Whole-body Vibration at Work of Urban Traffic Drivers

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Urban traffic drivers are exposed to mechanical whole-body vibration during their work. Some drivers suffer from low back pain caused by vibration. However, due to the lack of investigations there is no evidence of a relationship between the whole-body vibration from the means of conceyance and low back pain or occupational disease. A field study was conducted in order to characterice the health risks associated with trolleybus driving work. Five different types of trolley cars were tested at different loading with the driver/seat interface (*x*-, *y*-, and *z*-axes). The vibration was compared with the health risk guidance according to ISO 2631 (1). The findings of this study indicated that under current working conditions drivers should not operate the type 9TRG trolleybus.

Key words: whole-body vibration, urban traffic driver, low back pain, health risk, occupational disease of vibration, frequency weighted root mean square (r.m.s) acceleration, estimated vibration dose value, exposure duration

INTRODUCTION

Low back pain disorders occurring among proffesional drivers have been investigated in several studies (2, 3). In two studies (4, 5) authors investigated the prevalence of several types of low back symptoms among bus drivers employed at a public transport company. Most of the studies were not informative, because the data were poorly documented.

Urban traffic drivers are exposed to mechanical whole-body vibration during their work, and some drivers suffer from low back pain due to their driving work in Latvia. In order to predict the health risk for drivers from vibration, it is necessary to evaluate the oscillatory motion of the means of conveyance so as to make a correlation between the vibration directed into the body and an occupational disease associated with vibration. To date, there has been no research regarding the whole-body vibration of trolleybuses cars.

The objective of the study was to measure the whole-body vibration on the trollebus driver's seat while driving and while the passengers getting out and in.

MATERIALS AND METHODS

Five traffic cars that are commonly used in Riga were used for characterizing vibration in different trolleybus models. Four different runs were chosen so as to give a wide variety of various intensities, frequencies and dominant directions. The running speed was the usual daily car speed. Only one driver participated in this study. The man was 52 years old, 175 cm tall and weighed 85 kg. He had approximately 30 years of experience in the public traffic work.

Vibrations were measured under actual working conditions according to the recommendations of the International Standard ISO 2631/1. The whole-body vibration for different work conditions of the means of conveyance was measured at the driver seat interface (*x*-, *y*-, and *z*-axes). Table 1 shows the measurement conditions.

Whole-body vibration was measured at the driver seat interface by using a B & K type 4322 triaxial seat pad accelerometer. Vibration measurements were performed by using a B & K type 2231 modular precision

Table 1. **Vibration measurement conditions used in each traffic car**

Run	Measurement condition
1	Idling without passengers
2	Driving without passengers
3	Idling with passengers
4	Driving with passengers

sound level meter. Three recorded acceleration signals for each of the conditions of Table 1 were acquired on a B & K type 2522 human vibration unit – a versatile addition to type 2231. Frequency-weighted accelerations were calculated by using the weight factors suggested by ISO 2631.

Experiments for each car were carried out separately, because it was not possible to instrument all five cars at the same time. Each experiment of testing one driver of one car on each of the four conditions took three hours. The driver was required to adjust the seat so as he wished at the start of the experiment and to sit comfortably. Each car was run on the same road with and without passengers.

RESULTS AND DISCUSSION

Table 2 shows the frequency-weighted r.m.s. acceleration of different working conditions of traffic means at the driver seat interface (*x*-, *y*-, and *z*-axes) according to ISO 2631.

From Table 2 the grand average *x*-, *y*-, and *z*-axes whole-body vibration magnitudes measured on cars were 0.144 $m.s^{-2}$ r.m.s. (range, 0.039–0.23 $m.s^{-2}$ r.m.s.) 0.128 $m.s^{-2}$ r.m.s. (range, 0.053–0.241 $m.s^{-2}$ r.m.s.), and 0.390 $m.s^{-2}$ r.m.s. (range, 0.061–1.27 $m.s^{-2}$ r.m.s.). These values are lower than in off-road vehicles and industrial machines (6).

There are no remarkable differences of the seat vibration magnitude with and without passengers. However, these differences become noticeable between older and younger models of the traffic means. The 14TRG models were made approximately fifteen years later than 9TRG.

The combined motion of all three axes could be greater than any one component and could possibly affect vehicle driver performance (1, 7). For predicting human health risk, overall weighted total r.m.s. acceleration may be used. Each frequency-weighted r.m.s. acceleration at the driver seat interface (*x*-, *y*-, and *z*-axes) is used to find the resultant, which is the overall weighted total r.m.s. acceleration, A_{WT}:

$$A_{WT} = \sqrt{(1.4a_x)^2 + (1.4a_y)^2 + (a_z)^2} \qquad (1)$$

The factor of 1.4 is the ratio of the values of the longitudinal and transverse curves of equal response in the most sesitive human response ranges.

Annex B of the IS 2631/1 provides guidance for the assessment of whole-body vibration with respect to health. It applies to people in normal health who are regularly exposed to vibration. It applies to vibrations along the *x*-, *y*-, and z-basicentric axes of the human body. The health guidance caution zone is indicated by dotted lines in Fig. B. 1 of Annex B of the ISO 2631/1. The r.m.s. value of the frequency-weighted acceleration can be compared with the zone shown in Figure B.1 at the duration of the expected daily exposure.

Table 2. **Frequency-weighted r.m.s acceleration ($m.s^{-2}$) magnitude from means of conveyance**

Type of car	Measurement conditions	*x*	*y*	*z*	A_{WT}
9TRG 2-891	1	0.106	0.079	0.119	0.220
	2	0.196	0.241	0.868	0.976
	3	0.111	0.082	0.099	0.217
	4	0.136	0.183	0.679	0.750
	average	0.137	0.146	0.441	0.540
9TRG 1-805	1	0.138	0.098	0.533	0.583
	2	0.312	0.183	1.27	1.37
	3	0.101	0.121	0.353	0.415
	4	0.323	0.211	0.981	1.12
	average	0.218	0.153	0.784	0.872
14TR 2-1035	1	0.113	0.089	0.213	0.245
	2	0.203	0.205	0.556	0.692
	3	0.101	0.099	0.175	0.197
	4	0.211	0.195	0.322	0.515
	average	0.157	0.147	0.316	0.412
14TR 1-1159	1	0.088	0.053	0.108	0.122
	2	0.194	0.126	0.354	0.482
	3	0.102	0.054	0.144	0.166
	4	0.156	0.141	0.361	0.465
	average	0.135	0.093	0.41	0.319
14TR 1-2329	1	0.039	0.029	0.079	0.103
	2	0.111	0.150	0.288	0.393
	3	0.041	0.053	0.061	0.112
	4	0.109	0.183	0.236	0.380
	average	0.075	0.103	0.166	0.247
	grand average	0.144	0.128	0.390	0.467

In this study, the overall weighted total r.m.s. acceleration data were compared with the lower bound of the zone given by equation B.2 in Figure B.1 of the ISO 2631/1, because, although the exact values are given by equation B.2, these values are not given by equation B.1. This study only considered the daily lower vibration dose eVDV = 8.5 $m.s^{-1.75}$, depending on the frequency-weighted acceleration A_{WT} and the daily vibration exposure T. The daily vibration exposure time was calculated by the equation

$$T = (8.5)^4/(1.4)^4 \ . \ (A_{WT})^4 \qquad (2)$$

As is shown in Figure, for half of the seat vibration, it was clear that the drivers of the traffic means cannot work eight hours per day in safe conditions.

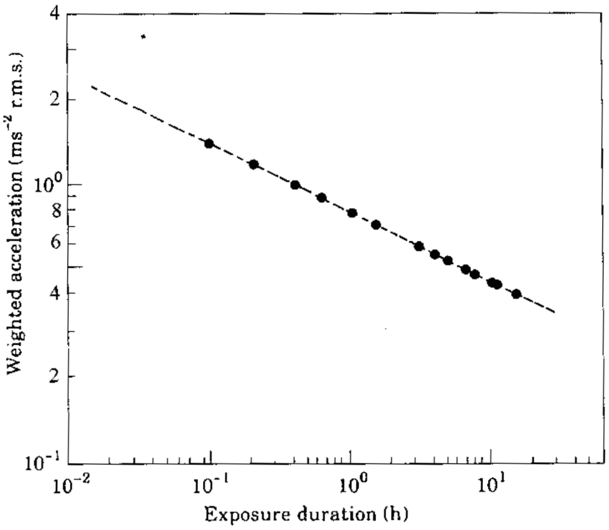

Figure. Comparison of the estimated overall weighted total r.m.s. acceleration A_{WT} values of the trolleybus and the health risk guidance line of the ISO 2631-1 Standard. Key: ●, estimated data; -------, health hazard (eVDV = = 8.5 $m.s^{-1.75}$)

In Latvia, the common operating time of urban traffic drivers is at least seven hours per day. Even though the common daily working time is seven hours, the estimated vibration dose values from the average overall weighted vibration magnitude A_{WT}(eVDV = $1.4A_{WT}T^{1/4}$) in two cases exceed the daily vibration dose eVDV = 8.5 $m.s^{-1.75}$ (9.5 $m.s^{-1.75}$ and 15.4 $m.s^{-1.75}$, both cars model 9TRG). Also, according to the guide to the effect of vibration dose values of the standard BD 6841 (8), it is known that vibration magnitudes and durations that produce vibration dose values in the regions of 10 $m.s^{-1.75}$ will usually cause discomfort. It is reasonable to assume that a longer exposure to vibration will be accompanied by increased risk of health troubles. It is clear that part of urban traffic drivers are exposed to harmful vibration magnitudes. Therefore, new more modern traffic cars and new work-rest schedules for urban traffic drivers should be considered.

CONCLUSIONS

This field study was conducted to evaluate the ergonomic hazards associated with the use of urban traffic cars. One male driver perfomed conveyance work using five different traffic cars. Whole-body vibration measurements and health risk assessments were performed. The study was carried out in accordance with the measurement and health risk assessment outlined in the standard ISO 2631. The following findings were obtained from this study.

1. The grand average *x-*, *y-*, and *z*-axes whole-body vibration magnitudes measured on the driver's seat of traffic cars were 0.144 $m.s^{-2}$ r.m.s. (range, 0.039–0.323 $m.s^{-2}$ r.m.s.), 0.128 $m.s^{-2}$ r.m.s. (range, 0.053–0.241 $m.s^{-2}$ r.m.s.), and 0.390 $m.s^{-2}$ r.m.s. (range, 0.061–1.27 $m.s^{-2}$ r.m.s.), respectively.

2. The estimated vibration dose values of the 9TRG model cars exceeded the daily vibration dose eVDV = 8.5 $m.s^{-1.75}$. Even though the common daily working time is seven hours, it is clear that the drivers should not be allowed to work their seven hours a day under current vibration conditions.

3. It is thus clear that a new more modern cars are required in place of type 9TRG cars, and the work–rest schedules of drivers should be considered.

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VISO KŪNO VIBRACIJA MIESTO TRANSPORTO VAIRUOTOJŲ DARBO METU

S a n t r a u k a

Miesto transporto vairuotojai savo darbe patiria vibraciją, kas sąlygoja sveikatos sutrikimus, ypatingai nugaros juosmens skausmus. Atlikus tyrimus pagal ISO 26B1(1) įvairiuose 5 skirtingų tipų troleibusuose išaiškėjo, kad dalį vairuotojų veikia padidintos rizikos vibracija. Todėl siūloma peržiūrėti vairuotojų darbo trukmę ir senus 9TRG tipo troleibusus pakeisti naujais.

Raktažodžiai: kūno vibracija, vairuotojai, nugaros juosmens skausmai, sveikatos sutrikimai