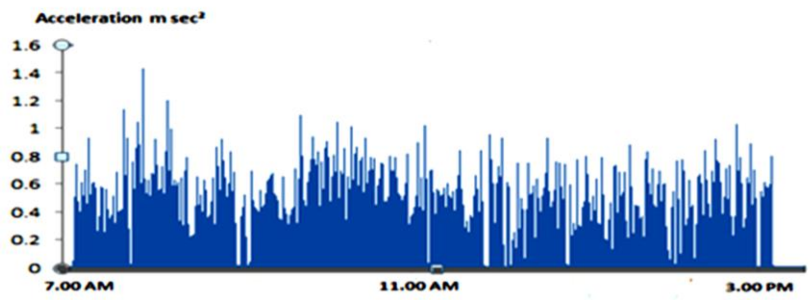
The value of daily exposure to vibration and vibration dose value were 0.4166 msec^{-2} and 7.5871 m sec$^{-1.75}$, respectively. It seems possible that these results are influenced by the condition of the taxi and the conditions of the route, the Karak–Kuala Lumpur road is winding. Table 4 indicates that whole-body vibration measurement in two taxis with daily exposure to vibration A, VDV, daily EAV time and daily ELV time. Meanwhile, only 13 h 2 min per day EAV time is required to meet the standardized value of 0.5 m sec$^{=2}$ for an 8 h reference period. This is quite astonishing because this result does not exceed the standard time for whole-body vibration assessment which was 8 h as stated in ISO 2631-1: 1997. For whole-body vibration, 8 h EAV of 0.5 m sec^{-2} is stated. Once EAV is exceeded, employers should monitor the health of their workers and they have to take precautions such as minimizing exposure to mechanical vibration.



(a) RMS x-axis for taxi 1.

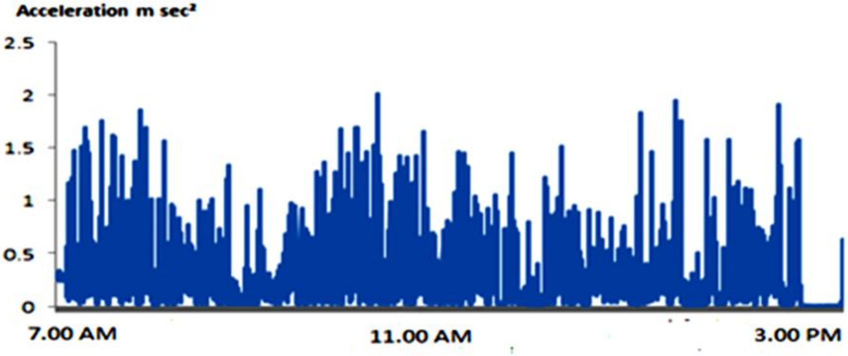


(b) y-axis

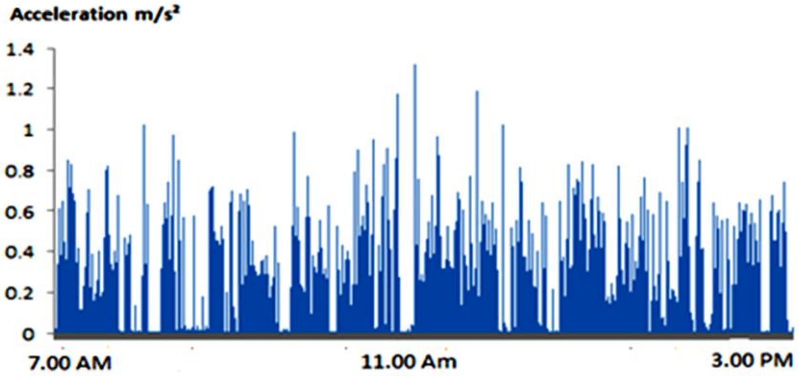


(c) Z-axis

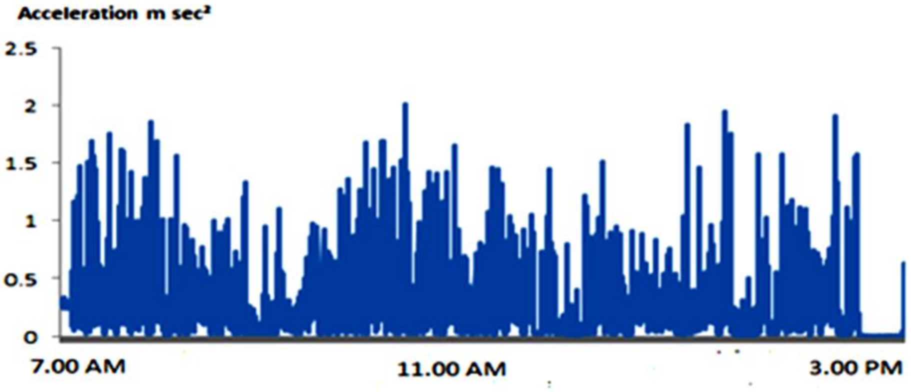
Figure 2. RMS for Taxi 1.



(a). x-axis



(b). y-axis



(c) z-axis

Figure 3. RMS for Taxi 2.

Whole-body vibration magnitudes measured on a truck in the x, y and z axes were 0.76 ms^{-2}, 0.79 ms^{-2} and 1.1 ms^{-2} respectively [8]. The truck was an off road industrial vehicle with machinery and carried a large load [8]. In comparison, the taxi is for human transportation and travels along made routes rather than the unmade routes taken by the truck. Furthermore, with regard to the condition of the vehicles themselves, the truck has a harder suspension system compared to the taxi so that it can carry very large loads. From the results it can also be seen that the heavier the truck, the more likely it will experience greater vibration, and this is due to the poor suspension system.

The suspension system plays an important role in any vehicle in minimizing the the magnitude absorbed by the vehicle.

Ismail et al. studied train passengers [7]. The highest value of daily exposure to vibration was 0.3749 ms^{-2}, which is smaller than the research results of 0.3917 ms^{-2}. They conducted experiments by taking three routes compared to the research route where only two routes were taken into account. The time measurement was also different as they conducted their research in ranges of half an hour only but this research conducted experiments over 8 h which is the normal working condition. The researcher's values were higher because a taxi driver is seated in the driving compartment where there is a very high incidence of vibration transmitted from the vehicle [9], but train passengers are seated in passenger compartments where there is little exposure to high vibration. Perhaps the passenger compartment is more comfortable than the train driver's. One journal is related to the measurement of whole-body vibration in taxi drivers [10]. They assessed health by using the formula from ISO 2631-1: 199 and found it to be 0.44 ms^{-2} compared to the research result of 0.4166 ms^{-2}. This result was smaller than that of Funakoshi et al. [9]. This is due to the prolonged exposure of taxi drivers to vibration. Their working time exceeded 8 h for almost all of their subjects compared to the research subjects who work for only 8 h or less than one hour. The comfort value was also different from the research result, see ISO 2631-1: 1997 Annex C. This shows that Funakoshi et al. [9] achieved 0.38 ms^{-2} and the researcher attained 0.3315 ms^{-2}, this is due to prolonged exposure to vibration and drivers being too long seated in the taxis. Moreover, they have many subjects compared to the researcher so their result is more accurate.

CONCLUSIONS

In conclusion, based on the data obtain from the measurement, the whole-body vibration value recorded for this study does not exceed the permissible value. Therefore, the lower whole-body vibration exposure reduces the chance of contracting lower-back pain symptoms. Recommendations for future research include external factors such as the taxi driver's posture while driving and to undertake optimization or modelling in designing the experiment.

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