THE EFFECT OF THORACIC KYPHOSIS AND SAGITTAL PLANE ALIGNMENT ON VERTEBRAL COMPRESSIVE LOADING

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INTRODUCTION

Hyperkyphosis of the thoracic spine is a strong and independent risk factor for vertebral fractures. One possible mechanism underlying this increased fracture risk is an increased moment arm between the spine and the superincumbent body weight that it must support, which has the net effect of increasing vertebral loading and thus fracture risk [1]. In an effort to maintain stability, upright posture, and horizontal eye gaze, there are multiple postural adjustments that an individual can employ in response to an age-related increase in thoracic kyphosis [2]. However, it is not known how these adjustments might interact with the thoracic kyphosis angle to influence forces applied to the vertebrae. The purpose of this study was to determine the effect of increased thoracic kyphosis on the magnitude of vertebral compressive loading during two different standing tasks, and to examine how three different posture conditions (an uncompensated increase in thoracic kyphosis, a compensated increase in thoracic kyphosis, and maintenance of congruency between the lumbar and thoracic spine) interact with the thoracic kyphosis angle to affect vertebral compressive loading.

METHODS

We used a static musculoskeletal model of the spine [3] to estimate vertebral compressive force at T8 and T12 for two different activities: 1) upright standing with arms hanging down and 2) upright standing with elbows flexed to 90° and 5 kg weights in each hand. Baseline spinal curvature and pelvic orientation for the model were created using average values from the literature [4]. For each activity, we examined three different posture conditions: 1) an uncompensated increase in thoracic kyphosis; 2) increasing thoracic kyphosis with a compensatory postural adjustment, in this case tilting the pelvis posteriorly; and 3) increasing thoracic kyphosis concomitantly with lumbar lordosis to maintain congruency, which means that the thoracic and lumbar curves are proportional and balance each other. For the uncompensated posture condition, the T1-T12 Cobb angle was varied from 50° to 75° while all other spino-pelvic parameters remained fixed at their baseline values. For the compensated posture condition, pelvic tilt was varied (10° to 15.31° in 0.23° increments) concomitantly with the T1-T12 Cobb angle (50° to 75° in 1° increments) to maintain the sagittal alignment of the head and neck directly above the hip joint. For the congruent posture condition, the L1-L5 Cobb angle was varied (43° to 52.1° in 0.36° increments) concomitantly with the T1-T12 Cobb angle (50° to 75° in 1° increments) to maintain the sagittal alignment of the head and neck directly above the hip joint.

RESULTS AND DISCUSSION

Compressive force was higher at T12 than T8 and compressive force was higher for standing with weight in the hands than standing with no weight. At both T8 and T12, compressive loading increased with increasing thoracic kyphosis for each of the three postures, with the increase in loading being greatest for the uncompensated posture, followed by the compensated posture, and finally the congruent posture (Fig. 1).

Increasing thoracic kyphosis increased vertebral compressive loading more in the uncompensated condition than in the compensated or congruent
conditions because it shifted a greater amount of body mass forward. This generated higher flexion moments which required larger muscle forces to equilibrate. The congruent and compensated posture conditions countered the anterior shift in body mass associated with an increasing thoracic kyphosis, with the congruent posture condition being more effective. The clinical implication is that some older individuals who have a very high thoracic kyphosis angle may not be at an elevated risk for fracture because they have congruent posture. In comparison, those who have an age-related increase in thoracic kyphosis, and do not have a congruent spinal configuration, may have a greater risk for fracture than someone with the same thoracic kyphosis angle but who maintains a congruent posture.

CONCLUSIONS

We suggest that the current theory ascribing increased spinal loading to greater amounts of thoracic kyphosis is overly simplistic as it does not take into account other postural adjustments that accompany age-related increases in thoracic kyphosis, and which act to modulate any increases in loading. Our results indicate that in addition to measuring thoracic kyphosis angle, it is also necessary to evaluate overall posture and spine-pelvic alignment when assessing one’s risk for degenerative spinal pathology due to altered spine biomechanics, such as vertebral fractures. When treating spinal deformities, clinicians should strive to restore congruent posture because of its positive effects on spinal loading, balance, and eye gaze.

REFERENCES


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