Relationship Between Thoracic and Lumbar Spinal Curvature During Unsupported Sitting
Deborah L. Givens¹, Gregory M. Freisinger², Jackie Lewis², Michael McNally², Steve T. Jamison³, and Ajit M. W. Chaudhari²

University of North Carolina¹, Chapel Hill, NC, USA
The Ohio State University², Columbus, OH, USA
University of Delaware³, Newark, DE, USA
email: deborah_givens@med.unc.edu, web: http://www.med.unc.edu/ahs/physical/faculty/deborah_givens

INTRODUCTION

Maintaining the natural curvature of the lumbar, thoracic, and cervical spine, or “neutral spine” posture while sitting is widely recommended for good spinal segment alignment.[1] A common clinical approach to correcting seated posture is to teach people to reduce posterior rotation of the pelvis in order to improve the lumbar lordotic curve and reduce mechanical stresses on the spine.

Changes in lumbar lordosis while sitting can result in compensatory adjustments in the cervical spine to maintain the orientation of the head, which have the potential to impact the spinal loading.[2] However, little is known of how the curvature and motion of the lumbar region correlates with the adjacent thoracic region while seated. Although the thoracic and lumbar regions have the potential to move independently and, therefore, respond to postural changes differently, we hypothesized that the curvatures of the thoracic and lumbar spine in the sagittal plane would be coupled during sustained, unsupported sitting.

METHODS

Forty individuals at the 37th Annual Meeting of the American Society of Biomechanics in Omaha, NE participated in this study. Study volunteers assented that they were free from back pain while sitting or standing for a period of 15 minutes. Thirty-five participants (21 males, 14 females, mean age=33.8 ± 10.6y) had complete data for analysis.

Each subject sat on a backless stool while wearing a chest harness and belt. Markers with moiré patterns and unique markings on them were placed over the spine and pelvis (Figure 1). Subjects were instructed to maintain an erect sitting posture for 15 minutes while utilizing a hand-held iPad to play games that challenged the brain. The three-dimensional locations and orientations of each marker were obtained using a moiré pattern motion capture system at 1 Hz [MC 40180; Metria Innovation, Milwaukee, WI]. The Metria system has been validated to provide accuracy within 1mm and 0.05 degree.[3]

The radius of curvature (RoC) in the sagittal plane for the thoracic spine was estimated using the intersection of vectors normal to the face of each marker, which were located on the proximal and distal aspect of the thoracic spine (yellow in Figs 1, 2a). The lumbar RoC was estimated similarly with a marker on the lumbar spine and the combined orientation of 2 markers on the posterior superior iliac spines (red in Figs 1, 2a). Spinal curvature was calculated from the inverse of each RoC.

RESULTS AND DISCUSSION

The medians and ranges for the thoracic and lumbar curvature were 2.20 [0.26, 4.81] m⁻¹ and 0.70 [-1.85, 5.96] m⁻¹, respectively. A Spearman’s rank correlation coefficient (ρ) was calculated between the thoracic and lumbar curvature for each subject (Figure 2b). All ρ were different from 0 (p<0.01), with the exception of subject 6 (blue point in Fig. 1b, p=0.12). The range was from ρ = -0.74 to ρ = 0.86. When each subject’s curvature data was normalized to his/her initial thoracic and lumbar...
curvature, the thoracic and lumbar curvature were significantly correlated for the group, though the relationship was weak (overall $\rho$ for the group = 0.12, $p<0.001$).

These results suggest that thoracic and lumbar curvature may be coupled for most individuals, but the relationship varies widely in both strength and direction, even among these subjects without back pain during unsupported sitting.

**CONCLUSIONS**

These data suggest that monitoring and correcting the lumbar spine curvature tends to influence the thoracic spine curvature in most individuals without back pain during sustained, unsupported sitting. However, the relationship between lumbar, thoracic, and cervical curvatures is probably more complex than is generally accepted clinically. Lumbar curvature and pelvic rotation should be considered when improvement of thoracic posture is also desired. Future studies should investigate coupling patterns of the lumbar and thoracic spine in people with back pain during sustained sitting and in patients with musculoskeletal disorders of the spine.

**ACKNOWLEDGMENTS**

The authors gratefully acknowledge support for this study from the organizing committee of ASB 2013, Metria Innovation for loaning the motion capture system during the meeting, and the members of ASB for participating.

**REFERENCES**


---

**Figure 2.** A) Radius of curvature for the thoracic and lumbar spine was found by the intersection point of vectors perpendicular to the moiré marker face. B) Spearman’s rank correlation coefficient ($\rho$) of the thoracic and lumbar curvatures for each subject individually. The blue point indicates Subject 6, the only participant for whom $\rho$ was not significantly different from zero.