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Original article

Can we reduce the effort of maintaining a neutral sitting posture? A pilot study

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ABSTRACT

Neutral sitting postures encouraging lumbar lordosis have been recommended in the management of sitting-related low back pain (LBP). However, prolonged lordotic sitting postures can be associated with increased fatigue and discomfort. This pilot study investigated whether changing the type of chair used in sitting can reduce the effort of maintaining a neutral sitting posture. The muscle activation of six trunk muscles was recorded using surface electromyography in 12 painfree participants. Participants were facilitated into a neutral sitting posture for 1 min on both a standard backless office chair and a dynamic, forward-inclined chair (Back App). Lumbar multifidus activity was significantly lower on the Back App chair ($p = 0.013$). None of the other five trunk muscles measured demonstrated a significant difference in activity between the chairs. There was no significant difference ($p = 0.108$) in the perceived effort of maintaining the neutral sitting posture on the two chairs. This study suggests that the lumbar multifidus activation required to maintain a neutral sitting posture can be reduced by considering the type of chair used. The mechanism through which the Back App chair reduces lumbar multifidus activation is unclear, but the greatest difference between chairs is the degree of hip flexion. The ability to maintain a neutral lumbar posture with less lumbar multifidus activation is potentially advantageous during prolonged sitting. Further investigations of the effects of chair design on longer duration sitting, and among LBP subjects, are warranted.

1. Introduction

Low back pain (LBP) is a common musculoskeletal disorder (Woolf and Pfleger, 2003), with many different contributing factors including provocative spinal postures (Pynt et al., 2001; Pope et al., 2002; Scannell and McGill, 2003; Lis et al., 2007). While daily sitting duration may not be a major factor in developing LBP (Hartvigsen et al., 2000; Lis et al., 2007; Roffey et al., 2010), sitting is a commonly reported aggravating factor (Williams et al., 1991; O'Sullivan, 2005). Therefore, addressing provocative spinal postures is commonly advocated in LBP management (Poitras et al., 2005).

The habitual sitting posture of some LBP subjects differs to that of matched controls, with both increased (Christie et al., 1995; Vergara and Page, 2002; Dankaerts et al., 2006b; Van Dillen et al., 2009) and decreased (Dankaerts et al., 2006b; Womersley and May, 2006) lordosis reported. Different sitting postures have varying effects on trunk muscle activation and spinal loading (Adams and Hutton, 1985; O'Sullivan et al., 2006a; Claus et al., 2009b), and it remains unclear what constitutes an optimal seated lumbar posture. Lordotic seated postures interspersed with movement are commonly advocated (Williams et al., 1991; Lengsfeld et al., 2000; Womersley and May, 2006; Bettany-Saltikov et al., 2008; Pynt et al., 2008), however lordotic sitting has also been associated with increased discomfort (Lander et al., 1987; Bennett et al., 1989; Vergara and Page, 2002).

It has been proposed that assuming a neutral lumbar spine position of approximately 30% from end-range extension which involves some anterior pelvic tilt and lumbar lordosis with thoracic relaxation, may be preferable to end-range postures for subjects with LBP (O'Sullivan et al., 2010). This would avoid end-range postures associated with increased spinal stiffness (Beach et al., 2005), as well as facilitating low-level trunk muscle activation (O'Sullivan et al., 2006a; Claus et al., 2009b; Reeve and Dilley, 2009). Such a neutral sitting posture is commonly considered an optimal sitting posture by physiotherapists (O'Sullivan et al., 2012). While physiotherapists can consistently facilitate this neutral sitting posture (O'Sullivan et al., 2010), it may be difficult to adopt

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without manual or verbal facilitation (Claus et al., 2009a), questioning its clinical applicability. Consequently, methods which reduce the effort of neutral sitting are worthy of investigation.

Many different chair designs have been advocated in the management of seated LBP. Forward-inclined chairs increase lumbar lordosis closer to that observed in standing (Bennett et al., 1989; Gale et al., 1989). Interestingly, both decreased (Koskelo et al., 2007) and increased (Lander et al., 1987; Bennett et al., 1989) lumbar muscle activation have been reported using these chairs. Dynamic chair designs have also been advocated, with a view to increasing spinal motion (Van Dieen et al., 2001) and altering trunk muscle activation (Gregory et al., 2006; Kingma and van Dieen, 2009). However, most studies suggest dynamic sitting has little effect on trunk muscle activation (McGill et al., 2006; O'Sullivan et al., 2006b) or seated discomfort (Beach et al., 2003; Aota et al., 2007; Lengsfeld et al., 2007). The Back App combines these two approaches, as it involves both a forward-inclined seat and a dynamic base of support. Both the chair height and the degree of motion available can be adjusted. It has the potential to reduce the effort of lordotic sitting, however this has not yet been investigated. Thus this pilot study aimed to investigate whether this dynamic, forward-inclined chair can reduce the effort of maintaining a neutral sitting posture among painfree participants.

2. Methods

2.1. Study design

A single session, repeated measures study. All participants completed the same protocol apart from the order of testing, which they randomly selected from a sealed opaque envelope. Ethical approval was obtained from the local university Research Ethics Committee.

2.2. Participants

Twelve (7F, 5M) pain-free participants were recruited from the local community. All participants provided written informed consent. Participants were aged >18 years, were not pregnant, had no LBP in the last two years, no previous spinal surgery, no current pain medications, had not received previous postural control training, and could speak/understand English. Participants mean(± SD) age was 23.3(±3.6) years, height was 169.5(±5.7) cm, mass was 65.9(±10.2) kg and body mass index was 22.9(±3.2) kg/m^2.

2.3. Instrumentation

2.3.1. Kinematics

Lumbo-pelvic posture was monitored using a wireless posture monitor (BodyGuard, Sels Instruments, Belgium) which incorporates a strain gauge that analyses the relative distance between anatomical landmarks. Posture is expressed as a percentage of strain gauge elongation, so that spinal flexion/extension is expressed relative to lower lumbar range of motion (ROM) (O'Sullivan et al., 2010). Postural data were recorded continuously in real-time at 1 Hz. This posture monitor has very good reliability (O'Sullivan et al., 2011) and validity (O'Sullivan et al., 2012) for the measurement of spinal posture. A strain gauge was positioned over the spinal levels of L3 and S2, since the lower lumbar spine is the most common reported area for LBP (Dankaerts et al., 2006b) and the upper and lower lumbar spine regions demonstrate functional independence (Dankaerts et al., 2006b; Mitchell et al., 2008). The spinal levels of L3 and S2 were identified by manual palpation in a slightly flexed sitting posture. Participants then performed maximal lumbar ROM to ensure the device was securely attached. To calibrate the posture monitor, manual and verbal facilitation were used to guide subjects through full ROM. Subjects were placed into maximum anterior pelvic tilt and lumbar lordosis in sitting which was set as 0% of their lumbar ROM, and then into a fully flexed sitting posture with maximum posterior pelvic tilt, which was set as 100% of their lumbar ROM (O'Sullivan et al., 2010). This was repeated five times, to obtain a representative ROM value.

2.3.2. Trunk muscle activation

The activation of six trunk muscles was analysed using surface electromyography (sEMG). A Motion Lab Systems MA-300 multichannel EMG system (Motion Lab Systems Inc., Baton Rouge, Louisiana, USA) collected sEMG data using bipolar, pre-amplified, circular electrodes 12 mm in diameter, with a fixed inter-electrode distance of 18 mm. The sample rate was 1000 Hz per channel, with a bandwidth of 0–500 Hz, and a gain setting of 2000. The common mode rejection ratio was >100 dB at 60 Hz. Three abdominal and three back muscles of the right hand side of the trunk were analysed, after preliminary testing had demonstrated no significant difference between right and left sides in pain-free participants during such a relatively static task. The skin was prepared for electrode placement by abrading the skin with fine sandpaper, shaving any hair and cleansing the skin with isopropyl alcohol solution to reduce skin impedance, in line with recommendations (Hermens et al., 2000). Pairs of surface electrodes were positioned parallel to the fibre direction of each muscle (O'Sullivan et al., 2006a), and secured with clear adhesive tape. The muscles studied were superficial lumbar multifidus (LM) (L5 level, parallel to a line connecting the PSIS and L1–L2 level); iliocostalis lumborum pars thoracis (ICLT) (L1 level, midway towards the lateral border of the trunk); thoracic erector spinae (TES) (5 cm lateral to T9 level); external oblique (EO) (below the rib cage, along a line connecting the inferior costal margin and the contralateral pubic tubercle); internal oblique (IO) (1 cm medial to the ASIS); and rectus abdominis (RA) (1 cm above umbilicus and 2 cm lateral to midline). A common earth electrode was placed over the ulnar styloid. Good electrode contact was confirmed by visually examining the sEMG output while applying manual resistance. EMG data were normalised to maximum voluntary isometric contraction (MVIC). To generate MVIC for the abdominal muscles, three exercises were used (O'Sullivan et al., 2006a). First, the participant lay supine with their legs straight and strapped with a belt. A resisted curl-up with maximal manual isometric resistance applied symmetrically through their shoulders was used for RA. A resisted crossed curl-up, with the right shoulder moving towards the left and maximal manual isometric resistance applied through the right shoulder was used for EO. For IO, the same procedure was repeated on the opposite side. One exercise was used for all back muscles (O'Sullivan et al., 2006a). The participant was positioned prone, legs straight, and strapped with a belt. The participant, with their hands behind their neck, lifted their head, shoulders and elbows off the examination table and symmetrical maximal manual resistance was provided to their scapular region. To avoid fatigue, contraction time for all MVIC trials was 5 s (Soderberg and Knutson, 2000) with a 3 min rest between trials (McLean et al., 2003). The middle 3 s of EMG data, from the 5-s testing period, were analysed. The highest contraction from any of the abdominal tests was taken as the MVIC for each abdominal muscle, and the highest generated MVIC from three repetitions of the back muscle test was taken for each back muscle (O'Sullivan et al., 2006b).

2.3.3. Chairs

The Back App facilitates dynamic sitting in multiple planes through an unstable ball positioned at its base (Fig. 1), whose