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Early static standing is associated with prolonged standing induced low back pain

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ABSTRACT

Previous research points to the lack of movement during prolonged standing as a pre-disposing factor to low back pain (LBP). Such movements could be at the level of the lumbar spine or at the foot–ground interface. The primary purpose of this *in vivo* study was to determine if there were differences in magnitude, region, and frequency of movement patterns between non-pain developers (non-PDs) and standing induced pain developers (PDs). Thirty-two participants reported their LBP development using a visual analog scale over 2-h of prolonged standing. Time-varying lumbar spine kinematics were used to assess the magnitude and frequency of lumbar spine fidgets and shifts. Ground reaction forces were used to assess the magnitude and frequency of whole body weight transfers and anterior–posterior center of pressure movements. Fourteen of 32 participants (43.75%) were categorized as PDs. The first 15 min of standing distinguished the two pain groups, as non-PD performed a higher frequency of lumbar spine flexion/extension fidgets and large body weight transfers. Both of these differences may be pre-disposing factors for transient LBP development, as they both occurred prior to PDs reaching the 10 mm visual analog scale threshold for LBP classification.

1. Introduction

In light of research on the negative health impacts of a sedentary lifestyle (Dunstan et al., 2010; Gardiner et al., 2011; Healy, Matthews, Dunstan, Winkler, & Owen, 2011; Teras, Gapstur, Diver, Birmann, & Patel, 2012) performing tasks while standing has become a targeted workplace intervention. Despite this, research has shown that standing is also related to cardiovascular and musculoskeletal disorders (Waters & Dick, 2015). In both field (Andersen, Haahr, & Frost, 2007; Roelen, Schreuder, Koopmans, & Groothoff, 2008; Tissot, Messing, & Stock, 2009) and lab studies (Gallagher, Campbell, & Callaghan, 2014; Marshall, Patel, & Callaghan, 2011; Nelson-Wong & Callaghan, 2010b), low back pain (LBP) has been found in individuals required to perform prolonged static standing tasks. In a sample of individuals who do not report a low back injury that required them to visit a medical professional or miss three consecutive days of work, at least 40% of participants report LBP within 30–60 min of standing (Gallagher et al., 2014; Marshall et al., 2011; Nelson-Wong & Callaghan, 2010b). This pain is an acute and transient response to standing exposure as it goes away once the task is terminated. A worker who endures such pain daily could also put themselves at risk for future low back problems, as transient prolonged standing induced LBP has been shown to be a predictor of future LBP leading to healthcare involvement (Nelson-Wong & Callaghan,

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2014). A common recommendation is to incorporate movement to break up a prolonged sedentary task (Latouche et al., 2013); however, the definition of movement that could help people with transient prolonged standing induced LBP is unclear since the underlying pain mechanism is unknown. Given the lack of research on how prolonged standing induced LBP pain developers (PDs) and non-PDs move while standing, this study compared the body weight transfers and lumbar spine movement between the two groups.

Previous research points to a lack of movement during standing as a potential predisposing factor for LBP development. Field studies have shown that standing for greater than 30 min predicts LBP status (Andersen et al., 2007) and there is a higher prevalence of LBP reports in those who stand in constrained areas with no freedom to sit compared to those who stand with freedom to sit (Tissot et al., 2009). Higher bilateral gluteus medius co-activation exists in PDs during prolonged standing (Marshall et al., 2011; Nelson-Wong & Callaghan, 2010b; Nelson-Wong, Gregory, Winter, & Callaghan, 2008) whereas non-PDs demonstrated reciprocal firing of the right and left gluteus medius muscles (Nelson-Wong et al., 2008). This co-activation occurs prior to pain development and has been proposed to compensate for an inability to control trunk and abdominal muscles for effective postural control during prolonged standing (Nelson-Wong & Callaghan, 2010b). We originally hypothesized that co-activation may prevent PDs from transferring their weight between their legs; however, weight transfers from one leg to another become more frequent the longer a person stands, independent of pain group (Gallagher, Nelson-Wong, & Callaghan, 2011). Non-PD also utilize a greater range of their lumbar spine motion during both standing and sitting when working at a computer compared to PDs, and the large shift from standing to sitting reduced the self-reported LBP reports of PDs (Gallagher et al., 2014).

In contrast to the lack of movement hypothesis, Gregory and Callaghan (2008) found that when monitoring the first 15 min of standing, a higher number of anterior–posterior center of pressure shifts of two standard deviations in size and the time muscles spent at rest were associated with higher low back discomfort ratings. They hypothesized that a person could (1) move around too much and cause pain, or (2) be aware that they would develop LBP when standing and tried to move around as a pre-emptive strategy (Gregory & Callaghan, 2008). More recent work shows that PDs demonstrate no differences in their fear beliefs prior to prolonged standing (Nelson-Wong & Callaghan, 2010b). A limitation to the study by Gregory and Callaghan (2008) is that only one size of shifts was investigated and the participant only stood on one force plate. If the lack of movement during prolonged standing is a pre-disposing factor to pain development, more information is required to provide advice to workers regarding the size, body region involved, and frequency of movements that they should perform.

During prolonged standing, we can assess body weight transfers and center of pressure movement at the feet – ground interface, or movement at the lumbar spine where the pain develops. In standing, loading and unloading of the lower limbs is a common movement pattern that should allow for relaxation of the muscles in the unloaded limb (Carlsöö, 1961). We previously assessed body weight transfers from one leg to another during prolonged standing (Gallagher et al., 2011); however, we did not separate out different magnitudes of movement between PDs and non-PDs. In order to quantify the types of movement occurring in standing, Duarte and Zatsiorsky (1999) defined three types of center of pressure patterns evident in unconstrained standing (1) fast and large displacement of center of pressure that returns to approximately the same location (fidget), (2) a fast displacement of the center of pressure from one location to another (shift), and (3) a slow continuous displacement (drift). In standing, fidgeting of the center of pressure is the most common pattern, followed by shifting (2–3 times less frequent) and drifting (6 times less frequent) (Duarte, Harvey, & Zatsiorsky, 2000). Assessing weight transfer and center of pressure movements is important because the kinematics of the lower limb alters pelvis and lumbar spine posture (Dolan, Adams, & Hutton, 1988). Similarly, lumbar spine movements can be broken into different patterns based on the categories proposed by Duarte and Zatsiorsky (1999). During sitting, large shifts in lumbar spine posture are a good indicator of low back discomfort and the shifts were larger and faster in the presence of pain, while small movements around a global posture maintained for several minutes are hypothesized to alleviate or prevent pain development by reducing muscular strain (Vergara & Page, 2002). Dunk and Callaghan (2010), who also applied the algorithm by Duarte and Zatsiorsky (1999) to lumbar spine angles during prolonged sitting, found that those who had LBP shifted more frequently and the amplitudes of the movements were 1.5–2.5 times greater in amplitude than those of controls participants. Only one study has assessed lumbar spine movement in standing (Gregory & Callaghan, 2008); however, they did not separate out the size of the movement patterns. As a result, this was the first study to take a comprehensive assessment of weight transfers, center of pressure movements, and the lumbar spine movements to assess the influence of size, body region, and frequency of movements on prolonged standing induced LBP development.

The primary purpose of this study was to determine if differences in the magnitude, region, and frequency of movement patterns exist between prolonged standing PDs and non-PDs. In this study, participants reported their LBP development every 7.5 min during a 2-h prolonged occupational standing simulation. Data from motion capture and two force platforms were continuously collected to provide time-varying kinematics of the lumbar spine and ground reaction forces, respectively. For each variable, we examined different magnitudes of movement and compared movement frequency between pain and non-PDs. Our first hypothesis was that non-PDs would have a higher frequency and magnitude of movement patterns of their lumbar spine, especially the fidgets, and large weight transfers, yet similar frequency and size of small weight transfers and center of pressure movements compared to PDs. Our second hypothesis was that thesis differences would be evident before PD developed LBP.