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Occupational sitting behaviour and its relationship with back pain – A pilot study

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ABSTRACT

Nowadays, working in an office environment is ubiquitous. At the same time, progressively more people suffer from occupational musculoskeletal disorders. Therefore, the aim of this pilot study was to analyse the influence of back pain on sitting behaviour in the office environment.

A textile pressure mat (64-sensor-matrix) placed on the seat pan was used to identify the adopted sitting positions of 20 office workers by means of random forest classification. Additionally, two standardised questionnaires (Korff, BPI) were used to assess short and long-term back pain in order to divide the subjects into two groups (with and without back pain). Independent t-test indicated that subjects who registered back pain within the last 24 h showed a clear trend towards a more static sitting behaviour. Therefore, the developed sensor system has successfully been introduced to characterise and compare sitting behaviour of subjects with and without back pain.

1. Introduction

Many people in Western industrial nations suffer from back pain, with a prevalence of up to 90% within their lifetime (Airaksinen et al., 2006; Breivik et al., 2006). Chronic low back pain (LBP) has an international prevalence of 23% and is thereby the most common form of chronic pain (Airaksinen et al., 2006; Balague et al., 2012). Numerous psychosocial and physical aspects may be responsible for its development, as well as its progression into a chronic condition (Kröner-Herwig, 2011). However, literature clearly linking causation to any specific factor is lacking. In combination with these aspects, static loading, physical and psychological stress, are additional pressures present in the office environment (Chou and Shekelle, 2010). It therefore comes as no surprise that prolonged static sitting is also thought to be associated with an increased risk of developing musculoskeletal disorders in the back, neck, shoulders, arms and legs (Naqvi, 1994; Winkel and Jorgensen, 1986). However, recent literature reviews (Hartvigsen et al., 2000; Kwon et al., 2011; Lis et al., 2007; Roffey et al., 2010) have failed to find evidence of a causal relationship between sitting and the presence of LBP and therefore concluded that a sedentary lifestyle alone is not able to increase the risk of LBP.

According to May and Lomas (2010), the lack of a connection between sitting and LBP is a result of the insidious nature of back pain, since LBP is a highly multifactorial condition that can hardly be localised precisely. Furthermore, in their systematic review, Kwon et al. (2011) emphasised the difficulty of establishing causation of LBP, but also identified several methodological weaknesses that likely contributed to the inability to find an interrelationship between occupational sitting and LBP. Nevertheless, Lis et al. (2007) suggested that the combination of an awkward sitting position and/or body vibration (as might occur during long-distance driving) with a prolonged static sitting behaviour increases the likelihood of suffering from LBP. Despite controversial discussion in the literature, it is conceivable that discomfort or low levels of comfort caused by unfavourable or un-ergonomic sitting positions, sitting behaviour or working conditions, is able to lead to musculoskeletal complaints such as LBP (Vink and Hallbeck, 2012).

The optimal occupational sitting position and sitting behaviour has been extensively discussed in the literature in recent years. The long-standing doctrine of an ideal sitting position that is "as upright as possible" has been strongly questioned (Marx and Wirth, 1996) and has been slowly replaced by the concept of "Dynamic Sitting",

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where sitting positions are continuously altered (Lueder, 1983; van Dieen et al., 2001). A literature review conducted by Pynt et al. (2001) suggests that there is no ideal sitting posture. According to these authors, regular movements and a seated posture with preferred lumbar lordosis is essential for preventing LBP. Changing the sitting position is able to alter spinal geometry (Baumgartner et al., 2012; Zemp et al., 2013) as well as to change lumbar disc pressure (Andersson and Ortengren, 1974; Wilke et al., 1999, 2001). Therefore, a dynamic sitting behaviour is able to vary the loading conditions of spinal segments, which induces an effective pump mechanism in the vertebral discs (Grandjean and Hunting, 1977). This mechanism is thought to be critically important for intervertebral disc nutrition as well as resistance against degenerative changes (Krämer, 1973). Therefore, it could be concluded that office workers should move more during their working hours. However, overly frequent movements are maybe also an indication of discomfort and instability, but a suitable range of movement quantity has yet to be established (Graf et al., 1995). On the other hand, recent systematic reviews have indicated that there is no evidence that dynamic sitting alone has a positive effect on the management of LBP (O'Sullivan et al., 2012), but also that dynamic sitting does not significantly alter trunk muscle activity (O'Sullivan et al., 2013). Hence more scientific studies are clearly needed before a full understanding of the possible influences of dynamic sitting on the human body can be gained.

Sitting behaviour has been analysed by means of different methods such as force (Yamada et al., 2009; Zemp et al., 2015a) and pressure distribution sensors (Arnrich et al., 2010; Dunk and Callaghan, 2005; Mota and Picard, 2003), accelerometers (Ryan et al., 2011), optoelectronic motion analysis (Dunk and Callaghan, 2005), human observation (Graf et al., 1995), activity diary (Womersley and May, 2006), video analysis (Womersley and May, 2006), rachimeter (thin and flexible goniometer with a small inclinometer) (Vergara and Page, 2002) as well as actigraphy (Telfer et al., 2009). Previous studies that have investigated pressure mats for classification of sitting position reported accuracies of up to 87.6% (Mota and Picard, 2003) and 98.9% (Kamiya et al., 2008) for dynamic and static assessments respectively. Therefore, pressure distribution measuring systems as well as force sensors integrated within the seat pan and the backrest seem to be an accurate and reliable way of investigating static sitting positions as well as dynamic sitting behaviour (Mutlu et al., 2007; Zemp et al., 2015a). Furthermore, compared to other systems, pressure mats are relatively cheap, easily applicable and have almost no influence on the individual's adopted sitting position (Zemp et al., 2015b), and therefore offer a practical solution for examining a subject's behaviour.

Subjects with LBP or perceived lumbar discomfort have been reported to adopt a more static sitting behaviour with less frequent micro-movements and infrequent but large shifts in posture (O'Sullivan et al., 2012; Telfer et al., 2009; Vergara and Page, 2002). Consequently, subjects with LBP sit for longer periods of time in an uninterrupted sitting position (Womersley and May, 2006).

Since subjects with back pain are known to sit in a less dynamic manner than their more healthy counterparts, a vicious circle can ensue where the frequent movements associated with preserving spinal health are absent. However, we are not aware of any study that has addressed the sitting behaviour of subjects with and without back pain using an objective measuring method, and it remains unclear whether a relationship exists between sitting behaviour and LBP. Therefore, the aim of this pilot study was to lay the foundations for comparing the sitting behaviour of subjects with and without back pain by means of dynamic pressure distribution measurements.

2. Materials and methods

2.1. Measuring system

Sitting behaviour was analysed by means of our in-house developed *SIT-CAT* (Sitting Categorisation Technology). *SIT-CAT* consists of a textile pressure sensor mat (PST04, SensingTex, Barcelona, Spain) with an 8×8 sensor matrix (size 35×35 cm), a data acquisition/transmission unit (SDK DEMO KIT, SensingTex) and a mobile phone (Nexus 5, Google, LG, Seoul, Korea) with an appropriate application to receive as well as to store the pressure data using Bluetooth technology (Fig. 1). The textile pressure mat was laterally fixed using two elastic straps around the seat pan with two Velcro strips fastened around the backrest in order to prevent the pressure mat from sliding during the measurement period. Pressure data were recorded at 5 Hz and a resolution of 12 bits.

2.2. Participants

Twenty complete sitting behaviour data sets of voluntary subjects working in an office chair were recorded each during one working day. All subjects (7 females and 13 males) with an average age of $M = 45$ years (27–57 years), a height of $M = 1.75$ m (1.60–1.89 m) and a weight of $M = 71$ kg (50–105 kg) provided written informed consent to participate in this pilot study, which was approved by the ethics committee of the University of Potsdam (no. 42/2014) and confirmed by the local ethics committee of the ETH Zurich. The measurements were carried out with employees of the Swiss accident insurance company SUVA (Luzern, Switzerland) at their own workplace.

2.3. Experimental design

Prior to the beginning of the working day, the subjects' office chairs were each equipped with *SIT-CAT* (Fig. 1) and the pressure data recording was started. The subjects performed their usual VDU work with a minimal working time of 3 h including a 15-min-break in the morning, with a similar schedule in the afternoon, resulting in a working and measurement time of at least 330 min. After the working day, data acquisition was stopped and calibration measurements for the detection of the sitting positions were performed. To do so, subjects were asked to sit four times in seven different sitting positions (upright, reclined, forward inclined, laterally tilted right/left, crossed legs right over left/left over right; Zemp et al. (2015a)). The examiner started the 1-s calibration measurements after subjects had comfortably adopted the particular sitting position. The subject-specific office chair settings were maintained for both the sitting behaviour as well as the sitting

Fig. 1. Schematic drawing of the *SIT-CAT* sensor system with the textile pressure sensor mat (1), the data acquisition/transmission unit (2) and the mobile phone (3).