Methods for movement analysis of bus drivers for prevention of work-related musculoskeletal disorders: short review

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ABSTRACT
Work-related Musculoskeletal Disorders are usually evaluated by control banding methods as RULA, OWAS, REBA, that although being specially developed to evaluate human movement, have serious limitations concerning reliability. The aim of this study is to review systematically the relevant literature on applicable motion analysis methods to bus drivers. The search was performed based on PRISMA statement methodology. Using a set of key words as driver, human body motion, posture assessment, ergonomic assessment, occupational biomechanics, musculoskeletal disorders, sensor, pose estimation, work movement, task analysis, wearable sensor and xsens, and also exclusion and eligibility criteria to select the most significant articles, 11 studies were found. A review of different approaches for human movement was noted that the simultaneous utilization of the different methods allows achieving better human movement analysis, compared to situations when each one of them was used individually.

KEYWORDS: Body motion tracking; Ergonomic assessment; Occupational biomechanics; Work movement analysis

1. INTRODUCTION

Work-related Musculoskeletal Disorders (WMSD) are considered the third main reason for disability and early retirement in the U.S. and are widespread in many occupations (Peppoloni et al., 2016). Driving as a profession involves routine muscular effort (e.g., steering), awkward sitting postures, and exposure to whole-body vibration. Bus drivers are further exposed to biomechanically strenuous activities (such as bending, and twisting). Thus, the work tasks put drivers at risk for WMSDs and its consequences (fatigue, road accident, sickness absence ...). The prevalence of WMSDs among drivers has been shown between 53% and 91% (Szeto and Lam 2007). Fatigue is accounting for up to 20% of serious casualties on motorways and monotonous roads (Jahangiri et al., 2013).

One of the most important things for prevention of WMSDs is assessing movement to determine what factors can be changed. Research on human action recognition is receiving growing attention in a wide variety of disciplines (Chen, Jafari, & Kehtarnavaz, 2015). Applications of 2-D and 3-D biomechanical models to estimate compressive force on the low back, the strength requirements of jobs, application of guidelines and application of strain index and threshold limit value to address distal upper extremity musculoskeletal disorders were presented (Garg & Kapellusch, 2009). The capabilities of these applications have raised significant interest among researchers aiming to measure postures and body motions in various contexts, from daily activities (e.g. walking, running…) to complex work-related tasks (e.g. climbing, hammering...) and sport biomechanics, clinical purposes, rehabilitation and computer 3D animation.

In this context, this literature review aimed to systematize some of the existing knowledge regarding using different applications for bus drivers. For this purpose, the sensor and video base methods for movement analysis were compared and the results have been analyzed from a methodological and a practical perspective for identifying the best method for bus drivers' movement assessment.

2. MATERIALS AND METHODS

Previous studies indicate that prevalence of the various WMSD domains respectively from high to low prevalence, are low back pain, neck pain, upper back pain, shoulder pain, knee pain, ankle pain, elbow pain, and hip/thigh pain (Abledu, Offei, & Abledu 2014), For this reason, were designed this systematic review in order to non-gait-related and non-invasive body movement analysis tools to try to determine the best of them for movement analysis in bus drivers.

A systematic review of the literature were performed, searching all papers published until 2016 December 10th, with body movement analysis assessed by sensor based systems, excluding those related to gait, clinical purpose , rehabilitation and sport. The research was performed on five databases and scientific journals: Scopus, Medline, Web of science, Springer link and Pubmed between 2007 and 2016. The string used for the search was composed according to the following criteria: (1) At least one of the following words must be present in Title, Abstract or Keywords: "human body motion", "movement analysis", "sensor", "tracking", "posture assessment", "occupational biomechanics", "work related musculoskeletal disorders", "pose estimation", and the roots "ergonomic assessment", "bus driver"; (2) Any of the following words should be present neither Title nor Keywords: "gait", "clinical", "walk", "elderly", "jump", "rehabilitation", "sport", "questionnaires", "Electromyography EMG".

The outcomes of the five databases were merged, taking care to discard the duplicates, into a unique list of documents, excluding all records which were not full papers. The search was limited to English language items. Only scientific journals were considered.

3. RESULTS

Querying the databases resulted respectively in 3857 papers before exclusion criteria. Additionally 33 records were identified through other sources. The total number of papers after exclusion criteria was 621 and after eliminated duplicates was 502. Tacking in to account the selected keywords combinations that allowed greater result were "body motion" and "driver" with 123 and

"posture assessment" and "tracking" with 66. The search result after application of the exclusion and eligibility criteria is presented in Figure1.

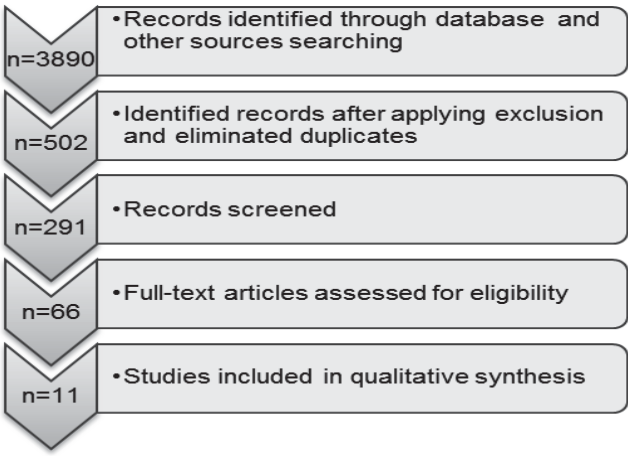

Figure 1 - Flow diagram of included studies

4. DISCUSSION

Prevalence of MSDs in bus drivers:

Neck and Low back: The prevalence of neck and low back musculoskeletal injuries in transit operators has been shown to be high; with work absences exceeding double the National Average (Albert et al. 2014).

Trunk: flexion increased during left turns as drivers needed to lean forward to look through the doors before making a proper left turn.

Shoulder and knee/thigh: neck, back, shoulder and knee/thigh areas had the highest 12-month prevalence rates ranging from 35% to 60%, and about 90% of the discomfort was directly related to bus driving (Szeto and Lam 2007).

Arms: drivers spent a significant percentage of time with arms in flexed and abducted positions (e.g. while holding the steering wheel, opening passengers') (Albert et al. 2014).

Foot: Several drivers mentioned that they had numbness and pain in their right foot due to driving (Albert et al. 2014).

Methodologies: Few comprehensive studies have been conducted in field of movement analysis for bus drivers with sensors or videos. Much of the existing literature in field of occupational safety and health is limited to questionnaire-based studies or observational evaluations of musculoskeletal symptoms. However, in other fields (Computer modeling, Sports, car design) other methods are applied.

Sensors: This systems permit a real-time ergonomic assessment of manual tasks in various environments: hand pose estimating (Kortier et al. 2015); evaluation of human body motion (Valero et al. 2016); assessment of risk for biomechanical load in repetitive efforts (Peppoloni et al. 2016).

Video: The use of marker-less video is simple and doesn't require attaching sensors to the body which often interferes with the job and possibly movement patterns and exertions. This could lower the instrumentation barrier and make routine analysis of upper limb work-related occupational hazards more accessible to general industry (Chen et al. 2013). assessing posture at work with Using Kinect™ sensor that is observational method (Diego-Mas and Alcaide-Marzal 2014). These devices record body positions at high sampling frequency, thus providing accurate and reliable estimates of frequency and duration of risk exposure.

Video and sensor: The pressure on the seat and back rest were analyzed by sensors and video and seat pressure mapping was used to monitor changes in driving posture such as cycles relating to right turn, left turn, passenger stops and driving straight were clipped using video capture software (Albert et al. 2014).

According to the applied methods, different results can be obtained. However, the application of videos requires overcoming problems such as lack of accuracy when the tracked subject is not visible to the camera is sensitive to lighting, illumination changes, background clutter and camera calibration. However video base analysis is cost effective, widely available and it is easy to operate and provides rich texture information (Chen et al. J 2015).

On the other hand the result of sensor base device is sensitive to sensor location on the body and sensor drift and intrusiveness of wearing single or multiple sensors (Chen, et al. 2015). Although they are Cost effective, widely available, have a high sampling rate, Can work in total darkness and can work in unconfined environment.

5. CONCLUSIONS

A review of different approaches for human movement was done and, it was noted that the simultaneous utilization of the different methods allows achieving better human movement analysis, compared to situations when each one of them was used individually.

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