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ORIGINAL ARTICLE

Survey of Vibration Exposure and Musculoskeletal Disorder of Zahedan City Tractor Drivers by Nordics Questionnaire

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ABSTRACT

Exposure to vibration is the cause of some occupational injuries and diseases. Objective of this study was determination of vibration exposure of tractor drivers and assessment of musculoskeletal disorder. This cross-sectional and descriptive- analytical study was administrated to 95 tractor drivers to census method and measuring induced vibration to the drivers was done in three axis, x, y, and z in tractors with load (10000 liter water), without load, with 10 km/h speed, by the vibration meter instrument "Sevantek". The information related to musculoskeletal disorder was collected by using Nordic questionnaire. Data from both parts was analyzed by using SPSS. In the over load tractor group and with velocity vibration 10km/h, 50% of workers were in the range of reduced comfort boundary, 39.3% in the range of fatigue decreased proficiency boundary and 10.7% in over exposure limit. This results were in the without load tractor group and with the same velocity, 23.8% of people were in the range of reduced comfort boundary, 42.9% in the range of fatigue decreased proficiency boundary and 33.3% in the range of over exposure limit and waist with 56.8% had the greatest rate of pain and ankle with 9.5% had the least amount of pain rate. Using of many tractors in city to displace water and other applications, paying attention to the health of drivers and checking the periodically, is needed.

Keywords: *Vibration, Tractor, Musculoskeletal disorder, Drivers, Iran*

INTRODUCTION

All of the machineries with moving parts, in addition of being noise sources, are considered as vibration sources, too. Among these, motor vehicles such as heavy vehicles, in particular agricultural and road building machineries are some of important vibration sources, that many workers are exposed to the hazard of vibration produced by these machineries.

In America, more than 7 million workers are exposed to the whole body vibration and 1 million workers are exposed to the hand- arm vibration and in Iran, there are many workers exposed to this hazard [1]. White finger disease caused by vibration or hand- arm vibration syndrome is the most common occupational injuries caused by vibration [2]. Various studies about long-term effects of mechanical vibration overall body showed that these vibrations in human body might cause unspecific changes in different parts of organs and systems of the body, such as procreation system in women, sense organs, and blood circulation system [3].

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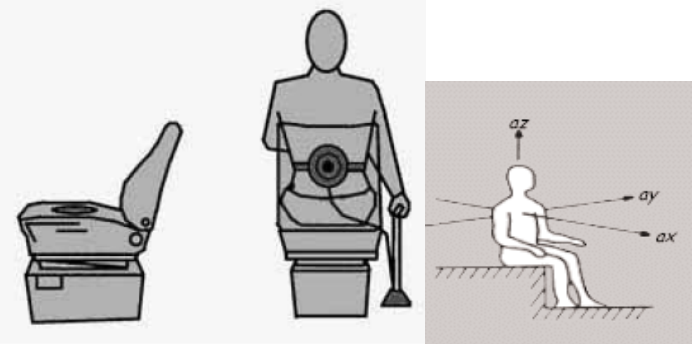

Fig 1. Measurement locations and axes, x, y, and z (for a seated person, the point of entry would be: the seat surface and the seat back–rest)

Fig 2. The view of the SVAN 948 instrument with the seat accelerometer, the preamplifier and the microphone

Different studies were administered to tractor drivers, to measure vibration and investigate vibration effects on the health of the drivers [4-6].

According to the regional and geographical situation, tractor is one of the important conveyances of Zahedan City, eastern Iran, and a great part of transportation, including the transportation of drinking water, displacement of soil, and other building materials in different parts of Zahedan is done by tractor. Thus, many occupiers are exposed to the vibration caused by tractor, that most of them are unaware of its harmful effects. Besides this, people do not pay attention to the repairing and maintenance of tractors, because of their low income and bad economical situation, which this causes increasing of vibration in tractors. In addition, tractors' drivers are mainly people with low education and do not pay attention to their health, which it causes the increase of the effect of vibration on them.

Thus according to the increase of occupiers and the exposure of the whole body of the drivers to vibration, and harmful effects of vibration on human body, this study was conducted in Zahedan City in 2008, for determination of the rate of exposure to vibration and assessment of musculoskeletal disorders of tractor drivers by Nordics questionnaire.

MATERIALS AND METHODS

This descriptive- analytic study was administered to 95 porterage tractor drivers with more than one-year work history. Sampling of derivers was according to census method and for measuring the vibration to the body of drivers, all available porterage tractors of ITM model made by Iran. Tabriz Tractor Manufacturing Company, in Zahedan, was selected. Vibration parameters, such as rms, maximum transient vibration value (MTV-V), and Vibration Dose value (VDV) were measured and assessed in three axes, x, y, and z (according to Fig. 1) randomly by using the vibration meter "Seventek", (Fig. 2). Those subjects with the background of accident, incident, or diseases that cause musculoskeletal disorders were left out of the study. For measuring vibration, the tractors were moving in a specified asphalt track and a particular trailer with 10 km/h speed (Average velocity of tractors with load in Zahedan). Measuring vibration to the body of drivers was done by using standard methods of International Organization for Standardization [7], in tractors with load (10000 liters water), without load, and with 10 km/h. Then data related to vibration measurement was recorded in designed forms, and in later stages, by using the modified Nordics questionnaire, musculoskeletal disorders caused by vibration were assessed and

Table 1. Mean and standard deviation of measured variables of vibration from tractor wheel to hand and arm with the speed of 10 km/h and the state of load

Assessed variable / Measured variable	Tractors with load and the speed of 10 km/h		Tractors without load and the speed of 10 km/h	
	Hand- arm vibration		Hand-arm vibration	
	Mean	Standard deviation	Mean	Standard deviation
Speed (wheel to hand in m/s)	21.6	9.7	28.6	32.3
Acceleration (wheel to hand in m/s^2)	12.2	4.7	23.7	16.7
VDV(m/s)	1.71	0.75	1.77	0.7
MTV-V(m/s^2)	1.36	0.47	1.5	0.52

* Vibration Dose value
* * Maximum transient vibration value

Table 2. Mean and standard deviation of measured variables of vibration to the waist and side of the tractor driver with the speed of 10 km/h and the state of load

Assessed variable / Measured variable	Tractors with load and the speed of 10 km/h		Tractors without load and the speed of 10 km/h	
	Waist and side (Y, X)		Waist and side (Y, X)	
	Mean	Standard deviation	Mean	Standard deviation
VDV*(m/s)	1.87	0.93	3	2.1
MTV-V** (m/s^2)	1.8	0.72	2.4	1.1

* Vibration Dose value
** Maximum transient vibration value

investigated. Data from both parts of vibration measurement and the questionnaire was extracted and analyzed by SPSS software.

RESULTS

The average age of the subjects was 28±10.8 years, the average of their work history 6.2±6.6 years, the average of their height 173±19.7 cm and the average of their weight was 70±15.8 kg.

According to data of Tables 1 and 2, vibration to the whole body and hand-arm of tractor drivers with load and speed of 10 km/h was less than that of the tractor drivers without load and with the same speed. As 50% of drivers with load were in the edge of comfort loss, but this percentage for tractor drivers without load was reduced to 24%, and instead the ratio of drivers in the edge of the reduction of skill and fatigue and above the exposure limit rate for these drivers has increased (Table 3).

According to the results, independent *t*-test was done among vibration averages produced by tractors with and without load with the speed of 10 km/h, and showed that there is a significant level (p=0.04) between the means of effective acceleration (in m/s^2) and between the means of maximum transient vibration value (MTV-V) measured in axes of x and y in both modes, also there is a significant level (p= 0.023) between the measured means of VDV (Vibration Dose Value in m/s) in both situations in axes of x and y, but these correlations were not significant in the mean values of axis z (p> 0.05).

In this study, also the assessment of musculoskeletal disorders was done by Nordics questionnaire, that some of the results of the assessment are summarized in Table 4.

The results showed that among the body organs of tractor drivers, waist with 56.8% had the greatest rate of pain, and elbow with 9.5% had the least amount of pain rate, and chi-square test showed the correlation between pain and the organs significant with p<0.05. Besides, the results showed that 39% of tractor drivers in Zahedan, were employed before 18 years old, that is before the legal age for working as a tractor driver, and now 11.6% of tractor drivers in Zahedan have less than 18 years old.

DISCUSSION

The results of this study indicated that tractor drivers with load complain of the pain in different organs of their body (neck, shoulder, waist, back, elbow, wrist and hand, hips, knee, and ankle), and among these, the most painful organs are waist and back (56.8% waist and 20% back), one or both of the knees (33.4%), shoulder (30%), wrist and hand (29.5%), respectively. It is showed that vibration of whole body is one of the reasons of the pain in waist and back, and different studies are conducted on the pain of organs caused by vibration, that they showed similar results. For example, the study that was administered in Amsterdam University by Hendrick et al. was in this type, in which, after the comparison between the pain in the back of tractor drivers and those who were not tractor drivers, it

Table 3. Frequency percentage of drivers exposed to the whole body vibration in each of the assessed variables, standard ISO-2631-1985) ، ACGIH (1997)

Assessed variable / Standard scale	Tractors with load and the speed of 10 km/h	Tractors without load and the speed of 10 km/h
	Frequency percentage	Frequency percentage
Reduced comfort Boundary	50	23.8
Fatigue-Decreased Proficiency Boundary	39.3	42.9
More than the permissible exposure limit	10.7	33.3

Table 4. Frequency distribution of pain in different organs of the body of porter tractor drivers in Zahedan

Assessed organ	Frequency	Percentage
neck	17	17.9
shoulder	26	30
waist	54	56.8
back	19	20
elbow	9	9.5
Wrist and hand	28	29.5
One or both of the hips	19	20
One or both of the knees	32	33.4
One or both of the feet and ankles	11	11.6

was obvious that tractor drivers had 10% more pain in their back comparing with the control group [8].

In another study in Italy that was administered on 1155 tractor drivers and 220 office workers about the pain in waist, the prevalence of pain in waist in drivers was more than in office workers [9]. The results of another study in India about the effect of vibration on regular pain in back in tractor drivers and non-tractor drivers of farmers indicated that backache in tractor drivers was 56 % but in other farmer drivers who were riding other devices except tractor in farms was 32% [10].

One of the other findings of this study is that tractors with load with the same speed (10 km/h), comparing with tractors without load was producing more vibration acceleration and other measured variables transferring from wheel to the hand. We did not find in our investigations a similar study with the respect of a trailer with or without load, but these findings with the findings of another study that was done on three tractors with different types of Fergusson Copper model 165, Jandier model 3140, and Universal model 651, on asphalt track with two driving speeds of 4.1 and 7.6 km/h by six drivers with weights of 55, 65. 70, 75, 85, and 100 kg while transporting plow instruments in Iran, indicated that with the decrease of the weight of the driver, the average of acceleration vector on the body of these people was increased. As for a driver with 100 kg weight, the average of acceleration vector was 3.3 m/s^2 while for a driver with 55 kg weight; it was 9.8 m/s^2. Comparing of the averages of acceleration on the body of different drivers with universal standards, showed a low level of comfort for these people while driving with tractor [11]; that is with the decrease of weight, there is an increase of acceleration.

The results of this study, in comparison with standard scales of ISO 2631 (1985), show that a high percentage (60%) of people, when driving with tractors without load, are exposed to a vibration more than the exposure limit (5.6 m/s^2). Exposure limit applies to situations where the health and safety of the worker such as back injuries and injuries to internal organs, is of concern. In a study in Finland, the acceleration of vibration from 9 tractors in three axes of x, y, and z was measured while plowing. In all of the cases, the average of vibration in 8 hours exceeded the boundary of tiredness, as vibration acceleration of one-third octave of moment band was 2 to 3 times of the standard level [8]. This result corresponds with the findings of this study that vibration level to 76.2% of tractor drivers without load was more than the boundary of comfort. Fatigue decreased proficiency boundary is applied to situations where maintaining operator efficiency of a vehicle is of concern. The results indicated that among body organs, waist had the most disorder (56.8%), which it can be because of nonergonomic chairs and sudden vibration strikes from the chair of tractor. In addition, prevalence of the pain in knee (33.3%) was high among people, that inappropriate angle of knee while sitting on the chair, not regulated height of the chair, and vibration from moving can be some of the reasons of this prevalence. Like knee, wrist and hand have also a high disorder that hand - arm vibration transferring from the wheel is one of its reasons.

CONCLUSION

According to the obtained results and the available conditions, reduction of the time of exposure, using of soft cushions made from material that eliminate vibration on the chair of the driver and training the driver in order to habituate himself to alternative short-time rest after every 1 hour of driving and holding the wheel properly the driver are suggested to improve state of drivers and decrease the transformed vibration and reduce the damages to drivers and accordingly to decrease the prevalence of musculoskeletal disorders.

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