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Full Length Article

Low back cutaneous vibration and its effect on trunk postural control

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ABSTRACT

The current study investigated the effects of a low back pain (LBP) vibration modality on trunk motor control. Trunk repositioning error and responses to a sudden loading trunk perturbation were evaluated pre- and post-vibration (15 min vibration exposure while sitting on a standard chair) as well as when concurrent cutaneous low back vibration was applied. Only minor effects were observed post-vibration when compared to pre-vibration. However, when vibration was applied at the same time as the sudden trunk perturbations, lumbar erector spinae and external oblique muscles were significantly more delayed in activating following the perturbation. In addition, the resting muscle activation prior to the trunk perturbation was higher in both the back extensor and abdominal muscles when concurrent vibration was applied. These findings suggest that cutaneous low back vibration significantly alters motor control responses and this should be considered before implementing cutaneous vibration as a low back pain management strategy.

1. Introduction

In 2010, low back pain (LBP) was ranked as the greatest contributor to global disability (Hoy et al., 2014) and it affects 84% of the population worldwide at some point during their lifetime (Balagué, Mannion, Pellisé, & Cedraschi, 2012). Diagnosing, treating, and managing those who experience LBP places great financial burden on health care systems (Martin et al., 2009). It is therefore critical to continually expand and advance LBP treatments to alleviate pain to improve these individuals' quality of life as well as reduce healthcare expenses. Research investigating safe, non-pharmacologic pain modality alternatives has led to the production of LBP vibration-based modalities, although typically these are marketed for massage (Imtivaz, Vegar, & Shareef, 2014). Vibration has the potential to reduce pain by inhibiting the sensors that perceive pain stimuli (Kakigi & Shibasaki, 1992). Further, vibration has also been shown to potentially improve trunk neuromuscular control (Boucher, Abboud, Nougarou, Normand, & Descarreaux, 2015), thereby supporting the use of vibration as a LBP treatment. However, the use of vibration as a treatment of LBP pain has been debated (Perraton, Machotka, & Kumar, 2011).

Whole-body vibration exposure, has long been considered a significant risk factor for LBP (Burström, Nilsson, & Wahlström, 2015) and has also been shown to negatively alter proprioception, which can persist even after the vibration stimulus is removed (Cordo, Gurfinkel, Bevan, & Kerr, 1995; Shinohara, 2005; Wierzbicka, Gilhodes, & Roll, 1998)). This is critical because the sensation of muscle lengthening, a consequence of vibration exposure to a muscle, is involved in overall body proprioception and if the feedback is altered or insufficient, perception of one's muscle length and joint position could be affected (Brumagne, Lysens, Swinnen, & Verschueren,

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1999; Roll & Vedel, 1982). Interestingly, when vibration is applied to the whole body, rather than locally to the muscle, improvements in proprioception and joint repositioning have been noted (Fontana, Richardson, & Stanton, 2005). However, this is not how vibration is typically applied through LBP modalities such as vibration/massage belts.

If localized vibration applied through a vibration belt does negatively alter proprioception, it is possible it could also increase the risk of low back injury. Delayed neuromuscular responses to sudden loading have been shown to be significant predictors of low back injury (Cholewicki et al., 2005). If wearing a vibration belt alters proprioception of the trunk, it may also result in delayed muscle responses, thereby increasing an individual's susceptibility to injury.

The purpose of this study was to investigate the effects of low back cutaneous vibration via a LBP vibration-based modality on trunk postural control in healthy individuals. It was hypothesized that participants would demonstrate delayed muscle activation in response to a sudden trunk perturbation and would display greater trunk repositioning error when exposed to low back vibration. If such effects are observed with the use of a vibration belt, its safety as a LBP modality may be questionable.

2. Methods

2.1. Participant sample

Fifteen healthy individuals (7 males and 8 females; aged 22.3 ± 2.76 years, height of 176.19 ± 7.64 cm, and mass of 67.59 ± 9.06 kg) participated in the current study. Participants were excluded if they had experienced LBP for more than three consecutive days in the previous year. Individuals with a previous history of neuromuscular, postural, visual, vestibular, skeletal, intervertebral disc, or musculoskeletal disorder were excluded. All participants read and signed an information consent form, and the study protocol was approved by the University Research Ethics Board.

2.2. Instrumentation

Muscle activity was collected using pre-gelled Ag-AgCl surface EMG electrodes (Ambu Blue Sensor, Denmark) with an inter-electrode distance of 3 cm. To reduce impedance, skin was prepared by shaving and cleaned with 70% isopropyl-rubbing alcohol. Bilaterally, electrodes were positioned on four muscles: rectus abdominis (RA; 3 cm lateral to the umbilicus), lumbar erector spinae (LES; 3 cm lateral to the L3 spinous process), thoracic erector spinae (TES; 5 cm lateral to T9 spinous process), and the external oblique (EO; approx. 15 cm lateral to the umbilicus). A ground electrode was positioned over the left anterior superior iliac spine of the pelvis. All EMG data were amplified and bandpass filtered from 10 to 1000 Hz (Bortex, Calgary, Alberta), converted with a 16-bit A/D board and sampled at 2048 Hz.

Kinematic data were collected with an electromagnetic motion capture system (Liberty, Polhemus, Colchester, Vermont) with sensors positioned over spinous processes L1 and S1 in order to determine lumbar spine posture. Sensors were firmly secured with double-sided tape. All kinematic data were sampled at 32 Hz.

2.3. Experimental protocol

All participants underwent both a control and experimental day (order randomized) which were approximately one week apart from each other. On each day, two maximum voluntary contractions (MVCs) tasks were performed consisting of a Biering-Sorensen resisted back extension (for normalization of the TES and LES) as well as a modified resisted sit-up protocol (for normalization of the RA and EO). Briefly, for the back extensor MVC, participants lay prone on a physiotherapy table while their torso hung off the end. While secured to the table (strap positioned over the calves and around the table), participants then maximally extended (statically) against the resistance of the researcher. For the abdominal MVC, participants sat on the table with their knees and hips bent to 90° and performed maximal static flexion, twist, and lateral bend (consecutively) against resistance.

To assess the trunk postural control, a series of four sudden trunk perturbations and three active trunk-repositioning tests were performed at three separate times on both the control and experimental day: baseline (pre-vibration exposure), post-vibration, and vibration-ON (Fig. 1). On the control day, following the first set of motor control tasks, participants sat on a standard computer chair while wearing the vibration belt (turned OFF) for 15 min. The motor control tasks were then repeated a second time, after which the participants then sat for another 15 min while wearing the vibration belt (turned OFF). A third and final set of motor control tasks were then performed again while wearing the vibration belt (turned OFF). On the experimental day, the same protocol was followed; however during the two 15-min sitting periods, the vibration was turned ON applying cutaneous vibration to the low back at a frequency of 53 Hz (factory setting). During the first two sets of motor control tasks, the belt was worn, but the vibration was turned OFF; however during the last set (after the second 15 min vibration period), the motor control tasks were performed while vibration was concurrently applied to the low back (Fig. 1).

2.3.1. Sudden trunk perturbation

To elicit a trunk perturbation, each participant held a container approximately 5 cm away from his/her abdomen. A board was placed in front of the participant's direct line of sight to eliminate visual cues (Fig. 2). The perturbation was elicited by dropping a 6.78 kg weight randomly within a 10 s window from a height of approximately 2 cm into the container held by the participant (Gregory, Brown, & Callaghan, 2008). The onset of each perturbation was determined using an accelerometer secured to the container held by the participants. Pre-perturbation muscle activity, muscle onset latency, post-perturbation muscle activity, and lumbar