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The effect of short duration low back vibration on pain developed during prolonged standing

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ABSTRACT

The purpose of this study was to determine if vibration, a potential method of pain management, applied to the low back could alleviate pain developed during prolonged standing. Eighteen healthy individuals participated in a 2.5-h standing task during which vibration (3-min duration) was applied at the 2-h and 2.25-h marks. During the full 2.5 h, participants recorded their perceived pain scores every 15 min using a 10 cm visual analogue scale (VAS). Following each vibration bout, those who developed low back pain (LPB) reported statistically lower VAS scores compared to prior to the vibration; however, when the vibration ceased, LBP returned to pre-vibration levels. It appears that vibration may be an effective method of alleviating LBP caused by prolonged standing; however, the effects seem to be temporary. Further research is needed to investigate the optimal vibration frequency and time period to maximize pain management effectiveness.

1. Introduction

In North America, low back pain (LBP) is one of the most frequent causes for work absences. In Canada, it results in medical expenditures between $6 and $12 billion annually (Busse et al., 2015). Evidence has shown that a 2-h bout of prolonged standing causes LBP in a previously asymptomatic population (Gallagher and Callaghan, 2015; Gallagher et al., 2011; Nelson-Wong et al., 2010; Gregory and Callaghan, 2008). LBP impacts productivity and socioeconomic status if the pain limits the ability to work (Xu et al., 1997). Prolonged standing has also been shown to be associated with potentially negative health outcomes, such as muscle fatigue and discomfort, cardiovascular problems, and issues in pregnancy (Waters and Dick, 2015).

Some of the interventions currently being used to treat LBP during prolonged standing include standing on softer floors, anti-fatigue floor mats, and wearing cushioning in-soles (Waters and Dick, 2015; Aghazadeh et al., 2015). Recent studies have also shown that trunk flexion and standing on a sloped surface may help reduce LBP brought on by standing (Stewart and Gregory, 2016; Nelson-Wong and Callaghan, 2010). Another emerging pain modality is the use of vibration. Currently, vibration is utilized in two ways as a treatment for LBP. The first method is whole body vibration (WBV) through standing on a vibrating platform (Perraton et al., 2011). It is thought that WBV may reduce pain by turning on trunk muscle stretch reflexes, activating and strengthening the abdominal and back extensor muscles, and inducing muscle relaxation, thereby decreasing any muscle spasms in the back (Perraton et al., 2011; Rittweger et al., 2002). The second treatment modality is vibration applied directly to the low back which is typically marketed for the purpose of massage (Imtiyaz et al., 2014). However, based on the gate control theory of pain, it is plausible that such vibration applied via massage devices could help alleviate LBP. It is thought that when vibration is applied directly to the skin, the large afferent nerve fibres are activated and the small afferent nerve fibres are inhibited (Magee et al., 2007). This allows signals to be sent to the spinal cord from the large fibres and not the small fibres, which normally transmit signals of pain. The positive outcome is that less pain is felt (Magee et al., 2007).

Further research into using vibration to reduce LBP during prolonged standing is warranted, as very little scientific evidence to support its use as a treatment modality has been found. The primary purpose of this study was to determine if vibration applied directly to the low back can alleviate LBP developed as a result of prolonged standing. The secondary purpose was to determine if vibration affects movement of the centre of pressure (CoP) at the feet following 2 h of prolonged standing. It was hypothesized that 1) vibration would significantly reduce LBP developed as a result of 2 h of prolonged standing, and 2) vibration would significantly reduce CoP movement at the feet.

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Table 1
Average (standard deviation) characteristics of participants.

	Male (n = 9)	Female (n = 9)
Age (years)	20.1 (2.2)	20.7 (0.87)
Height (m)	1.81 (0.05)	1.64 (0.08)
Weight (kg)	76.0 (8.3)	56.1 (6.2)

2. Methods

Eighteen individuals (Table 1), 9 male and 9 female, participated in this study. Inclusion criteria included being between 18 and 35 years of age, self-assessed as being in good health, and be able to stand for 2.5 h. Exclusion criteria included any prior history of low back or lower limb pain, a low back surgery or any chronic musculoskeletal disorders. This study was approved by the University's Research Ethics Board.

2.1. Protocol overview

Participants visited the lab on one occasion during which they were required to stand on a force plate (4060-PT-1000, Bertec, Columbus, Ohio) for 2.5 h while performing tasks at a standing desk directly in front of them. The height of the desk was adjusted such that the forearms of the participants could comfortably rest on the table top. Participants completed five consecutive 30-min tasks (randomized) resembling jobs that often require prolonged periods of standing: small object assembly, currency sorting, barcode scanning, and typing. Participants were instructed to not lean on the desk in front of them and to remain on the force plate during the collection period; however, participants were allowed to shift their feet on the force plate. Personal athletic footwear was worn by each participant.

Prior to the 2.5 h standing period, each participant was fitted with a vibrating massage belt (Zewa Spa Buddy; 53 Hz vibration; vibration surface was approximately 22 cm long by 18 cm wide by 3.5 cm thick; Fig. 1) underneath their shirt such that the vibration was applied directly to the skin over the lower back. The belt was worn for the entire duration of the study, but was not turned on until the 2-h mark. The vibration was then activated for a 3-min period, followed by a 12-min inactive period, followed by an additional 3-min active period, and a final 12-min inactive period (totaling 30 min; Fig. 2). Participants continued to perform their precision task while the vibration was applied.

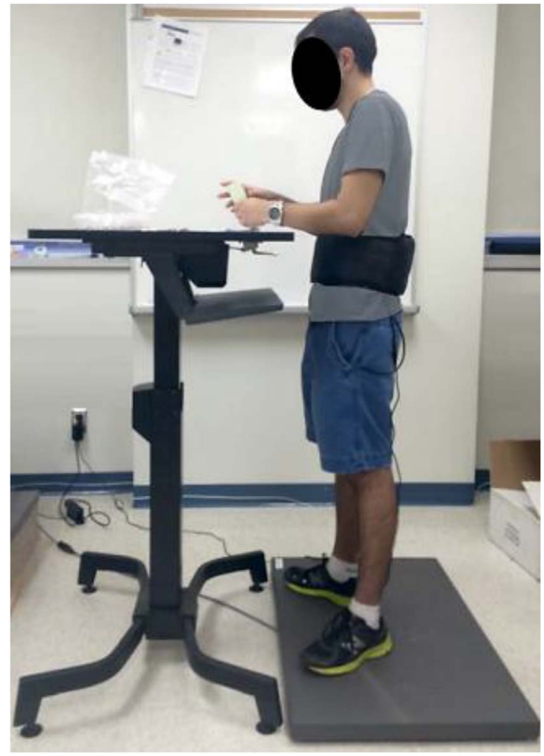

Fig. 1. Image of experimental set-up. Note that in this figure, the belt is over top of the clothes in order to see the location of the belt on the low back. However, for collections, the belt was worn under the clothes against the individual's skin. The vibration motors are only located within the portion of the belt that is up against the low back region and not in the straps of the belt that wrap around to the abdominal region.

2.2. Data collection

Force plate data were sampled at 128 Hz for 3 min at the start of the standing period and then for four additional 3-min periods starting at time (in minutes) 105 (no vibration), 120 (during first bout of vibration), 135 (during second bout of vibration), and 147 min (no vibration). Ratings of perceived pain were obtained using a 10 cm visual analogue scale (VAS) with anchors of no pain and worst pain imaginable. Ratings of perceived pain were completed at the start (0 min) and end of the study (150 min), every 15 min in between, and immediately following each bout of vibration (13 in total) (Fig. 2). Participants rated pain in four body regions: head-neck, upper back, lower back, and legs-feet, as well as their overall pain. Participants also had the opportunity to indicate on the same form if they were feeling any of the following symptoms in their backs: tiredness, soreness, numbness, sharp, dull, tingling, distributed, and localized (de Looze et al., 2003).

2.3. Data analysis

2.3.1. Pain development

Pain intensity was quantified by measuring the distance from the origin (0 cm) to the participant's mark on the 10 cm VAS scale; the greater the distance measured, the more intense the pain. From these VAS values, participants were separated into two groups: those who developed pain during the first 2 h of the standing protocol and those who did not. Those who reported at least 1 cm of LBP at any point during the first 2 h of standing were classified as pain developers. Those who never reached a VAS of 1 cm in the low back region during the first 2 h of standing (prior to the application of vibration) were classified as non-pain developers. Further, based on when LBP was recorded, two different groupings were made: Grouping 1 was such that any participant who had a VAS score in the low back region of greater than 1 cm at *any point* during the first 2 h was considered a “mid-point pain developer”. Grouping 2 was such that any participant who had a VAS score in the low back region of greater than 1 cm at the *2-h mark* (regardless of whether or not they had LBP at any other point) was considered an “end-point pain developer”. For example, if a person reported greater than 1 cm pain at the 1.5-h mark, but less than 1 cm pain at the 2-h mark, they would be classified as a mid-point pain developer but not an end-point pain developer. Literature has reported 1 cm to be a clinically significant value for LBP and has been used previously (Gallagher et al., 2011; Nelson-Wong and Callaghan, 2010; Hagan and Albert, 1999). The two different pain developer groupings were used as previous research has typically used the “mid-point pain” methods for grouping; however since the intervention examined in this study was applied to the end of the 2-h standing period, the “end-point pain” method for grouping was also examined. This allowed us to determine if the timing of pain development affected the efficacy of vibration.

2.3.2. Centre of pressure

Force plate data were low-pass filtered at 6 Hz using a second order dual-pass Butterworth filter. The centre of pressure (CoP) at the feet was then determined from these data in order to calculate the following