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Walking breaks can reduce prolonged standing induced low back pain

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ABSTRACT

Standing is commonly recommended to reduce sedentary behavior in the workplace; however, constrained prolonged standing has also been linked to musculoskeletal symptoms, such as low back pain (LBP). Light physical activity breaks, such as walking, may change lumbar spine posture enough to reduce LBP during standing. This study assessed the effectiveness of inserting 5-minute walking breaks every 25 min for reducing prolonged standing-induced LBP development. Nineteen participants completed two bouts of standing lasting 2 h – one with a 5-minute walking break every 25 min and one with no breaks. Pain measures were completed throughout the trial to categorize participants as pain developers (PDs) or non-pain developers (non-PDs). Lumbar region kinematics angle and range of motion were measured continuously. In standing, 58% (11/19) of participants were PDs, compared to just 26% when walking breaks were inserted. Seventy-three percent (8/11) were categorized as non-PDs with walking breaks. Median lumbar flexion increased during walking compared to standing. Lumbar region range of motion in the coronal and transverse planes also increased during walking. The intermittent lumbar flexion may help decrease LBP during prolonged standing. These results demonstrate that walking breaks may help promote lumbar movement and reduce prolonged standing-induced LBP.

1. Introduction

After establishing the link between sedentary behavior to musculoskeletal and cardiovascular disorders (Waters & Dick, 2014), research now focuses on how we can effectively break up these sedentary behaviors that occur during the workday. While intermittent standing is commonly recommended to reduce prolonged sitting (Buckley et al., 2015; Coenen, Gilson, Healy, Dunstan, & Straker, 2017; Davis & Kotowski, 2015), prolonged standing is associated with low back pain (Callaghan, De Carvalho, Gallagher, Karakolis, & Nelson-Wong, 2015; Coenen, Parry, et al., 2017), carotid atherosclerosis (Krause et al., 2000), stroke and transient ischemic attack (Hall et al., 2018), and heart disease (Smith, Mustard, Gilbert-Ouimet, Glazier, & Ma, 2017). Recommending light physical activity, such as walking, is also common (Buckley et al., 2015); however, no current study has assessed its impact on low back pain (LBP). With a focus on prolonged standing, this study looked at the effect of intermittent walking on prolonged standing-induced LBP development.

Field (Andersen, Haahr, & Frost, 2007; Tissot, Messing, & Stock, 2009) and lab-based (Gallagher & Callaghan, 2015; Nelson-Wong & Callaghan, 2010c; Sorensen, Norton, Callaghan, Hwang, & Van Dillen, 2015) studies have demonstrated a relationship between

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prolonged standing and LBP. Mild lumbar flexion, whether through sitting (Gallagher, Campbell, & Callaghan, 2014) or the use of commonly recommended standing aids (Fewster, Gallagher, & Callaghan, 2017; Gallagher & Callaghan, 2016; Gallagher, Sehl, & Callaghan, 2016; Lee, Baker, Coenen, & Straker, 2018; Nelson-Wong & Callaghan, 2010b; Son et al., 2018) demonstrates positive effects on reducing prolonged standing-induced LBP. While these interventions are useful, they still do not promote a dynamic workplace. With the need to reduce both the risk factor of musculoskeletal and cardiovascular disorders, interventions that reduce LBP and promote physical activity would be ideal.

Walking may reduce prolonged standing-induced low back pain by promoting cyclic lumbar intervertebral joint movement. During walking, the lumbar spine performs tri-planar compensatory movements to offset the natural movement of the pelvis to maintain the upright position of the trunk and location of the center of mass. For example, when the iliac crest on the side of the swing leg elevates during walking, the lumbar spine must bend in the contralateral direction to negate this movement, resulting in a lateral bend towards the side of the swing leg (Neumann, 2013). A study that used bone pins inserted from the L1 to S1 vertebrae demonstrated up to 4 degrees of intersegmental movement in the lumbar spine during walking, with the greatest motion occurring in the coronal plane (MacWilliams et al., 2013). While these compensatory movements are small, they may be valuable at creating enough movement in the lumbar spine to negate LBP from prolonged standing.

Walking may also change the basic posture of the lumbar spine compared to prolonged standing. The lumbar spine flexes slightly while walking when compared to standing (Taylor, Goldie, & Evans, 1999). PDs demonstrate more extension of their lumbosacral spine (Gallagher et al., 2016; Sorensen et al., 2015) and lumbar and hip flexion have been shown to reduce pain reports (Gallagher & Callaghan, 2016; Gallagher et al., 2014). As a result, the slight flexion induced by walking may provide a break to the typical extended lumbar posture and reduce this LBP.

The purpose of this study was to determine how breaking up a two-hour prolonged standing task with walking breaks would affect prolonged standing-induced LBP development. Our first hypothesis was that inserting walking breaks into a 2-hour bout of prolonged standing would reduce pain reports in those who develop prolonged standing-induced LBP. Those who did not have prolonged standing-induced LBP would continue to have no pain with intermittent walking breaks. Our second hypothesis was that low back kinematics would differ between the walking and standing trials.

2. Methods

2.1. Participants

Twenty participants between the ages of 18–40 years old with a body mass index between 18 and 35 kg/m^2 were recruited to participate in this study. Volunteers were excluded from participating if they had a previous lumbar region injury that required a visit to a medical professional or off of work/school for more than three days, prior history of lower limb cardiovascular issues, an allergy to rubbing alcohol, or a history of fainting or dizziness. None of the participants had jobs that required prolonged standing. One participant was removed from the data analysis because they sat during the walking break trial; therefore, only 19 participants were used in the study (Table 1). The Institutional Review Board at the University of Arkansas approved study and informed consent procedures. All participants provided written informed consent before data collection.

2.2. Instrumentation

A 100 mm visual analog scale (VAS) was presented on a piece of paper to assess LBP development. The scale was anchored with a horizontal line on the left with “No pain” and on the right with “worst pain imaginable” and participants placed a vertical line to mark their CURRENT level of pain. Participants reported VAS scores for their low back region when the entered the lab on both trial days, at the start of the two-hour protocol, and every 15 min during the protocol.

A Qualysis motion capture system (Qualysis AB, Göteborg, Sweden) was used to capture passive reflective markers (100 Hz, Fig. 1). Two rigid plates were used to track lumbar region movement– one at the level of L1/L2 and one on the sacrum. The rigid body on the sacrum had a portion that secured to the skin and bent over the participant’s garment waist and stuck out as a fin. A belt could not be used in this instance because of a simultaneous measurement that required access to the femoral artery. Individual reflective markers placed on anatomical landmarks (bilateral ribs, the highest point on the crest of the iliac crest, ASIS, and PSIS) were captured while the participant stood in anatomical position.

2.3. Experimental protocol

The participants came to the Exercise Science Research Center on two occasions separated by at least one week. To ensure that

Table 1
Participant demographics.

	Age (years)	Height (cm)	Mass (kg)
Male (n = 12)	22.3(3.3)	180.3 (8.1)	77.4(9.8)
Female (n = 7)	21.7(1.5)	165.7 (6.2)	60.8(10.5)

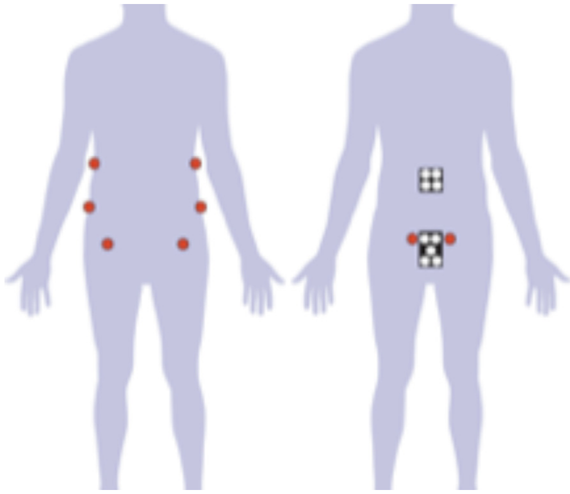

Fig. 1. Marker setup from an anterior (left) and posterior (right) view. Rigid plate markers are in white, and calibration markers are in red. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

participants performed similar activities before the trial, participants came in at the same time of day and day of the week for both lab visits. Informed consent was completed on the first visit. For both visits, participants filled out a VAS to record their pain upon entering the lab. Participants were first instrumented with the reflective markers. The participant stood for 10 s in anatomical position to obtain their natural standing posture and to build the kinematic model.

On the first lab visit, the participant randomly entered one of two trials – prolonged standing only and prolonged standing with four 5-minute walking breaks. During the standing-only trial, participants stood on a treadmill and watched a video on a computer screen for two hours. Participants were instructed to stand as they usually would for an extended amount of time. They were not allowed to lean on the treadmill arms or dashboard, and their feet had to remain on the treadmill belt for the entire time. During the walking trial, the participant stood for 25 min on the treadmill and then the treadmill was turned on. The participant walked for 5 min at 4 km/hr (2.5 mph). This speed was used to represent a leisurely walk. After five minutes, the treadmill was stopped. The participant resumed standing for the next 25-minute block. This was repeated three more times. VAS responses were recorded at 15-minute intervals starting at the very beginning of the trial (0 min).

2.4. Data analysis

Visual analog scales were reported nine times during each lab visit. The VAS scores at the start of the two-hour trial were subtracted from all VAS scores that followed. As a result, all participants began with an initial score of 0 mm. Participants were categorized as PDs based on their low back VAS scores reported during the standing only condition. A threshold of 10 mm above baseline at any point during the trial was used to categorize a participant as a PD (Gallagher & Callaghan, 2015; Marshall, Patel, & Callaghan, 2011; Nelson-Wong & Callaghan, 2010a). The clinically important difference for patients to feel their LBP symptoms worsening is 8 mm (Hagg, Fritzell, Nordwall, & Swedish Lumbar Spine Study, 2003); therefore, 10 mm is chosen as a conservative threshold to use for categorizing participants as PDs.

Marker locations were imported into Visual3D (v5, C-Motion, Inc., Germantown, MD, USA) for post-processing. Segment locations were defined using the individual calibration markers with the participant in anatomical position. A third order polynomial was used to fill any gaps up to a maximum of 0.5 s (50 frames) (Howarth & Callaghan, 2010). The signal was then low pass filtered (Butterworth, second order, dual pass) with an effective cut-off frequency of 6 Hz. The lumbar segment was defined proximally by the rib makers and distally by the iliac crest. The ASIS and PSIS markers defined the pelvis (Fukuchi, Arakaki, Orselli, & Duarte, 2010). The orientation of each local coordinate system had +x pointing laterally to the right (flexion/extension axis), +y pointing anteriorly (lateral bend axis), and +z pointing proximally (axial twist axis), The three-dimensional lumbar region angle was defined as the lumbar segment with respect to the pelvis using a flexion/extension-lateral bend-axial twist rotation sequence. The lumbar region angle from the 10-second standing trial was determined to be 0 degrees. All angles were expressed relative to this posture.

An amplitude probability distribution function (APDF) was used to calculate the median (50th percentile) and range of motion (the difference between the 90th and 10th percentiles) for the flexion/extension, lateral bend, and axial twist joint angles. The APDF was performed to give the median and range for the entire two hours of the standing-only trial (STAND), the standing portion of the walking breaks trial (STAND-W) and collectively for the 20 min of walking (WALK). We initially processed the data by separating the two hours of standing into 20-minute blocks to assess for any changes in our variables over time. No differences were found across time; therefore, we chose to collapse the variables.

Table 2
Pain categorization (n) on standing only and standing with walking breaks trials.

		Standing-Only		
		Non-PD	PD	
Walking Breaks	Non-PD	6	8	total = 14
	PD	2	3	total = 5
		total = 8	total = 11	

2.5. Statistical analysis

All statistical analyses were performed in JMP statistical software (version 13.1). Descriptive statistics were tabulated for the maximum VAS score during each trial. A McNemar test was run on the frequencies of the participants who remained in the same group and changed from PD to non-PD and vice versa (Table 2). A t-test was run to compare the maximum pain scores between PD and non-PD to ensure that participants were not clustered around the 10 mm threshold. The three-dimensional lumbar region median angle and range of motion outcome variables were entered into a two-way analysis of variance with a between factor of pain group (PD/non-PD) and within factor of condition (STAND/STAND-W/WALK). Tukey post-hoc tests using the least square means were used to analyze significant main effects. Simple effects were used to assess significant interactions. The alpha level of significance was set at alpha < 0.05 for all tests. Unless otherwise noted, all values are presented as mean (standard deviation). Effect sizes are presented as Cohen's d when calculating the standardized mean difference between the two pain groups.

3. Results

3.1. Pain reports

Eleven of the 19 participants (58%) exceeded the 10 mm VAS threshold during the two-hours of prolonged standing (Table 2). The maximum VAS score was 4.6 (3.46) mm for the non-PDs and 21.5 (9.3) mm for the PDs ($p < 0.0001$, Hedges' $g = 2.16$)

When walking breaks were inserted, 14 were participants characterized as non-PDs. Eight PDs during the standing-only trial were non-PDs when the walking breaks were inserted (Table 2). Their VAS during the standing-only trial was 22.1 (10.8) mm compared to 6.4 (1.8) mm during the walking break trial. The result of the McNemar test; however, was not significant ($p = 0.0578$).

In five of the participants, the insertion of walking breaks was not successful in reducing or preventing pain reports. Two of the six non-PDs during standing-only were PDs during the walking break trial, and three were PDs in both trials. For these five participants, their maximum VAS during the walking breaks trial was on average 20.8 mm, with a range of 11–44 mm.

3.2. Lumbar region kinematics

There was a significant main effect of condition for the median flexion/extension lumbar region angle ($p < 0.0001$, Table 3). In walking, the lumbar region was more flexed compared to the standing-only day ($p < 0.0001$, $d = 1.54$) and the standing portion of the walking break day ($p < 0.0001$, $d = 1.11$). There was no significant main effect of condition for the median lateral bend ($p = 0.9488$) and axial twist ($p = 0.6786$) angles. There were no main effects or interactions containing pain group.

There was a significant main effect of condition for lumbar region range of motion for all axes. The lateral bend ($p = 0.0023$) and axial twist range ($p = 0.0129$) of motion showed significant differences between the range of motion when standing on the walking break day, and the walking breaks themselves (Table 3). The range of motion was higher in the frontal ($p = 0.0016$, $d = 1.0$) and transverse plane ($p = 0.0099$, $d = 1.1$) when walking compared to standing within the same trial. For flexion/extension, there was no significant difference between the flexion range of motion when walking and when standing on the walking break day ($p = 0.0921$, $d = 0.61$). The range of motion when walking did differ from the standing-only day ($p = 0.0037$, $d = 1.0$). As opposed to the other

Table 3
Average (standard deviation) three-dimensional lumbar region angle median (50th percentile) and range of motion during the three conditions from the amplitude probability distribution functions. The lumbar region angles are expressed with respect to an upright standing trial taken at the beginning of the data collection, which was defined as 0 degrees.

	Median – Degrees			Range of Motion – Degrees		
Condition	Flexion/Extension	Lateral Bend	Axial Twist	Flexion/Extension	Lateral Bend	Axial Twist
Standing Only	−1.0 (3.8)^{A}	−0.3 (1.4)	−0.7 (2.0)	8.0 (2.6)^{A}	4.8 (3.0)^{A,B}	4.9 (4.1)^{A,B}
Standing – Walking Breaks	−2.0 (5.8)^{A}	−0.2 (1.9)	−0.5 (1.8)	7.2 (2.7)^{A,B}	3.6 (2.6)^{A}	3.2 (1.3)^{A}
Walking Breaks	−8.2 (5.5)^{B}	−0.3 (1.8)	−0.2 (2.1)	5.9 (1.4)^{B}	6.1 (2.2)^{B}	6.1 (3.7)^{B}

Notes: For median, a negative angle is flexion, left lateral bend, right axial twist. For each column, cells with different letters denote significant differences between the conditions.

two axes, the range of motion about the flexion axis was less when walking compared to the range of motion during the standing-only trial (Table 3).

4. Discussion

Many people use standing workstations to minimize their sedentary activity over a workday; however, some are also prone to prolonged standing-induced LBP. The purpose of our work was to determine how inserting short walking breaks into a bout of prolonged standing would affect pain reports and lumbar region kinematics. Fifty-eight percent of participants (11/19) developed prolonged standing-induced low back pain without intermittent walking. When walking breaks were inserted, only three of these participants developed low back pain over two hours. Walking resulted in more lumbar region flexion and a greater range of motion. Since walking helped mitigate prolonged standing-induced LBP in many participants, it may be a positive habit to use in combination with exercise (Nelson-Wong & Callaghan, 2010a) or engineering interventions (Fewster et al., 2017; Gallagher & Callaghan, 2016; Gallagher et al., 2016; Lee et al., 2018; Nelson-Wong & Callaghan, 2010b; Son et al., 2018)

The percentage of classified PDs (58%) on level ground in this study is similar to previous work that has reported between 40 and 71% are PDs (Gallagher & Callaghan, 2015; Gallagher et al., 2014; Marshall et al., 2011; Sorensen et al., 2015). Eight of 11 PDs had VAS scores lower than 10 mm when the walking breaks were inserted. These results align with studies that have demonstrated that it is possible to alter prolonged standing-induced LBP development (Gallagher & Callaghan, 2016; Nelson-Wong & Callaghan, 2010a, 2010b). While not statistically significant, altering the pain outcomes of 6 participants to below 10 mm still has clinical implications for the potential to address prolonged standing-induced LBP in the short-term.

Median lumbar flexion increased during walking compared to standing trials, which aligns with previous work (Taylor et al., 1999). Pain developers tend to demonstrate increased lumbopelvic extension during standing (Gallagher et al., 2016; Sorensen et al., 2015) and all beneficial standing aids promote lumbopelvic and hip flexion (Dolan, Adams, & Hutton, 1988; Fewster et al., 2017; Gallagher & Callaghan, 2016; Gallagher et al., 2014; Nelson-Wong & Callaghan, 2010b). As a result, the 20 cumulative minutes of lumbar flexion may have assisted with alleviating pain development over the two hours.

In this study, walking promoted an increase in frontal and transverse plane motion; however, previous results on the benefits of lumbar region movement and decreased transient pain during standing is mixed. Non-PDs show increased sagittal lumbar region movement either at the beginning (Gallagher & Callaghan, 2015) or entire duration (Gallagher & Callaghan, 2016) of a prolonged standing protocol. Commonly used interventions promote changes in sagittal plane posture (Fewster et al., 2017); however, they do not always promote increased lumbar region movement (Gallagher & Callaghan, 2016; Gallagher et al., 2014). General movement within the lumbopelvic region may help reduce prolonged standing-induced LBP; however, effective standing interventions still should promote a change in overall lumbar region posture.

Walking in the workplace is also implemented through dynamic workstations, such as treadmill desks. Previous studies on the effectiveness of treadmill desks have used speeds slower than in our study. Koepp et al. (2013) capped the treadmill speed at 2 miles/hour, and other studies have demonstrated that participants had an average walking speed of about 1 mile/hour (Levine & Miller, 2007; Thompson & Levine, 2011). As a result, it may not be beneficial to use a treadmill desk to alleviate prolonged standing-induced LBP since the range of motion and spinal flexion induced by walking are not as prominent at slower speeds (Callaghan, Patla, & McGill, 1999; Taylor et al., 1999).

This intervention was not favorable for all participants, as five did not see any benefits. Since the mechanism that induces prolonged standing-induced LBP is unknown, it is difficult to determine why a majority of the individuals saw reduced LBP, while these five individuals did not. Pain development during the prolonged standing protocol had an 83% repeatability when participants were tested on two occasions separated by four weeks (Nelson-Wong & Callaghan, 2010d), so it is possible that some participants may have been miscategorized; however, this could also be the same for those who saw differences. Since faster walking speeds demonstrate increased movement and a more flexed posture (Callaghan et al., 1999; Taylor et al., 1999), the speed in the study may not have been fast enough for them to receive any positive benefits and for two participants, it had an adverse effect. Some participants may also benefit more from walking at a self-selected speed or another movement break activity that reduces weight-bearing, such as cycling postures. Alternatively, it could be that for the three participants that became pain developers with the walking breaks, the increased motion of the spine could have resulted in the pain they felt.

Only one stand-walk schedule and walking speed were assessed in this study. We acknowledge that this schedule may not be feasible in all workplaces; however, the purpose of this schedule was to determine if it was possible to influence prolonged standing-induced LBP development. Previous work has shown that implementing an intervention after LBP development may only provide short-term relief. As a result, the schedule was chosen to intervene earlier rather than later into the bout of standing. Previous studies have shown an increased range of motion and a more flexed lumbar region posture when walking speeds increase (Callaghan et al., 1999; Taylor et al., 1999). If we had chosen a faster walking speed, we may have seen more movement and a more flexed spine posture, which could have influenced LBP in those who did not get benefits from walking. Lastly, we only had a small sample size of individual's who did not respond to the walking intervention and therefore could not analyze the potential reasons for being non-responders. Future studies could assess multiple interventions on the same individuals that address changes in posture and movement in different ways to determine if people are consistently successful or if it is intervention specific.

5. Conclusions

Using walking breaks as a method to promote movement during prolonged standing reduced pain reports to below 10 mm in 73%

of prolonged standing-induced LBP developers. While there were no kinematic differences between PDs and non-PDs, walking promoted mild flexion of the lumbar region, which has also been noted in other beneficial standing aids. Walking also promoted an increase in lumbar region range of motion about the coronal and transverse planes. As a result, inserting walking breaks throughout the day as a person begins to address prolonged standing-induced LBP may be beneficial in combination with other exercise and engineering interventions. Since lumbar region posture and movement are influenced by walking speed, future work should address the impact of both fast and slow walking speeds on prolonged standing-induced LBP.

Conflict of interest

The authors have no conflicts of interest to report.

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Appendix A. Supplementary data

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