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Original article

Lumbar repositioning error in sitting: Healthy controls versus people with sitting-related non-specific chronic low back pain (flexion pattern)

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ABSTRACT

Studies examining repositioning error (RE) in non-specific chronic low back pain (NSCLBP) demonstrate contradictory results, with most studies not correlating RE deficits with measures of pain, disability or fear. This study examined if RE deficits exist among a subgroup of patients with NSCLBP whose symptoms are provoked by flexion, and how such deficits relate to measures of pain, disability, fear-avoidance and kinesiophobia. 15 patients with NSCLBP were matched (age, gender, and body mass index) with 15 painfree participants. Lumbo-pelvic RE, pain, functional disability, fear-avoidance and kinesiophobia were evaluated. Participants were asked to reproduce a target position (neutral lumbo-pelvic posture) after 5 s of slump sitting. RE in each group was compared by evaluating constant error (CE), absolute error (AE) and variable error (VE). Both AE ($p = 0.002$) and CE ($p = 0.006$) were significantly larger in the NSCLBP group, unlike VE ($p = 0.165$) which did not differ between the groups. There were significant, moderate correlations in the NSCLBP group between AE and functional disability ($r = 0.601$, $p = 0.018$), and between CE and fear-avoidance ($r = -0.577$, $p = 0.0024$), but all other correlations were weak ($r < 0.337$, $r_s < 0.377$) or non-significant ($p > 0.05$). The results demonstrate increased lumbo-pelvic RE in a subgroup of NSCLBP patients, with the selected subgroup undershooting the target position. Overall, RE was only weakly to moderately correlated with measures of pain, disability or fear. The deficits observed are consistent with findings of altered motor control in patients with NSCLBP. The mechanisms underlying these RE deficits, and the most effective method of addressing these deficits, require further study.

1. Introduction

Low back pain (LBP) is a very common and costly musculoskeletal disorder (Woolf and Pfleger, 2003), and is one of the main reasons for seeking medical treatment (Kerssens et al., 1999). While outcomes for most people with first-episode LBP are positive, some develop chronic ongoing pain and disability (Pengel et al., 2003; Costa et al., 2009). The lack of a specific diagnosis in most patients has resulted in this group being described as having non-specific chronic low back pain (NSCLBP). Within this broad NSCLBP group, subgroups with specific impairments related to their ongoing pain and disability may exist, with each subgroup requiring a tailored management approach (Borkan et al., 1998; O'Sullivan, 2005). It has been proposed that a large subgroup of patients with NSCLBP present with a primary deficit in motor control, which contributes to their ongoing NSCLBP disorder (O'Sullivan, 2005). In recent years, considerable evidence has emerged regarding the importance of altered motor control and movement patterns in NSCLBP (Mok et al., 2007; Tsao et al., 2008; Dankaerts et al., 2009; MacDonald et al., 2009; Sheeran et al., 2012), supporting the contention that motor control impairments may be a significant factor in NSCLBP (O'Sullivan, 2005).

Motor control has several components, incorporating posture and muscle activation patterns, as well as requiring normal processing of sensory inputs such as proprioception. Proprioception has been investigated in peripheral musculoskeletal disorders (Machner et al., 2003; Thijs et al., 2007; Yokoyama et al., 2008), as well as more recently in both cervical (Sterling et al., 2003; Treleaven et al., 2006; Lark and McCarthy, 2007) and lumbar (Lam et al., 1999; Newcomer et al., 2000b; O'Sullivan et al., 2003) disorders. There is some evidence that patients with NSCLBP have

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reduced proprioceptive awareness (Parkhurst and Burnett, 1994; Gill and Callaghan, 1998; Brumagne et al., 2000; Newcomer et al., 2000a; O'Sullivan et al., 2003; Sheeran et al., 2012), although other studies have questioned this (Newcomer et al., 2000b; Koumantakis et al., 2002; Assell et al., 2006). The lack of significant differences in some studies may be due to heterogeneity within the NSCLBP population (Newcomer et al., 2000b; Koumantakis et al., 2002; Assell et al., 2006), since those using a specific motor control impairment subgroup appear to demonstrate proprioceptive deficits (O'Sullivan et al., 2003; Sheeran et al., 2012). This is consistent with evidence that while the overall NSCLBP population may be no different to painfree participants, when NSCLBP patients are analysed according to their specific subgroup, significant differences in parameters including posture and muscle activation are apparent (Dankaerts et al., 2009; Astfalck et al., 2010; Sheeran et al., 2012).

Proprioception has been assessed using different methods including perceived muscle tone (Leplow et al., 1992), body sway (Mientjes and Frank, 1999) and a range of kinematic variables (Allison and Fukushima, 2003; Sheeran et al., 2012). Methodological variations in how proprioception was assessed may be a factor in the discrepancies between studies. Kinematic variables are most commonly used, such as the ability to detect passive motion (Parkhurst and Burnett, 1994; Taimela et al., 1999), using gross measures of trunk position (Newcomer et al., 2000b; Allison and Fukushima, 2003; Descarreaux et al., 2005), and using repositioning error (RE) (Parkhurst and Burnett, 1994; Brumagne et al., 2000; O'Sullivan et al., 2003; Sheeran et al., 2012). Assessment of RE typically involves participants trying to reproduce a specific target body position, which may be a more appropriate measure of lumbo-pelvic proprioception (Brumagne et al., 2000; O'Sullivan et al., 2003; Sheeran et al., 2012) than non-functional tasks such as motion detection threshold. Increased RE may reflect altered sensory input or motor output, impaired central nervous system (CNS) processing, or be related to levels of pain, fear, motivation, or concentration.

It remains unclear how RE relates to measures of pain, functional disability, fear-avoidance and kinesiophobia in NSCLBP. One study reported weak correlations between RE and functional disability (Assell et al., 2006), however this study did not examine a specific subgroup, and did not evaluate a full range of RE parameters. Neither of the studies on a specific subgroup of NSCLBP patients (O'Sullivan et al., 2003; Sheeran et al., 2012) correlated RE with common measures of pain, disability, fear or kinesiophobia. Considering the importance of psychosocial factors in NSCLBP (Ramond et al., 2011), and their relationship with CNS changes which can affect sensory and motor function (Flor, 2003; Wand et al., 2011a), the relationship between these factors and RE should be evaluated.

Several different subgroups within the NSCLBP population have been proposed (O'Sullivan, 2005; Dankaerts et al., 2009). Previous studies of RE among a specific subgroup of NSCLBP patients (O'Sullivan et al., 2003; Sheeran et al., 2012) have examined sagittal plane RE among the most commonly reported subgroup – a specific flexion pattern (FP) subgroup. Therefore, this study investigated whether the same FP subgroup displayed greater RE than painfree participants, and investigated the relationship between RE and measures of pain, disability, fear-avoidance and kinesiophobia.

2. Methods

2.1. Study design

A single session study. Ethical approval was obtained from a local Research Ethics Committee.

2.2. Participants

22 participants with NSCLBP were recruited from private physiotherapy practices and by advertising within the local community. Only those meeting the criteria for the FP subgroup of motor control impairment (O'Sullivan, 2005) were eligible for inclusion. Briefly, this included NSCLBP for >3 months, increased symptoms during prolonged sitting, and reduced symptoms during standing and walking. Persons were excluded if they had previous back surgery, neurological symptoms, a history of ear or visual disturbances, symptoms suggestive of serious "red flag" pathology, and if they were pregnant or <six months post-partum. All participants were aged 18–65 years. As well as these self-reported criteria, all participants were physically examined by two investigators to assess if they adopted flexed lumbo-pelvic postures during sitting. After this, 15 individuals were included. The painfree group consisted of 15 individuals recruited from within the local community who had not experienced LBP during the last two years. They were matched for gender, age (±2 years), and body mass index (BMI) (±2 kg/m^2), with the NSCLBP group. All participants provided written informed consent. Prior to testing, all participants with NSCLBP completed measures of average daily pain (Verbal Numeric Rating Scale), functional disability (Oswestry Disability Index), fear-avoidance (Fear-Avoidance Beliefs Questionnaire) and kinesiophobia (Tampa Scale for Kinesiophobia). Each of these measures has evidence of reliability and validity, with established scores for people with mild or severe NSCLBP. Participant characteristics are represented in Table 1.

2.3. Instrumentation

Lumbo-pelvic RE was determined using a wireless posture monitor ("BodyGuard", Sels Instruments, Belgium) (Fig. 1). This minimally-invasive device incorporates a strain gauge that estimates flexion/extension range of the lumbo-pelvic region by the degree of strain gauge elongation. Posture is expressed as a percentage of strain gauge elongation, so that the degree of spinal flexion/extension is expressed relative to a referenced range of motion (ROM), rather than being expressed in degrees. Postural data were recorded in real-time at 20 Hz. This device has been shown to have very good reliability (intra-class correlation coefficient - ICC - >0.8) (O'Sullivan et al., 2011), and validity (O'Sullivan et al., 2012a,b), for the measurement of lumbo-pelvic posture. Expressing posture relative to ROM can be justified on the basis that while patterns of movement may differ among people with NSCLBP, overall ROM does not appear to be significantly different (Esola et al., 1996; O'Sullivan et al., 1997). Calculation of posture relative to ROM has been used in previous spinal posture research (Edmondston et al., 2007; Van Hoof et al., 2012), and is similar to electromyography normalisation of muscle activity relative to submaximal voluntary contraction (Dankaerts et al., 2006a).

Table 1
Characteristics of the study sample (mean ± SD).

Characteristics	NSCLBP (n = 15)	HC (n = 15)
Age (years)	31.3 ± 10.3	32.1 ± 9.2
Gender	10M/5F	10M/5F
BMI (kg/m^2)	24.3 ± 3.2	23.8 ± 2.0
NRS (0–10)	3.3 ± 1.9	N/A
ODI (%)	14.1 ± 7.8	N/A
FABQ	34.8 ± 14.4	N/A
TSK	36.1 ± 6.8	N/A

NSCLBP – non-specific chronic low back pain; HC – healthy control; BMI – body mass index; NRS – numeric rating scale; ODI – Oswestry disability index; FABQ – fear-avoidance beliefs questionnaire; TSK – Tampa scale for kinesiophobia; N/A – not applicable.

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