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The use of intermittent trunk flexion to alleviate low back pain during prolonged standing

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ABSTRACT

The current study examined of the effect of intermittent, short-term periods of full trunk flexion on the development of low back pain (LBP) during two hours of standing. Sixteen participants completed two 2-h standing protocols, separated by one week. On one day, participants stood statically for 2 h (control day); on the other day participants bent forward to full spine flexion (termed flexion trials) to elicit the flexion relaxation (FR) phenomenon for 5 s every 15 min (experimental day). The order of the control and experimental day was randomized. During both protocols, participants reported LBP using a 100 mm visual analogue scale every 15 min. During the flexion trials, lumbar spine posture, erector spinae and gluteus medius muscle activation was monitored. Ultimately, intermittent trunk flexion reduced LBP by 36% (10 mm) at the end of a 2-h period of standing. Further, erector spinae and gluteus medius muscle quietening during FR was observed in 91% and 65% of the flexion trials respectively, indicating that periods of rest did occurred possibly contributing to the reduction in LBP observed. Since flexion periods do not require any aids, they can be performed in most workplaces thereby increasing applicability.

1. Introduction

Low back pain (LBP) is a common, chronic and recurrent condition that affects approximately eighty-five percent of Canadians (Cassidy et al., 2005) with the highest incidence occurring between the ages of 30–50 years old (Hoy et al., 2010). Further, LBP has been found to be strongly associated with static postures related to a sedentary lifestyle such as standing (Janwantanakul et al., 2011; Mohseni-Bandpei et al., 2011). Occupations such as assembly-line workers, bank tellers and grocery store cashiers along with various other professions, require workers to stand for extended periods of time, increasing the incidence of LBP.

Despite minimal compressive loading of the low back during prolonged standing (Nachemson, 1981), LBP persists. It is hypothesized that individual differences in how a person stands impacts the severity of LBP development during prolonged standing (Gregory and Callaghan, 2008). Further, neuromuscular activity varies between acute LBP developers and non-pain developers during prolonged standing. Greater co-contractions of the gluteus medius (Nelson-Wong et al., 2008) and trunk musculature (Nelson-Wong and Callaghan, 2010a) are found in people who develop acute LBP in comparison to non-pain counterparts. Alterations in muscle recruitment strategies are also found between these two cohorts (Nelson-Wong et al., 2012). Additionally, postural control strategies during standing reflect differences in people who experience LBP and those who do not (Gregory and Callaghan, 2008). Knowledge of neuromuscular and postural control strategies may be helpful in early identification of at-risk LBP populations.

In 1951 Floyd and Silverman identified the flexion relaxation phenomenon (FRP), characterized by back extensor muscle quiescence near peak lumbar flexion. It is theorized that passive tissues (the intervertebral disc and posterior ligaments) take over for the trunk extensor musculature to support the increased moment about the spine during peak flexion. While silencing of the extensor muscles occurs, small amounts of force are still theoretically generated elastically through passive stretching (McGill and Kippers, 1994).

Myoelectric silencing of the back musculature is often absent or reduced in individuals with chronic LBP (Sánchez-Zuriaga et al., 2015; Maroufi et al., 2013; McGorry and Lin, 2012; Mak et al., 2010; Neblett et al., 2003; Mannion et al., 2001; Kaigle et al., 1998; Shirado et al., 1995). Kaigle et al. (1998) identified only a 13% silencing of the lumbar erector spinae muscles in chronic LBP individuals

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as compared to 78% silencing shown by healthy controls. The authors proposed that continuous myoelectric activity in chronic LBP individuals restricts intervertebral motion as a means to stabilize the injured or diseased spine. Likewise, Shirado et al. (1995) found that FRP occurred in 100% of a sample of healthy controls; in contrast, 0% of chronic LBP patients examined experienced FRP at any point during the study (Shirado et al., 1995).

Differing from chronic LBP patients, FRP has been shown to occur in acute LBP participants (Horn and Bishop, 2013; Nelson-Wong et al., 2010). Interestingly, acute pain developers, after prolonged standing, report the desire to flex forward in an attempt to alleviate their pain (Gregory and Callaghan, 2008) despite known findings that flexion can be a risk factor for LBP (Solomonow et al., 2003). Similarly, Dolan et al. (1988) found that individuals tended to commonly adopt postures that result in a flexed spine. It is possible that desired reports to flex forward after prolonged standing may reduce LBP through the onset of FRP, inducing periods of muscle rest. Additional studies have further examined the impact of spine flexion to alleviate/prevent LBP. Nelson-Wong and Callaghan (2010b) found that standing on a sloped surface (eQ Almond, Alberta, Canada) decreased reports of LBP by 59.4%, which has been shown to induce flattening the lumbar spine through posterior rotation of the pelvis and flexion of the lumbar spine and trunk (Gallagher et al., 2013).

It is important to develop methods that alleviate and potentially prevent LBP in order to increase quality of life and the productivity of workers in occupations that demand prolonged standing postures. Therefore, the purpose of this study was to determine if transient trunk flexion would mitigate LBP development induced by prolonged standing in previously asymptomatic individuals (i.e. no pain at the start of a two-hour standing period and no previous history of chronic LBP in the past 12 months). It was expected that the FRP would occur in acute LBP populations, and that FRP would provide transient muscle rests throughout two hours of prolonged standing, in turn decreasing LBP development.

2. Methods

2.1. Participants

A sample population of young adults between 18 and 30 years of age (8 males and 8 females; $N = 16$; university population) were recruited for this study (Table 1). All participants reported having to stand for prolonged periods of time in either previous or current employment opportunities. Participants were excluded from the study if they had experienced chronic LBP in the past 12 months that required them to visit a doctor and/or take time off work. Participants were also asked to refrain from the use of non-steroidal anti-inflammatory drugs for the relief of pain 48 h prior to each collection day. Participants were asked to sign a formal consent form; the university ethics board reviewed and approved the study prior to data collection.

2.2. Experimental design and protocol

Participants were required to stand for two hours on two separate occasions, one week apart. One day was considered the control day during which participants were asked to stand for two continuous hours. On a separate day, the experimental day, maximum trunk flexion was tested as an intervention for LBP development (control and experimental day order was randomized). Two hours of standing was divided into eight 15-min blocks. At the start of the protocol, and after every 15 min, the participants were instructed to bend forward to maximum trunk flexion and then return to upright standing, for a total of nine flexion trials. Each flexion trial was 25 s consisting of five phases: (1) 5 s neutral standing, (2) 5 s flexion phase, (3) maintain full flexion for 5 s, (4) 5 s extension phase, and (5) 5 s standing neutral (Howarth et al., 2013). During the flexion phase, participants were instructed to bend forward as far as they could comfortably, let their arms and upper body hang freely and allow their back to relax fully. Data collections for both protocols were conducted at a similar time of day for each participant to avoid any diurnal effects. Fifty percent of the participants were randomly selected to participate in the morning and the remaining 50% were selected to participate in the afternoon.

Prior to and following each flexion trial, each participant completed a rating of perceived pain scale (RPP) for the lower back. Participants were asked to mark their pain by drawing a vertical line on a 100 mm visual analogue scale, where 0 represented no pain and 100 represented worst pain imaginable. A total of 18 measures were collected on the experimental day. The same RPP scale was used to measure discomfort at the start, end and every 15 min during the protocol of the control day, for a total of nine measures.

To collect electromyography (sEMG) data, pairs of Ag–AgCl electrodes (Ambu Blue Sensor, Denmark) were placed over the lumbar erector spinae (LES) and gluteus medius (GM) (skin surface was shaved if necessary and cleaned with 70% isopropyl rubbing alcohol). The GM muscles were collected in addition to the LES muscles as previous research has shown a strong link between changes in the activation patterns of the GM and low back pain during standing (Nelson-Wong et al., 2008; Gregory and Callaghan, 2008). Since the GM muscle crosses the hip joint and is likely activated during trunk flexion, it was hypothesized that GM activation would also be affected in a similar fashion as the ES muscles during full trunk flexion. Further, it was hypothesized that GM activation would respond differently in those who develop LBP and those who do not. Electrodes were placed 3 cm lateral to L3 spinous process for LES (McGill et al., 1996), and 15 cm inferior and 5 cm posterior to each iliac crest for GM (Gregory and Callaghan, 2008). Additionally, a reference electrode was placed on the left anterior superior iliac spine. Following electrode placement, maximum voluntary contractions (MVC) for each muscle were collected to normalize the sEMG data. A resisted back extension was performed to determine the LES MVC. Participants' lower body was secured to a physiotherapy table with his/her torso suspended over the edge of the table while instructed to extend their torso against resistance. To obtain a GM MVC, participants were instructed to lie on their side opposite to the leg performing the MVC and abduct their leg against resistance. Each MVC was performed for 3–5 s during which verbal encouragement was provided.

All sEMG data were bandpass filtered from 10 to 1000 Hz, amplified (Bortec, Calgary, Alberta) and sampled at 2048 Hz (16-bit, NI USB-6218 BNC, National Instruments, Austin, Texas). Raw sEMG data were full-wave rectified and dual-pass filtered using a fourth-order Butterworth filter with a low-pass cut off of 2.5 Hz to create a linear envelope. The linear enveloped data were further normalized to each MVC performed and down sampled to 32 Hz to coordinate with kinematic data.

To capture lumbar flexion angles during flexion relaxation (FR) onset and cessation, an electromagnetic motion capture system was used (Liberty, Polhemus, Colchester, Vermont). Following

Table 1
Descriptive statistics of participants who completed the study; mean (SE).

	n	Height (cm)	(SE)	Weight (kg)	(SE)	Age (yrs.)	(SE)
Male	8	176.20	1.17	74.32	3.32	22.75	0.93
Female	8	171.13	1.73	66.10	2.22	22.88	0.99