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Use of a footrest to reduce low back discomfort development due to prolonged standing

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ABSTRACT

Prolonged standing is common in many occupations and has been associated with low back discomfort (LBD). No recent studies have investigated a footrest as an intervention to reduce LBD associated with prolonged standing. This study investigated the effect of a footrest on LBD and sought to determine if LBD changes were accompanied by changes in muscle fatigue and low back end-range posture and movement. Twenty participants stood for two 2-h trials, one with and one without a footrest. LBD, lumbar erector spinae electromyography, upper lumbar (UL) and lower lumbar (LL) angles were measured. A significant increase in LBD occurred in both conditions but the footrest did not significantly decrease LBD. The only significant finding between conditions was that UL lordosis became more similar to usual standing over time with footrest use. These findings suggest that footrest use may not reduce LBD development and that development of LBD with prolonged standing is unlikely to be due to muscle fatigue or end-range posture mechanisms.

1. Introduction

Standing for prolonged periods of over 30 min to several hours is a common feature of many occupations (Kim et al., 1994). For example, a survey of 4500 Australian workers revealed that 62% were involved with tasks that required standing in one place for prolonged periods (Safe Work Australia, 2011). Similarly, a Canadian survey found that 58% of 9425 workers reported prolonged standing at work (Tissot et al., 2005). Furthermore, there has been a growing trend in office workplaces of changing from sitting workstations to standing desks due to the negative health consequences of sedentary postures (Straker et al., 2016).

However, epidemiological studies have found associations between prolonged standing and substantial adverse health related consequences (Waters and Dick, 2015; Andersen et al., 2007; Coenen et al., 2016) including chronic venous insufficiency, preterm complications, and musculoskeletal symptoms such as low back pain (LBP) (Waters and Dick, 2015; Andersen et al., 2007; McCulloch, 2002). For example, Andersen et al. (2007) found standing for more than 30 min at work to be a strong predictor for LBP development. LBP creates a major burden in many societies (Vos et al., 2015), therefore reducing the impact of occupational risk factors such as prolonged standing should be a priority.

Previous studies have found that 40–64% of individuals exposed to prolonged standing will develop LBP despite having no history of LBP (Nelson-Wong and Callaghan, 2010). Classifying individuals into pain developers and non-pain developers has enabled researchers to detect factors that may be associated with LBP (Nelson-Wong and Callaghan, 2010). Additionally, in order to examine the mechanisms underlying LBP development due to prolonged standing, low back discomfort (LBD) has commonly been assessed in laboratory studies (Waters and Dick, 2015). Based on these studies, several proposed theories have evolved to explain how prolonged standing may cause LBD. Three of the more prominent theories suggest that LBD arises due to muscle fatigue, sustained end-range posture, and/or a lack of postural movement (Tissot et al., 2009; Nelson-Wong et al., 2010; Rahim et al., 2010; Gregory and Callaghan, 2008).

Prolonged standing requires the back extensors to remain active over an extended period of time, potentially leading to muscle fatigue (Rahim et al., 2010). Fatigue may arise from the increased production and accumulation of metabolic wastes that occurs due to prolonged static contraction (Zander et al., 2004). This can result in the muscles becoming hypersensitive and prone to nociceptive activation, thus causing discomfort.

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Prolonged standing may also involve static end-range spinal posture such as excessive lordosis (lumbar extension) which could be another possible mechanism of LBD development (Gallagher et al., 2014). These postures can lead to increased loading of facet joints, stretch on tissues such as spinal facet joint capsules, and decreased intervertebral foramen space (Gallagher et al., 2014). This theory has received some tentative support from recent studies which together suggested that standing with less lordosis may reduce the development of LBD (Nelson-Wong and Callaghan, 2010; Gallagher et al., 2012).

The third possible mechanism is that a lack of postural movement causes LBD development. When an individual's posture is constrained during standing whereby movement is limited (Gallagher et al., 2014), passive connective tissue creep might occur due to the sustained force, causing tissue lengthening (Caruso and Pleva, 2006). These tissues are sensitive to changes in length and pressure (Cavanaugh, 1995). Over a prolonged period of time stress on these tissues may activate the nociceptive receptors causing LBD (Gregory and Callaghan, 2008). Recently Gallagher et al. (2012). suggested that moving between postures of lumbar flexion and extension during prolonged standing may be another mechanism which can reduce LBD development, lending support to this theory.

Many interventions such as floor mats and shoe insoles have been investigated to address LBD caused by prolonged standing (Nelson-Wong and Callaghan, 2010; Zander et al., 2004; Lin et al., 2012). Recently, Nelson-Wong and Callaghan (2010) found that standing on a sloped platform significantly reduced LBD development and attributed this reduction to decreased end-range lumbar lordosis and increased postural movement. A similar intervention that is able to change lumbar posture during standing is a footrest (Bridger, 2008). To date, few studies have investigated footrest usage as an intervention for prolonged standing (Rys and Konz, 1994; Whistance et al., 1995; Bridger and Orkin, 1992; Mohan et al., 2014). Two of these studies found that using a footrest increased posterior pelvic tilt and prevented end-range lumbar lordosis (Whistance et al., 1995; Bridger and Orkin, 1992). Mohan et al. (2014) also found that footrest usage increased postural sway. However, the studies by Mohan et al. (2014) and Whistance et al. (1995) did not measure prolonged standing, only measuring standing over a 30 s and 10 min duration respectively. Moreover, none of these studies used LBD as an outcome measure; a global comfort rating was utilised rather than specific regional discomfort (Rys and Konz, 1994; Whistance et al., 1995). Hence, the potential of using a footrest to reduce LBD in prolonged standing has not been comprehensively explored.

Given the common occupational exposure and substantial health consequences of prolonged standing, as well as the current gap in the literature regarding the effects of footrest usage, the primary aim of this study was to investigate whether utilising a footrest reduces LBD development during standing over a period of 2 h. Furthermore, given that the mechanisms for LBD development during prolonged standing are not well understood, the secondary aim of this study was to investigate these mechanisms by examining if LBD development is accompanied by changes in low back muscle fatigue, low back end-range posture and low back postural movement.

2. Materials and methods

2.1. Participants

A convenience sample of 20 adults was recruited through personal and professional networks. Participant age, anthropomorphic, and occupational data are presented in Table 1. Exclusion criteria consisted of self-reported ongoing musculoskeletal disorders (LBP, joint disorders), existing cardiovascular conditions, or a history of injury likely to influence LBD.

Table 1
Descriptive statistics of the study sample.

	Males (n = 7)	Females (n = 13)
Age (years)	26.1 ± 11.6	29.2 ± 9.4
Height (cm)	174.1 ± 7.7	164.0 ± 7.6
Weight (kg)	69.1 ± 7.2	64.5 ± 12.1
Occupation		
Sedentary	4	9
Standing	1	3
Physical Work	2	1

Insert about here Table 1. Descriptive statistics of the study sample.

This study was approved by the Human Research Ethics Review Committee, Curtin University (RHS-266-15).

2.2. Study design and procedure

This study used a within-subjects experimental design, assessing two independent variables: 1) standing both with and without a footrest ["Z rest Mk1" Ergolink, Perth, Australia] and 2) time, with repeated measures over a period of 2 h. In the condition with the footrest, participants followed a prescribed standing protocol, switching repeatedly between three postures: having the right foot raised on the footrest, having the left foot raised on the footrest, and having both feet down on the floor (i.e. standing normally) – each for 5 min. Participants were not allowed to lean on the desk and were instructed to use only their forearms and hands for support. For both trials, participants performed self-directed computer activities such as reading documents and internet browsing. The desk height was adjusted to 5 cm below the participant's standing elbow height and the top of the computer screen was adjusted to eye level. The alternate footrest condition 2-h trial was conducted one week after the first, using a randomised order of conditions with the trials occurring at the same time of day on each occasion.

2.3. Dependent variables

2.3.1. Low back discomfort

Low back discomfort was quantified using a computer-administered body map with a visual analogue scale (VAS) with the anchors "no discomfort" on the left and "extreme discomfort" on the right (Summers, 2001). Participants indicated their discomfort along the VAS by drawing a line with the mouse. The files were later printed and the distance between the left anchor and the participant's mark was measured using a ruler and normalised to a 100 mm full scale. LBD was measured 5 times at 0, 30, 60, 90, and 120 min.

Participants were considered 'discomfort developers' if they indicated that their LBD level increased by more than 10/100 with respect to their baseline level. This VAS value was chosen to match prior studies (Nelson-Wong and Callaghan, 2010; Nelson-Wong et al., 2010) and be in line with previous reports which have suggested a minimum clinically significant difference in VAS of 9mm (Kelly, 1998).

2.3.2. Low back muscle fatigue

Muscle fatigue was quantified using the median frequency (MF) and amplitude of the right erector spinae muscle electromyography (EMG). These measures have demonstrated reliability and validity, in both our laboratory (Dankaerts et al., 2004) and previous studies (Kim et al., 1994; Rahim et al., 2010).