Health Effects of Long-term Occupational Exposure to Whole Body Vibration: A Study on Drivers of Heavy Motor Vehicles in Iran

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Introduction

Whole-body vibration (WBV) is a form of mechanical vibration transferred to the whole body with the frequency ranging from 2 to 100 HZ.1 Its long term effects mainly affect the musculoskeletal system.2 Exposure to WBV is common in industry. For instance, truck and bus drivers, operators of industrial machineries and miners have intense occupational exposure to WBV. It has been estimated that in the United Kingdom alone nearly 7.2 million males and 1.8 million females are occupationally exposed to WBV.1 Similarly, it has been reported that in the European Union about 40 million workers (more than 30% of the work force) suffer from WBV-induced musculoskeletal disorders.

Reduced visual acuity, gastrointestinal and musculoskeletal disorders, ischemic heart disease, obesity, autonomic nerve dysfunction, prostatitis and decreased peripheral nerve conduction velocity have been reported in male heavy vehicle drivers as a result of exposure to WBV. Additionally, spontaneous abortion and congenital malformations have been observed in the offspring of female motor vehicle drivers.1,4-7 It is estimated that the total expenses of work-related musculoskeletal disorders in Nordic countries is about 2-5% of gross national product.8

Abstract

Background: Drivers of heavy motor vehicles are occupationally exposed to intense whole body vibration (WBV) for several hours per day over their working lifetime. Therefore, they are at risk of WBV-induced occupational disorders. This study aimed to investigate health effects of long-term exposure to whole body vibration among a group of heavy vehicle drivers in Fars province, southwestern Iran.

Methods: Data on vibration-induced health effects were gathered through a checklist specifically devised for this purpose, interview and medical records of 155 male heavy vehicle drivers as well as 70 referent subjects. Signs and symptoms were classified into 6 categories of neuropsychological, gastrointestinal, ocular, auditory and metabolic and cardiovascular disorders.

Results: Symptoms such as neuropsychological, musculoskeletal, metabolic, visual and hearing disorders were significantly more prevalent among drivers than in referent individuals. Additionally, logistic regression analysis revealed that there were statistically significant associations between exposure to WBV and several outcomes.

Conclusion: Findings of the study indicate that long-term occupational exposure to WBV is a risk factor for neuropsychological, musculoskeletal, metabolic, visual and hearing disorders.


Keywords: Health effects, Occupational exposure, Whole body vibration

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Similarly, the annual national cost of musculoskeletal disorders in the United States of America is estimated to be between 45 to 54 billion dollars. Heavy vehicle drivers are exposed to various and complicated vibrations which are transferred to their bodies through different directions. Occupational fatigue, reduced performance and concentration are the direct consequences of working under these conditions, resulting in accidents and injuries. Nearly all clinical symptoms of WBV are related to frequencies below 20 Hertz (Hz). Cyclic forces act over a range of frequencies, typically between 0.5 and 80 Hz in forklift truck (forklift) drivers working in UK industries. Epidemiological studies in the US and Canada have indicated that professional drivers are at high risk of International Standardization Organization (LBP) and various spinal disorders and these symptoms are twice as much prevalent as in a group of unexposed referent population. Dupuis and Zerlett in their study on bus and truck drivers reported high prevalence rates of degenerative spinal changes due to exposure to WBV. In 2010, Massimo Bovenzi and colleagues in a study on professional drivers observed that the prevalence of LBP, intense pain and severe disability was 38.6%, 16.8%, and 14.4%, respectively. Milosevic showed significant changes in the diastolic blood pressure, body temperature and visual accommodation time after long-term exposure to WBV. Furthermore, vertebral disorders, in the cervical, thoracic and lumbar regions, chest pain and stomach complaints have been reported by Rosegger and colleagues among tractor drivers with a history of long-term exposure to WBV. Interestingly, the vibration levels of heavy equipment and machineries coincide with those of sensitive body organs and are higher than the ISO standards and permissible levels of WBV. To the best of the authors’ knowledge, so far, the effects of long term occupational exposure to WBV have not been studied in Iran. Additionally, apart from some case reports, no conclusive epidemiological evidence exists to convincingly demonstrate the possible health effects of long term occupational exposure to WBV. This study was, therefore, undertaken to investigate these issues more thoroughly.

Methods

This was a cross-sectional study in which data were gathered through a checklist designed for this purpose, interview and medical records of male heavy vehicle drivers exposed to WBV. To devise the checklist, the authors conducted a comprehensive search in the literature regarding disorders reported to be associated with exposure to WBV. These were then extracted and classified into 6 categories of neuropsychological, gastrointestinal, ocular, auditory and metabolic and cardiovascular disorders.

The studied population consisted of 155 male heavy vehicle drivers, all of whom had medical records files and were under active surveillance of a private Industrial Medicine Company in Shiraz for their compulsory annual periodic examinations, when the study was conducted in 2015.

Referent group consisted of all clerical staff (70 healthy males) of an industrial plant in Shiraz. They were similar to the exposed group in terms of age and gender. Inclusion criterion was history of at least one year of continuous driving experience for exposed and one year of service for referent individuals; the exclusion criteria included history of pre-existing medical conditions such as low back pain and other musculoskeletal disorders, hearing loss, metabolic disorders, and dyslipidemia. One of the coauthors who is an experienced Occupational Medicine specialist derived the information from the medical records of the drivers.

Chi-square of Fisher’s exact test and independent sample t-test were used to analyze the qualitative (low back pain, gastrointestinal symptoms, etc.) and demographic parameters, respectively. Association between exposure to WBV and different outcomes was evaluated by logistic regression analysis. This study was approved by ethics committee of Shiraz University of Medical Sciences. All subjects voluntarily participated in the study. They filled out an informed consent form before participating in the study. Additionally, they were assured that their medical information will be used solely for the sake of research purposes and will remain confidential.

Logistic regression analysis was used to control the effects of potential confounders. The statistical analyses were performed using SPSS statistical software, version 20.

Results

Demographic characteristics of the studied population are shown in Table 1. Apart from weight, BMI, family size and mean value of cigarettes smoked per day, no significant differences were noted between both groups as far as other variables were concerned. Table 2 displays the prevalence of neuropsychological disorders among the studied population.

As shown in Table 2, neurasthenia, nervousness and impatience were significantly more prevalent in heavy vehicle drivers than in referent subjects (P=0.001, P=0.01 and P=0.01, respectively).

Table 3 displays the prevalence of symptoms of musculoskeletal disorders. LBP, disc herniations, sciatica and muscular fatigue were significantly more common among WBV-exposed subjects than in referent population (P=0.001, P=0.01 and 0.001, respectively).
The prevalence of gastrointestinal disorders is shown in Table 4. Prevalence rates of chronic constipation, heartburn and hemorrhoid were significantly higher among heavy vehicle drivers (P=0.007, P=0.001 and P=0.007, respectively).

Results on the prevalence of metabolic and cardiovascular disorders are presented in Table 5. The prevalence rates of hypertriglyceridemia, overweight, hypercholesterolemia and hypertension were significantly higher among heavy vehicle drivers (P=0.02, P=0.001, P=0.03 and P=0.006, respectively).

The prevalence of visual and hearing disorders is displayed in Table 6. Decreased visual acuity, hearing loss and tinnitus among the exposed individuals were significantly higher than those in the non-exposed individuals (P=0.02, 0.002 and P=0.04, respectively).

Figure 1 illustrates the overall prevalence rates of different WBV-related disorders. As shown, the highest and lowest rates were related to neuropsychological and hearing disorders, respectively.

The association between exposure to WBV and the prevalence of different disorders is displayed in Table 7. Logistic Regression Analysis including independent variables of age, BMI, smoking habits, marital status and years of employment in the model showed that after adjusting for these confounders, there were statistically significant associations between exposure to WBV and the prevalence of all sign and symptoms.

**Discussion**

As shown in Table 1, drivers were, on average, 7 kg heavier than their referent counterparts. This difference which is statistically significant indicates that drivers are more prone to overweight presumably due to the lack of movement and non-sufficient physical activities (P=0.001). Additionally, drivers’ family size was significantly larger than that of the non-exposed individuals (P=0.001). No significant difference was
found between the exposed and non-exposed groups with respect to age, height and length of employment.

According to Table 2, significant differences were noted between the exposed and non-exposed individuals as far as symptoms of neuropsychological disorders such as neurasthenia, nervousness and impatience were concerned. In line with these findings, in some studies, psychological fatigue, irritability and headache have been reported as a result of exposure to WBV. 24

Concerning the symptoms of musculoskeletal disorders, significant differences were noted between the prevalence rate of LBP, muscular fatigue and disc hernitation among the exposed and non-exposed groups (Table 3).

Consistent with this finding, Kumar and colleagues showed that WBV and occupational posture were two crucial causal factors of musculoskeletal disorders. 25 In contrast, Battié MC and colleagues noted that disc degeneration did not differ between occupational drivers and their twin brothers. They also did not identify any overall tendency for greater degeneration or pathology in occupational drivers than their twin brothers.

While the exact reasons of these discrepancies are not known, factors such as differences in the drivers’ age, frequency and intensity of WBV to which they were exposed, length of their exposure to WBV as well as the model of the vehicles they drove may explain, at least in part, these inconsistencies.

Table 4 shows that symptoms of gastrointestinal disorders such as hemorrhoids, heartburn and chronic constipation were significantly more common in drivers than in referent subjects.

Although similar observations have been reported by others, the authors maintain that gastrointestinal disorders may not necessarily be causally linked with WBV and the role of other contributing factors such as irregular sleeping time and shift work should not be neglected in this scenario. 27

Table 5 shows the results of metabolic and cardiovascular disorders. As shown, the prevalence of hypertriglyceridemia, overweight, hypertension and hypercholestrolemia was significantly higher in the exposed group.

Table 6 shows the results of visual and hearing disorders. As shown, the prevalence of decreased visual acuity, cataract, tinnitus and hearing loss was significantly higher in the exposed group.

*Chi square or Fisher’s exact test; P<0.05; † Based on medical records
Diseases are considerably higher among drivers than in the non-exposed individuals. Reduced blood flow to the heart has been reported as a result of exposure to WBV. Vukas and colleagues exposed an isolated rabbit’s heart to WBV with frequencies of 50, 80 and 100 HZ and noticed that as vibration range increases, cardiac output and aortic blood flow decreases.

Table 6 shows that the prevalence of decreased visual acuity, hearing loss and tinnitus is significantly higher among drivers. Reduced visual acuity has been demonstrated as a consequence of exposure to WBV at 5 HZ frequency.

The results of logistic regression analysis (Table 7), where the role of potential confounders was controlled, provided further evidence in favor of a significant causal association between exposure to WBV and the prevalence of symptoms of multi-organ/system disorders.

### Conclusion

The findings of this study provide circumstantial evidence to support the notion that long term exposure to WBV is associated with increased prevalence of neuropsychological, musculoskeletal, gastrointestinal, visual, hearing, metabolic and cardiovascular disorders among heavy vehicle drivers. Engineering (ergonomic interventions and designing appropriate chairs to reduce the drivers’ exposure to WBV), managerial (reduction of exposure time to WBV), and medical controls (early diagnosis of vibration-induced disorders in periodic...
examinations) are recommended to reduce the exposure to WBV and/or to prevent its long term medical and health problems.

This study is subject to a number of limitations. First referent subjects were office staff. Second, quantitative data on drivers’ exposure to WBV are not available. Therefore, additional studies in which both exposed and referent subjects are selected from working populations and their exposure are quantified appropriately are strongly recommended to further substantiate these preliminary observations.

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References


