



Original article

Lumbar spine side bending is reduced in end range extension compared to neutral and end range flexion postures



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ABSTRACT

Lumbar side bending movements coupled with extension or flexion is a known low back pain (LBP) risk factor in certain groups, for example, athletes participating in sports such as hockey, tennis, gymnastics, rowing and cricket. Previous research has shown that sagittal spinal postures influence the degree of spinal rotation, with less rotation demonstrated at end of range extension and flexion. To date it is unknown whether sagittal spinal postures influence side bending. The aim of this study was to determine whether side bend range of motion (ROM) of the lumbar spine is decreased in end-range flexion and extension postures compared to a neutral spine. Twenty subjects between 18 and 55 years of age [mean age = 22.8 yrs (6.8)] with no history of LBP were recruited for this study. Upper (L1–L3) and lower (L3–L5) lumbar side bend, were measured utilising a 14 camera system (Vicon, Oxford metrics, inc.) in end-range flexion, extension and neutral postures, in both sitting and standing positions. The results revealed no statistically significant difference in upper and lower lumbar side bend ROM in an end-range flexion posture compared to a neutral spinal posture. A reduction was found in the range of upper and lower lumbar side bend ROM in an end-range extended posture ($p < 0.05$), compared to neutral and end range flexion postures. This ROM reduction was found in sitting and standing. These findings allow clinicians to better interpret combined movements involving side bending of the lumbar spine in clinical and real life settings.

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1. Introduction

Low Back Pain (LBP) is a common problem in sporting and manual working populations (Walker et al., 2004; Krismer and Van Tulder, 2007) and is associated with large economic and community costs (Walker et al., 2003). LBP is especially evident in sports involving combined spinal movements (rotation and side bending with sagittal movements) such as hockey (Weir and Smith, 1989), cricket (Glazier, 2010), tennis (Donatelli et al., 2012) and sweep rowing (Strahan et al., 2011). A strong relationship has been found between work related LBP and manual work involving combined movements of the lumbar spine (Hooper et al., 1998; Milosavljevic et al., 2007; Mitchell et al., 2008).

It has been proposed (Panjabi, 1992; Burnett et al., 2008) that because the passive lumbar spinal structures (lumbar spine discs and facet joints) are maximally compressed and strained at end-

ranges of sagittal spinal motion, greater risk of tissue damage exists when the spine is loaded in these ranges (Chosa et al., 2006). This risk is magnified when sagittal movements are combined with rotation and side bending (Panjabi, 1992), due to the passive spinal structures limiting further movement (Burnett et al., 2008). In contrast, when the spine is rotated or side bent in a neutral posture it is thought the increased compliance in the passive spinal structures of the motion segment reduces tissue strain risk (Panjabi, 1992; Burnett et al., 2008). These considerations are consistent with the neutral spine principle, where it's believed less resistance exists to movement in the lumbar spine in a mid range neutral posture during spinal loading (Wallden, 2009).

In spite of these widely held clinical beliefs, little research has been conducted to test these assumptions. Although side bending the lumbar spine combined with flexion/extension is a known risk factor for spinal injury (Chosa et al., 2006; Ranson et al., 2008) and is commonly examined as part of athletic and clinical assessment (Barret et al., 1999; Stuelcken et al., 2008; Stamos et al., 2012), the effect of a sagittal spinal posture on available side bend range of motion (ROM) has not been investigated. Previous studies have reported reduced lumbar rotation in trunk flexion when compared to upright sitting and standing (Gunzberg et al., 1991), with an

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in vitro study further confirming reduced rotation in extension compared to a neutral spine (Haberl et al., 2004). Burnett et al. (2008) confirmed axial rotation in the lower lumbar spine was reduced in both end-range flexion and extension postures compared to a neutral position during sitting and standing, in vivo. To our knowledge, no study has yet investigated the influence of a sagittal posture on the available range of side bend of the upper and lower lumbar spine in end range flexed and extended postures when compared to a mid-range neutral posture.

Therefore, the purpose of this study was to compare the magnitude of side bend range of motion for the upper and lower lumbar spine in end-range flexion and extension with a neutral spine posture in both sitting and standing positions. The hypothesis was that, in end range sagittal postures a reduction in side bend ROM would occur compared to a mid-range neutral spinal posture in both a sitting and standing postures.

2. Methods

2.1. Subjects

This study utilised a repeated measures observational design. Twenty asymptomatic healthy participants were recruited from Curtin University students, staff and the wider community [mean (SD) age: 22.8(6.8) years, mass: 69.1(12.2) kg and height: 1.75(0.89) metres]. Participants between the ages of 18 and 55 years were included. Subjects were excluded if they had experienced LBP within the 6 months prior to testing, had a known low back condition, had experienced any musculoskeletal injury restricting them from normal sporting and daily activities one week prior to testing or experienced pain or discomfort undertaking the experimental protocol.

2.2. Experimental protocol

The research questions were examined by recording end-range side bend ROM in mid-range neutral, maximum extension and maximum flexion in both sitting and standing using a valid, reliable 14 camera three-dimensional motion analysis system (Vicon: Oxford Metrics, inc.), with reconstruction errors of <1 mm (Ehara et al., 1995; Richards, 1999). For this, participants attended data collection at Curtin University motion analysis laboratory. Following their arrival participants were fitted with the lumbar spine and pelvis retro-reflective marker set (Table 1). The Vicon cameras tracked the three-dimensional position of each of these markers in real time, capturing at 250 Hz. Fig. 1

The experimental protocol began with the identification of reference postures (mid-range neutral, end range flexion and extension) in both sitting and standing. For all sitting trials, participants sat on a flat, horizontal surface stool with no back support.

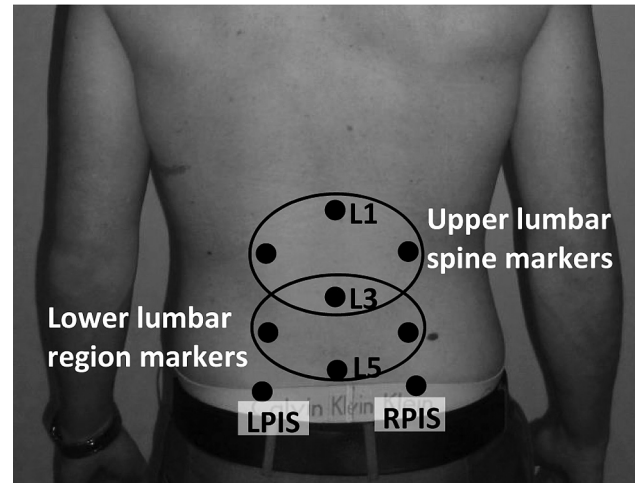


Fig. 1. Lumbar and pelvic marker locations (with the exception of the RAIS and LAIS).

The height of the stool was adjusted to around 90 degrees of hip and knee flexion (by eyeballing), with participant's feet flat on the floor, parallel and shoulder width apart as described by Burnett et al. (2008). Their arms were crossed with hands resting on their shoulders. For all standing trials, participants positioned their feet parallel and shoulder width apart, with arms crossed and hands resting on shoulders.

In both sitting and standing, participants were first shown a video demonstrating how to achieve maximum lumbar flexion and extension. They were then assisted into these positions with a combination of verbal cues and physical guidance where necessary. The flexed position was achieved by combined maximal; lumbar flexion, posterior pelvic rotation and thoraco-lumbar flexion in both the standing and sitting positions. Maximal lumbar extension was achieved by maximal lumbar lordosis with maximal anterior pelvic rotation in both standing and sitting positions. Each position was held for two seconds and repeated three times. These trials were then reconstructed using Vicon software (Oxford Metrics, Inc.), such that the distance between L1 and L5 could be determined for each trial. The reference end range flexion position was then defined as the average maximum distance between L1 and L5, with the reference end range extension position defined as the average minimum distance between L1 and L5. The mid point between these two reference positions was used as the representative mid-range neutral sagittal posture. Following the determination of reference postures, participants were guided into their end range flexion, extension and mid-range neutral postures using real time Vicon feedback and standardised verbal instructions for both the pelvic position and lumbar posture (e.g. 'increased/decreased lumbar flexion is required'). No physical or mechanical restraints were used to prevent pelvic movement. Where necessary participants were also shown the line graph of the real-time feedback and the required position. Participants were asked to actively repeat five trials of maximal left and right side bend in the three sagittal plane reference positions (neutral, end-range flexion, end-range extension). This required participants to maintain the nominated sagittal posture while they performed maximum side bend to their preferred side (i.e., left or right). The participant would then return to an upright position and repeat this process for the opposing side. The order of the sagittal postures was randomised. Sagittal plane angles were monitored closely throughout the side bend data acquisition trials. Any trials where the sagittal position deviated greater than five degrees during the side bend movement were later discarded after data analysis.

Table 1
Lumbar spine and pelvis marker set.

Marker names	Description
L1	Spinous process of 1st Lumbar process.
L3	Spinous process of 3rd Lumbar process.
L5	Spinous process of 5th Lumbar process.
UL bilateral markers left and right	2 cm bi-lateral of the junction of the 2nd and 3rd lumbar vertebrae.
LL bilateral markers left and right	2 cm bi-lateral of the junction of the 4th and 5th lumbar vertebrae.
RAIS	Right anterior superior iliac spine.
LAIS	Left anterior superior iliac spine.
RPIS	Right posterior superior iliac spine
LPIS	Left posterior superior iliac spine

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