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Can cutaneous vibration affect pain development? Testing the efficacy of a vibrating belt applied intermittently to the low back region during prolonged standing

Analyssa Cardenas [a], Diane E. Gregory [b, *]

[a] Department of Kinesiology, University of Waterloo, Waterloo, Canada
[b] Department of Kinesiology & Physical Education/Health Sciences, Wilfrid Laurier University, Waterloo, Canada

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ABSTRACT

Standing-induced low back pain (LBP) is becoming more common in the workplace and has been shown to develop in periods of as short as 2 h. The purpose of this study was to determine if vibration, an increasingly popular method of pain relief, applied intermittently (every 15 min) directly to the low back could alleviate pain developed during a 2-h period of standing. Two separate collection days were conducted (order randomized). During the control day, no vibration was applied during the 2 h of standing; on an experimental day, vibration was applied via a vibration belt in 3-min durations every 15 min for 2 h. During both data collections, perceived LBP was collected via a visual analogue scale every 15 min; on the experimental day LBP was collected just prior to and following each vibration bout. Force plate data were also collected to determine centre of pressure changed over time. LBP significantly increased over time on both collection days; however, on the vibration day LBP reported just prior to each vibration bout was significantly higher than that immediately following, suggesting a temporary relief of pain. However, this relief of pain was not sustained as the level of perceived LBP at the end of the 2 h on the control day was not significantly different from that on the vibration day. Decreases in anterior-posterior and medial-lateral centre of pressure movement were also observed during each bout of vibration compared to during the control day. In conclusion, while intermittent vibration applied to the low back appears to relieve LBP developed during standing, this relief is temporary.

1. Introduction

Low back pain (LBP) continues to be a prevalent cause of missed work and disability among the developed world (Hoy et al., 2014; Balagué et al., 2012). Typically, manual material handing is thought to be the major contributor of work-related LBP; however recent evidence has shown that sedentary tasks can have negative health impacts (Thorp et al., 2011; Tremblay et al., 2010) and can result in LBP in the case of prolonged sitting (Garcia et al., 2014; Womersley & May 2006; Videman and Battié, 1999) and standing (Coenen et al., 2017; Waters and Dick, 2015; Janwantanakul et al., 2011; Mohseni-Bandpei et al., 2011; Nelson-Wong and Callaghan, 2010a; Gregory and Callaghan, 2008; Andersen et al., 2007; Roelen et al., 2008). While a significant number of ergonomic interventions, primarily related to chair design, have been developed and examined for sitting, less focus has been placed on prolonged standing. The efficacy of a variety of ergonomic interventions including floor type and mats (Aghazadeh et al., 2015; Waters and Dick, 2015), intermittent spinal flexion (Stewart and Gregory, 2016), and standing on a sloped surface (Fewster et al., 2017; Nelson-Wong and Callaghan, 2010a) have been examined, however LBP still remains prevalent, suggesting a need for alternative pain mitigation strategies.

Recently, vibration, administered through whole body vibration (typically by standing on a vibrating platform; Perraton et al., 2011) or through the use of a massage device (Imtiyaz et al., 2014), has become more common for musculoskeletal pain management (Cochrane, 2017; Zafar et al., 2015; Lau and Nosaka, 2011). One possible hypothesis is that vibration inhibits nerve fibres responsible for transmitting pain (Magee et al., 2007). This hypothesis, termed the gate control theory of pain (Melzack and Wall, 1965),

* Corresponding author. Department of Kinesiology & Physical Education, Department of Health Sciences, Wilfrid Laurier University, 75 University Ave West, Waterloo, Ontario, N2L 3C5, Canada.
E-mail address: dgregory@wlu.ca (D.E. Gregory).

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suggests that vibration stimulates the same large diameter peripheral nerve fibres that are activated in response to pain (Melzack and Wall, 1965; Cochrane, 2011; Nanitsos et al., 2009), thereby preventing transmission of pain-related information.

Since prolonged standing has been shown to result in significant levels of LBP in previously asymptomatic populations after as little as 2 h (Stewart and Gregory, 2016; Nelson-Wong and Callaghan, 2010b; Nelson-Wong et al., 2010; Gregory and Callaghan, 2008), it is possible that exposure to low back vibration may help alleviate or reduce LBP in such individuals, providing an alternative mechanism of pain relief. Further, given the increased popularity of sit-stand workstations, the prevalence of prolonged standing is also increasing among many occupations. Therefore, the primary purpose of this study was to determine if intermittent bouts of vibration applied to the low back region through a vibrating massage belt is effective at reducing the level of LBP developed during a 2-h period of standing. The secondary purpose of this study was to determine if vibration alters movement of the centre of pressure (CoP) at the feet during prolonged standing. It was hypothesized that 1) vibration would significantly reduce LBP developed during prolonged standing, and 2) vibration would significantly reduce CoP movement at the feet.

2. Methods

2.1. Participants

A sample of 15 healthy participants (8 female; 7 male) were recruited from a university population (mean (standard deviation) age = 21 years (1.0); height = 1.67 m (0.09); mass = 62.6 kg (9.6)). Participants were required to be free of LPB for the previous 12 months and not have suffered from any neurological conditions that could affect balance. Participants were asked to come to the laboratory for testing on two separate days, one week apart, to perform a 2-h standing protocol.

2.2. Study protocol

On the first visit, participants were briefed on the study protocol, given the opportunity to familiarize themselves with the vibration belt device, and asked to review and sign a consent form for the study which had been approved by the University human ethics board. Participants were then instructed to stand for a 2 h period (on a 60 × 90 cm force plate; Bertec, Columbus, Ohio) while performing tasks resembling jobs that often require prolonged periods of standing: small object assembly, currency sorting, barcode scanning, and typing (each performed for 30 min). The desk on which these tasks were performed was set for each participant such that the elbow angle was slightly greater than 90° when the forearms rested on the table. This desk height was the same on both collection days. Leaning on the desk was not permitted, but the forearms were allowed to rest while performing the tasks. Further, individuals were instructed to keep their feet on the force plate but they could shift their weight and/or move their feet within the area of the force plate throughout the collection. Personal athletic footwear was worn by each participant.

Prior to both collection periods, each participant was fitted with a vibrating massage belt (Zewa Spa Buddy; factory setting vibration = 53 Hz) around his/her waist such that the vibration was applied to the lower back and sacrum region. On the control day, the belt was worn for the entire duration of the study, but it was turned off the entire time; on the experimental day, vibration was applied via the belt for 3-min durations every 15 min (total of 8 vibration periods). The order of the control and experimental days were randomized and each collection was completed at approximately the same time of day one week apart.

2.3. Data collection

Ratings of each of perceived LBP, leg/feet pain, and overall pain were recorded using 100 mm visual analogue scales (VAS) with the anchors of *no pain* (0 mm) and *worst pain imaginable* (100 mm). On the control day, ratings of perceived LBP were collected every 15 min during the 2-h standing protocol. On the experimental day, two ratings of perceived LBP were collected every 15 min; one just prior to the start of the 3-min vibration and one immediately following the vibration for a total of 16 ratings (Fig. 1). Participants also had the opportunity, if they wished, to indicate on the same form if they were feeling any of the following pain-related symptoms in their backs: tiredness, soreness, numbness, sharp, dull, tingling, distributed, and localized (de Looze et al., 2003).

Force plate data were recorded on both the control and experimental collection days. On the control day, 3-min periods were recorded just prior to each pain rating. On the experimental day, 3-min periods were recorded just prior to each vibration application (VibOFF) and during each 3-min vibration period (VibON); Fig. 1. Force plate data were sampled at 128 Hz.

2.4. Data analysis

Perceived pain was quantified by measuring the distance from the origin (0 mm) to the participant's mark on the 100 mm VAS; the greater the distance measured, the more intense the pain. Participants were subsequently classified as either LBP developers (reached a low back VAS score of at least 10 mm at any point during the control day standing period) or non-low back pain developers (never reached 10 mm during the control day standing period), as 10 mm has been previously considered a clinically significant level of LBP (Gallagher et al., 2011; Nelson-Wong and Callaghan, 2010a; Hagan and Albert, 1999).

Force plate data were low-pass filtered at 6 Hz using a second order dual-pass Butterworth filter and CoP at the feet was determined. Variables of interest, which were determined for each 3-min force plate collection period, included anterior-posterior (AP) CoP range (CoP_{AP}), medio-lateral (ML) CoP range (CoP_{ML}), AP root mean square (RMS) (CoP_{AP_RMS}), ML RMS (CoP_{ML_RMS}), AP velocity range ($Velocity_{AP}$), ML velocity range ($Velocity_{ML}$), AP velocity RMS ($Velocity_{AP\_RMS}$), ML velocity RMS ($Velocity_{ML\_RMS}$), and cumulative path length (CPL).

2.5. Statistical analysis

Three-way analysis of variance (ANOVA) tests and Tukey post-hoc tests (Statistical Analysis System (SAS) software) were used to examine the effect of vibration exposure (2 levels: control/experimental day (pre-vibration time points)), time point (8 levels; 15 min intervals; the pre vibration VAS scores on the experimental day were compared with the 15 min interval scores on the control day), and LBP classification (2 levels: yes/no) on VAS scores. A separate three-way ANOVA was conducted on only the experimental day data with the following factors: pre/post vibration, time point, and LBP classification on VAS scores. Similar three-way ANOVA statistical analyses were conducted on the aforementioned CoP variables. An alpha level of 0.05 was set as significant.