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Review Article

Could Whole-Body Vibration Lead the Professional Drivers to Fatigue? A Narrative Review

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ABSTRACT

Objective: To evaluate the fatigue in professional drivers due to the Whole-Body Vibration (WBV) in a narrative review.

Methods: Searches were conducted in the PubMed, Embase, Scopus databases, on November 12th, 2020. PICOS strategy method was used to define the main components of the research question. The selected publications showed effects WBV in individuals working drivers of different types of vehicles and its consequences, highlighting the fatigue.

Results: Seven articles were selected during the research process that specifically addressed the findings of reports on "whole-body vibration and professional driver and fatigue". In the answers obtained in the selected articles, it was observed the importance regarding the daily working time and the appropriate level of vibration to which the professional must be submitted.

Conclusion: It is concluded that, in general, in the selected studies, fatigue was reported in the professional drivers and this could be associated with the WBV transmitted to the body of the individual. This is relevant to establish policy of effective reduction of exposure of the WBV to professional drivers. It is considered that there are several limitations in the existing literature that prevent definitive conclusions on the subject and future studies to strengthen the evidence base are recommended.

Keywords: Whole-body vibration; Mechanical vibration; Professional drivers; Fatigue

INTRODUCTION

The field of occupational medicine generally views fatigue as the cumulative effect of one's work parameters [1]. Driver Fatigue (DF) is one of the biggest health and safety concerns in the road transport sector [2,3], reported that DF is present among professional drivers. DF is a serious safety problem that costs many people their lives [4]. Furthermore, [5] consider that DF is a significant contributor to motor vehicle crashes and fatalities, although the exact share of those events attributable to fatigue is not fully understood.

Fatigue is a worrying and undesirable clinical condition that can be characterized by a decline in the physical performance associated with an impairment to perform a task or physical exercise [6,7].

It is possible to consider that fatigue is a critical issue not only for driver safety, but for public safety in general. There are multiple factors that contribute to DF among professional

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drivers, including shiftwork schedules [8], high prevalence of alcohol and substance use [9], extended hours [10], comorbid medical conditions [11], such as pain [12], high prevalence of sleep disturbance [13] and circadian rhythms alterations [14].

Another potential factor that may contribute to health problems would be the Whole-Body Vibration (WBV) due to the transmission of mechanical vibration from the vehicle to the body of the driver [15]. In a systematic review pointed out that most of the selected studies indicated a significant association between WBV and fatigue or sleepiness [5].

WBV is also a clinical intervention, as an exercise [16], that has been used to the management of individual with different diseases [17] or to improve the fitness of trained [18] and untrained [19] individuals.

As pointed out that there are several limitations of the existing literature that preclude definitive conclusions regarding the impact of WBV on the fatigue or sleepiness in professional drivers [5]. Then, the aim of this brief narrative review was to evaluate if WBV could lead the professional drivers to fatigue.

LITERATURE REVIEW

Research question, search strategy

This narrative review aimed to answer the following question: "Could whole-body vibration lead the professional drivers to fatigue?" The PICOS (P:Patients; I:Intervention; C:Comparison; O:Outcomes; S:Studies design) method was used to define the four major components of the research question [20]. P:Professional drivers; I:receiving WBV; C:drivers with fatigue or not; O:improvement of fatigue; S:to be randomized controlled trial, clinical trial, cross-sectional observational, case-control and cohort studies.

Study selection and data extraction

The searches were performed in PubMed, Embase, Scopus databases using the search string "vibration and drivers and fatigue" held on November 12th, 2020.The keywords "vibrations and drivers and fatigue", "randomized controlled trial or clinical trial" were used in the search to find publications related.

All publication found on the databases were exported to a file, and the duplicates were manually removed by the author. Afterwards, four steps were considered in the review. Records were identified in the searched databases (Identification) and two reviewers (LFFS, MASG) individually evaluated the titles and abstracts and exclusion of irrelevant studies was made considering in eligibility criteria (Screening). Appropriated full texts were analyzed for eligibility (Eligibility criteria), and all relevant studies were taking in consideration to be selected to the current systematic review. The no agreements were solved by a third reviewer (ACCO). Gray literature was not considered in the current review.

The same researchers made the data extraction from the included studies. Data regarding study information (author, year, country, type of vehicles, body part committed, WBV assessment method and fatigue outcomes).The articles finally selected were very heterogeneous in vehicles characteristics, standards and measurement methods. It was concluded, therefore, that a narrative review would be more appropriate for this topic. The articles found with the systematic search are included in the narrative review.

Eligibility criteria

Inclusion criteria: This review focused on the link between WBV and drivers (i.e., professional drivers) and fatigue defined above. Only English full texts were included, and no publication date restrictions were defined. Articles that examined the relationship between exposure to WBV and the result related to fatigue only in professional drivers were included. Results included subjective measures of fatigue, including cognitive or visual performance or other physiological fatigue indicators.

Exclusion criteria: Dissertations, book chapters and conference abstracts were not included to guarantee a minimum quality limit based on peer review. Likewise, studies in the literature with the association of vibration with sound and acoustic issues, such as noise, were also excluded. Finally, articles that examined vibration in bridge structures, vibration in machine parts and other types of vibrations that are not related to the vibration that the professional driver's body is exposed to and articles related to attention, wakefulness, that were not related to feeling of fatigue in drivers were excluded.

RESULTS

Figure 1 shows a PRISMA flowchart [21] with the different steps of the current systematic review, showing the number of articles selected, as well as the entire search process. Two hundred and two papers were found from the data bases and a hundred sixty-one were deleted because they were reviews (narrative or systematic or metanalysis), duplicate papers, language different from the English and not-relevant articles. From a forty-one papers, thirty-four papers were excluded because they do not address specifically report findings of about WBV and fatigue in drivers, but in other comorbidities, remaining seven papers reached all the criteria to be included. At the end, a total of seven papers resulted that met all the criteria to be included in this qualitative study.

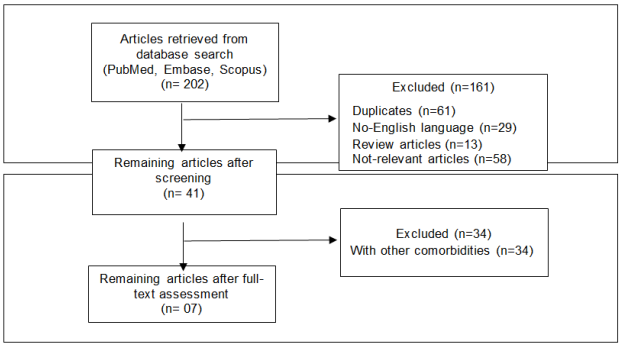

Figure 1: PRISMA flowchart of bibliographic research and its different stages of the process.

Table 1 shows the results according to the selected types of vehicles involved and the specific part of the body most affected

by vibration when driving [22]. Considering the specificities of the populations studied (professional drivers), two publications dealt with tractor drivers, four publications dealt with drivers of vehicles intended for use in the city (for example, cars, buses, vans and trucks) and one publication dealt with a military vehicle driver. In general, in the studies, fatigue was reported in the professional drivers. It is observed that the populations indicated in the publications were studied in different countries (USA, UK, Switzerland, Spain, Korea, Japan and Italy). It is important to consider this finding due to data that can help prevent or control events that may occur because of vibration in professionals worldwide.

Author/ year/ country	Vehicle (type)	body part committed	WBV assessment method	Comparison	Conclusion
Nishiyama et al. [22] (1998/ Japan)	Container tractor trucks	Low back pain (LBP)	Three-axis piezoelectric accelerometer on a semi-rigid pad	A tractor cab suspended by an air spring instead of a steel spring.	The level of WBI has decreased, but not enough to protect drivers from fatigue.
Pope et al. [23] (1988/USA and Sweden)	truck or bus	Low back, neck, and shoulder pain	Accelerometers were attached to the lumbar spine and to a bite bar. Electromyographic studies	Compare a truck seat with a gas spring to the standard spring seat.	A frequency shift toward lower frequencies also has been shown as an effect of fatiguing contractions.
Park et al. [24] (2020/ Korea)	Military vehicle	Trapezius and deltoid muscle	Surface electromyography. A MEMS-type 3-axis accelerometer. 6-DOF exciter was used to simulate the field terrain.	Simulate a vehicle seat in a Lab and compare the vibration.	The muscle fatigue of the subjects was increased after the vibration exposure.
Serrano-Fernández et al.[25] (2019/ Spain)	transport vehicle (Taxi Ambulance Freight)	Musculoskeletal disorders of the extremities	Rating scales	Accidental random sampling.	Reduce the incidence of musculoskeletal problems in professional drivers
Servadio et al.[26] (2007/ Italy)	Agricultural tractor	Driver's discomfort and spinal injury.	A tri-axial piezoelectric accelerometer on the driver's seat.	Driving seat vibrations on forward speed tractors using two types of tires	The performance of both tires is the same as fatigue within the limit of 4 h.
Wilder et al.[27] (1994/ USA)	truck	Low back pain	Acceleration transducers with tri-axial directions. electromyography electrodes	Truck seat with steel spring on its suspension and another gas	More sensitive fatigue measures of seat-driver interactions remain mechanical,
Smith et al.[28] (2015/ United Kingdom)	Vehicles designed for use in the city (e.g. buses, vans)	Right shoulder and lower back	50 minutes of driving WBV simulation. A seven-point scale was used based on Gyi and Porter's body map.	Comparing between an elevated posture seat and a conventional driving posture seat.	Effects of skeletal muscle fatigue for both postures

Table 1: Selected information obtained from the publications analysed.

DISCUSSION

WBV was defined as mechanical vibration delivered in the whole body of the professional driver driving a vehicle. Epidemiological studies have suggested that the WBV is an important risk factor for low back pain and various spinal disorders [23]. Prolonged exposure to WBV can be a decisive factor for specific back disorders. The most frequently reported effects are: Low back pain, early degeneration of the spinal system and herniated lumbar disc [24]. This data is certainly relevant for certain occupations, such as the professional driver [25-29].

The impact of vibration on physical and technical capacity of the drivers may be related to the exposure time, intensity and frequency, as well as the operational and environmental

conditions in which the activity is developed [30,31]. Evidence suggests that WBV exposure time triggers micro and macro impacts in the spine, and presents a clear relationship between the driver's position and the impact of transmission to important areas in the musculoskeletal system that directly compromises the absorption and dissipation of forces [32].

Laboratory studies have shown that exposure to WBV increases physical and mental fatigue, which are common issues professional drivers face [33]. Fatigue reduces driver alertness and increases reaction times, increasing the possibility of an accident [34]. Driver fatigue is a serious safety problem that costs many people their lives [35,36]. Fatigue has been implicated in approximately 35% of all fatal crashes occurring in rural areas and 12% of those in urban areas [37]. Furthermore, it is difficult to quantify the level of driver fatigue due to difficulties in objectively measuring the degree of fatigue involved in a crash [38]. The fatigue that was found in muscles after whole body vibration is indicative of the loads in the muscles [23].

Most workers, while reporting musculoskeletal disorders, only considered those diseases as a limiting factor for work when they are unable to perform their occupational activities. They use the knowledge acquired with the working practice to put them forward in a situation in which they are exposed to risks, such as in the case of WBV exposure [32].

Cab and seat suspensions have been an area of particular interest because of the considerable ride comfort improvements they provide [34]. Studies of the occupational environment reveal that many vehicles subject the worker to levels of vibration greater than that recommended by the International Organization for Standardization [39]. Seat suspensions can modify vehicle vibration environments, if designed and tested with due consideration for the driver who is subject to vibration-induced low back pain [27].Therefore, studies show a direct relationship between the professional driver and the variety of types of vehicles available to work. The vibration emitted by the track extends its effects in the cabin or in the driver's seat, which, depending on the intensity and permanence, make these professionals to develop a fatigue situation with disastrous consequences for your safety and for traffic. This would provide greater well-being and lead to a reduction in sick leave.

Considering the limitations, the findings must be interpreted with caution. Although three well-known databases were used, including more sources of data could have improved the amount of literature included in the review. The same goes for the search terms that, although inclusive, could have provided different results if a broader search strategy were used and therefore not all relevant studies were identified.

In addition, within the included studies, limitations are present in terms of study design and heterogeneity of vehicles for professional activity, driver's age and body mass, type and rigidity of the tire used, lane conditions, high density of traffic and the type of seat used. This heterogeneity makes the comparison among the selected studies and interpretation of WBV effects difficult. Regarding the included trials, they had small sample sizes and heterogeneous samples. Demographic data has not always been described. In addition, excluding publications in other languages than English may have excluded some relevant information.

The strength of this narrative review is related to the presentation of findings about possibility of WBV lead to fatigue of professional drivers. The application would be related to the potential use of the information to avoid that fatigue due to WBV might contribute to driver fatigue.

CONCLUSION

It is concluded that, in general, in the selected studies, fatigue was reported in the professional drivers and this could be associated with the WBV transmitted to the body of the individual. This is relevant to establish policy of effective reduction of exposure of the WBV to professional drivers. It is considered that there are several limitations in the existing literature that prevent definitive conclusions on the subject and future studies to strengthen the evidence base are recommended.

CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

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