Changes in the Standing Lumbar Spine at Above Bodyweight Loading

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1. Introduction

Understanding the mechanical response of the spine and intervertebral disc (IVD) to various loading situations is vital in predicting its behaviour, to verify computer models of the spine and in gaining insight in to how loading and spinal posture may cause or exacerbate injury. Studies of the lumbar spine and intervertebral disc under compression have typically been carried out *in vitro*; those which have used *in vivo* methods have mostly been conducted in the supine position at loading equal to or below static bodyweight. This study measures the lumbar spine response to above bodyweight loading in the standing position at loads equivalent to walking.

2. Methods

Sagittal plane magnetic resonance imaging scans of the spine were taken of nine asymptomatic male subjects (22-32 years of age, 167-195 cm, 66.3-93.2 kg) in the supine and standing positions with a third scan taken in the standing position with additional loading, with subjects holding a 6 kg kettlebell in each hand, enough to increase loading on the IVD to levels experienced during walking. Disc heights were measured as the average of anterior and posterior distance between adjacent vertebrae in the mid-sagittal plane. The relative angle between the lumbar spine and pelvis, measured as the posterior angle between L5 and S1 vertebrae and change in the upper lumbar spine, measured as the posterior tilt of L3 were used as measures of lordosis. Paired sample t-tests were used to determine if measured changes were significant.

3. Results

Increased axial loading resulted in reduced disc height and lumbar lordosis. Initial disc heights in the supine position for L3/L4, L4/L5 and L5/S1 were found to be 10.7±1.6, 12.0±2.8 and 11.4±1.9 mm respectively (Fig. 1L). These heights were reduced to 10.4±1.9, 11.4±2.1 and 10.8±1.6 mm in the standing position and 10.3±1.4, 11.4±2.0 and 10.4±1.8 mm with additional loading but these changes were not statistically significant (P>0.05). Lumbar angle in supine, standing and with additional loading was found to be 140±9, 145±11 and 145±12 degrees respectively (Fig. 1R) with L3 angled 0.7±3.5, 4.4±4.4 and 4.8±4.2 degrees posteriorly from the horizontal in the three loading positions (Fig. 1M). In all cases disc height change was greater posteriorly as loading increased lumbar lordosis. All numbers quoted are mean ± standard deviation.

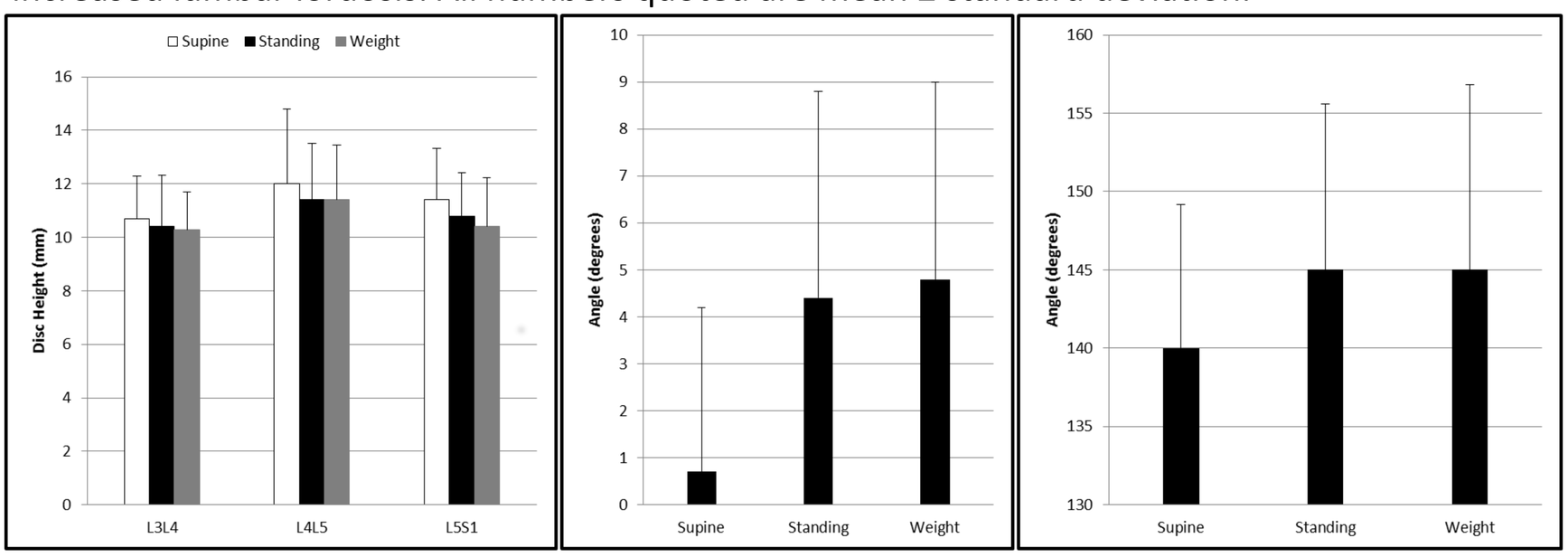

Figure 1 - (Left) Average IVD height of lower Lumbar discs in three loading positions. (Middle) Average Posterior tilt from vertical of L3 vertebrae in three loading positions. (Right) Average Angle between Lumbar and Sacral spine in three loading positions. Error bars show standard deviation.

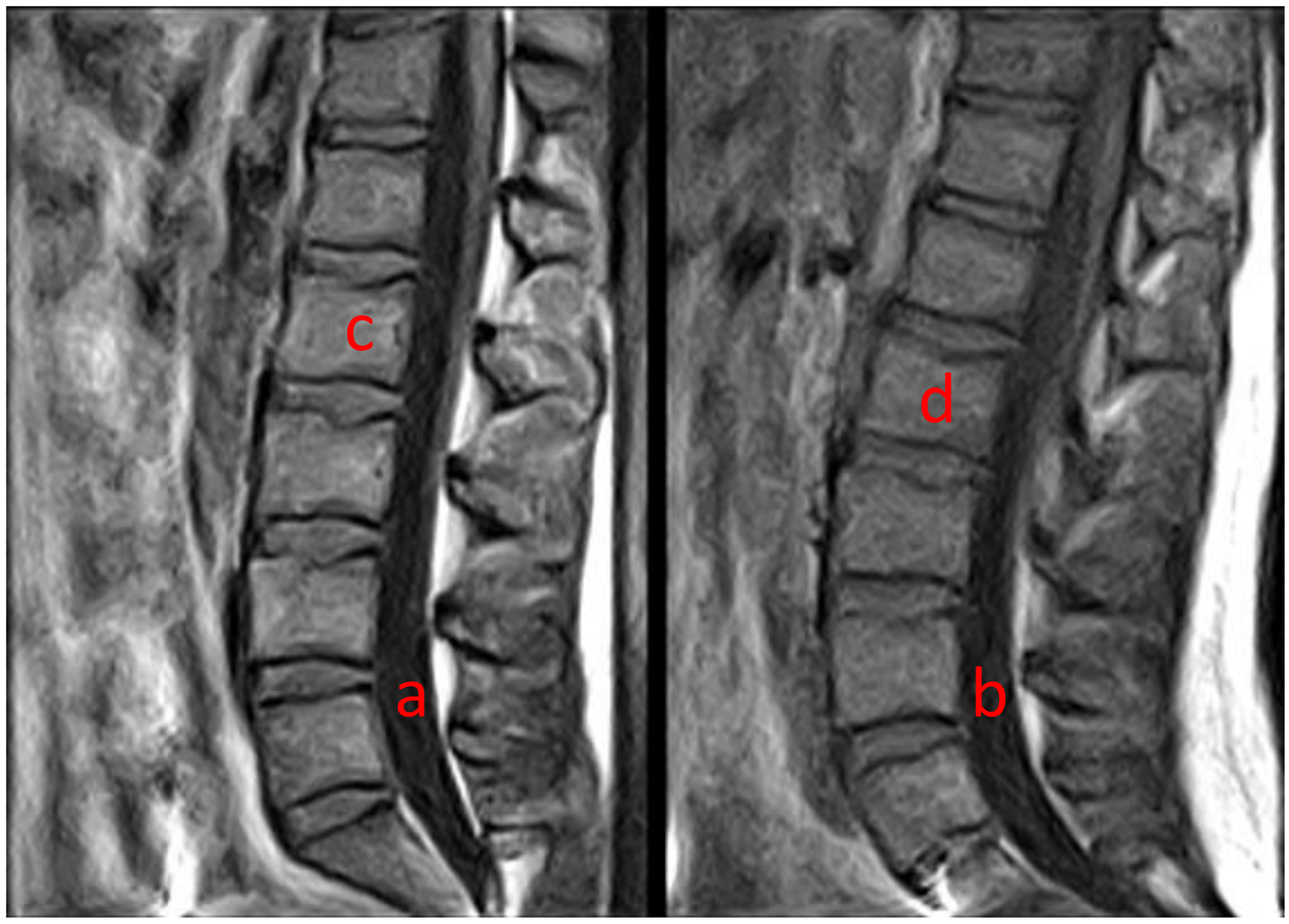

Figure 2 – (Left) The lumbar spine in the supine position. (Right) The lumbar spine in the standing position. Note the increased lordosis at b relative to a and the greater posterior tilt of the spine at point d relative to c.

4. Conclusion

Increased axial loading was found to progressively decrease intervertebral disc height in L3/L4 and L5/S1 discs; this change in height was not equal across the disc with reduced compression in the anterior region of the disc. The L4/L5 disc height reduced between supine and standing positions but no further change in height was observed when additional loading was applied. Lordosis in the lumbar spine was found to increase with progressive loading; L5/S1 angle was greater in the standing position than supine whilst the superior facet of the L3 vertebrae was increasingly rotated posteriorly. In standing the loading due to bodyweight reduces IVD height compared to supine position, but this reduction is not constant across the IVD with greater compression in the posterior region. Increasing body weight in standing by 12kg resulted in only small changes in lumbar compression and posture relative to the changes between supine and standing.

5. Further Work

A paper comparing these results with those from *in vitro* dynamic loading at levels equivalent to activities of daily living, *Changes in Intervertebral Disc Height In Vivo and In Vitro at Above Bodyweight Loading,* has been submitted for publication to *Spine*