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Macro repositioning movements of pelvis and trunk during simulated driving tasks

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ABSTRACT

Low back pain (LBP)[3] is one of the most important features of discomfort in prolonged sitting postures. This is evidenced by an increase in the number of postural changes called macro-movements. The focus of study was the frequencies of macro repositioning movements in prolonged sitting posture resulting from the perception of discomfort caused by low-back pain. Eighteen (18) drivers performed driving tasks for a period of 90 min. The results indicate that LBP participants performed more movements (10.52 rep/h), compared to without low back pain participants (8.52 rep/h). However, the latter moved more than expected due to joint macro movements of the pelvis and trunk. LBP subjects generally performed macro-repositioning movements of the trunk only, while without low back pain (WLBP)[4] subjects moved pelvis and trunk simultaneously. Although the WLBP participants moved less than those with LBP symptoms, they applied different movement strategies which should be considered in further research. Finally, the authors also propose that future research should be directed towards determining the influence of these lumbo pelvic movements when provided in a controlled manner, to improve comfort in seats and to help manufactures to offer better ergonomic seats.

Relevance to industry: According to the findings of this study, control of lumbo pelvic movements could be used to improve the design and production of ergonomic seats for driving activities.

1. Introduction

The perceptions of comfort and discomfort differ from each other. While comfort is instantly perceived and is related to the design's esthetic appeal and the sensation of wellbeing experienced, discomfort grows over time and is associated with the accumulation of fatigue that manifests itself as pain (Helander and Zhang, 1997). With regard to pain while seated, Vergara states that low-back pain is the most important feature of discomfort in sitting posture (Vergara and Page, 2002). This is because of the direct relation between the articular loads and the perception of discomfort (Vergara and Page, 2002; de Looze et al., 2003; Karwowski and Marras, 1999). Therefore, given the existence of such a close relation between low-back pain and sitting posture, the analysis of the latter is usually assessed according to the perception of discomfort brought about by low back pain. Although the existent scientific evidence does not show this association itself, in this study is considered that LBP leads to discomfort in prolonged sitting posture.

There are risk factors that cause low back pain to be more common within driver population (Lis et al., 2007; Massaccesi et al., 2003; Polo et al., 2006). The evidence shows that the prevalence of low back pain (LBP) for two weeks is 20.5% (Miyamoto et al., 2008), for one month is 50.3% (Miyamoto et al., 2000), and for a year 72% (Lis et al., 2007). This results in commercial drivers as one of the occupational groups with higher risk of developing low back pain in recent years (Massaccesi et al., 2003; Polo et al., 2006).

If the activity is done in a sitting posture, there are different factors that could increase risk. First, decreasing lumbar curvature and increasing intradiscal compression, the pressure on the ischial tuberosity and soft tissue is high. Second, the sitting posture and

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[3] LBP: Low Back Pain.
[4] WLBP: Without Low Back Pain.

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the symptomatology affect the trunk muscle activation that is necessary for lumbar spine stability (O'Sullivan et al., 2006; O'Sullivan et al., 1997). This is an element to be considered when repositioning is done in a sitting posture. Finally, vibration transmitted from vehicle to the seat is also a risk factor (Lis et al., 2007; El Falou et al., 2003). All these factors can explain discomfort in driving activities.

Thus, studies show that the relation between LBP and discomfort (Lis et al., 2007; Chen et al., 2009; Makhsous et al., 2009) could be explained by the fact that the intradiscal pressure applied during this position is greater than the pressure caused while standing (Callaghan and McGill, 2001; Wilke et al., 1999). Additionally, different research studies indicate that the perception of discomfort caused by LBP increases gradually over time (Vergara and Page, 2002; El Falou et al., 2003; Na et al., 2005; Dunk and Callaghan, 2010; De Carvalho and Callaghan, 2011; Callaghan et al., 2010).

In order to diminish the perception of discomfort over time, postural changes while sitting are often performed as a natural body response (Vergara and Page, 2002; Na et al., 2005; Vergara, 1998). These changes are movements which allow the release of internal loads and provide nutrients to the intervertebral discs in the lumbar area through an influx of fluids from the nucleus pulpous to the vertebral plateaus and vice versa (Adams and Hutton, 1983). It has been demonstrated that lumbar lordosis decreases in sitting posture due to the flexion of the trunk (Wilke et al., 1999), and the resulting compression of the intervertebral discs. The continuation of this posture for a long period of time results in dehydration of the disc and its progressive degeneration. This condition has been showed in the literature as harmful and as a potential for a variety of injury mechanisms (McGill and Brown, 1992; Solomonow, 2004; Keegan and Nebraska, 1953).

On the other hand, when it comes to prolonged sitting posture while driving, there is a severe limitation to the chances of getting such nourishment of the intervertebral discs and, thus, there is a prevalence of LBP in driving tasks (Harrison et al., 2000). The particular limitations of the car seat and activities such as seat belt use and the great visual effort, oblige the driver to maintain a rigid posture offering less possibilities of making significant postural changes, thus, increasing the risk of developing this pathology (Lis et al., Feb 2007).

The literature shows studies about comfortable driving postures (Park et al., 2000; Kyung and Nussbaum, 2008; Kyung et al., 2008) but in these analyses the fatigue associated to prolonged time and the postural changes, had not been evaluated. The majority of research studies dealing with this type of postural changes have explored this issue in office (Makhsous et al., Feb 2009; Fujimaki et al., 2005; Adler, 2007), but not in driving tasks. With respect to this, two postural changes have been found; the macro movements (large movements) and micro movements (very small and fast in motion) (Vergara and Page, 2002; Dunk and Callaghan, 2010). However, driving tasks differ from office tasks in the posture adopted. Generally, the feet do not bear part of the body weight, but are used for pedal control. In addition to this, the sitting posture needs to be maintained to ensure visibility, supervision and handling of controls. Hence, sitting posture during driving tasks is more static, kyphotic and prolonged, which explains why low back pain is more common and severer in drivers than in the rest of the population (Lis et al., 2007; Massaccesi et al., 2003; Miyamoto et al., 2008; Harrison et al., 1999).

There are a limited number of studies related to postural changes on driving activities. Zenk et al. (2012) conducted a study to evaluate "optimal load distribution" according to pressure distribution on the seat and intervertebral disc pressure. Grujicic et al. (2010) used an musculoskeletal computational analysis to predict the relationship between the body and the seat car, they found that both the physical components of seat and fatigue affects the perception of discomfort. However, these findings are not very accurate to real driving activity since the study was not conducted for a prolonged time and the driving task was simulated. Therefore, there was no postural changes assessment. On the other hand, De Carvalho and Callaghan (2011), found that pelvic postures are likely seat dependent and postural changes could be limited to the lumbar spine. In addition Adler (2007), studied the relation between system stress and seating comfort in driving activities. The result of this study showed that long-term seating comfort is the subjective response to the load and it is directly related to system stress. This stress induces behavior modifications. Nevertheless, this study did not obtain information about frequency and postural changes. Therefore, there is no research-based evidence to explain drivers' postural behavior when performing macro-repositioning movements as response to the perceived discomfort from low-back pain.

In addition to this, given the high prevalence of low-back pain among drivers, the authors presumed that this population performs their work activities under extremely difficult conditions. Evidence shows that although macro-repositioning movements are necessary while being seated, further research studies on office tasks indicate that such movements do not reduce the perception of discomfort (Dunk and Callaghan, 2010). Research-based data also indicate that individuals LBP perform macro-repositioning movements within a wider range of motion (RoM) of the lumbar spine during shorter periods of time, which suggests higher speed and greater amplitude. Additionally, this population has a lumbar repositioning deficit towards neutral position (O'Sullivan et al., 2003). In this case, the trunk muscle coactivation needed to maintain spinal stability might increase, and, may lead to an increased risk of suffering from low-back pain due to an augmentation of the intradiscal loads (Marras et al., 2001; Ferguson and Marras, 1997; van Dieen et al., 2003). Therefore, LBP drivers may have higher risks of continuing to develop such pathology.

Taking into account the previous information, it is suggested that there is not a clear understanding of the movements performed to reduce the perception of discomfort caused by low-back pain during sitting posture, and hence, more research into this matter needs to be conducted, particularly, focusing on driving tasks. Moreover, it is necessary to highlight that the research studies analyzing the frequency of movement have been based either on the flexion of the trunk (Dunk and Callaghan, 2010), or on the relation it has with the pelvis in terms of spinal angles (Vergara and Page, 2002), but have failed to consider the macro-repositioning movements from a more systemic perspective.

With the goal of understanding the postural strategies used as a response to prolonged driving tasks, this study was developed to determine the frequencies of the macro-repositioning movements resulting from the perception of discomfort caused by low-back pain.

2. Materials and method

2.1. Ethics approval

This research project was approved by the Ethics Committee of Pontificia Universidad Javeriana (Colombia), according the ethical considerations: the declaration of Helsinki and the report of Belmont for the involvement of humans in research.

2.2. Participants

The study was conducted with 18 participants. Participants were selected through a self-report which allowed the researchers to classify the subjects as suffering from low back pain (LBP), or