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

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INTRODUCTION

Musculoskeletal models are commonly used to estimate skeletal loading and fracture risk in populations at risk for musculoskeletal injury. Two populations in particular that have a heightened risk for skeletal fracture are the elderly and astronauts. Both groups experience declines in bone mineral density and strength, the former due to normal age-related changes and the latter due to prolonged exposure to a reduced gravity environment. The current study used a musculoskeletal model of the spine to examine how spinal curvature and overall sagittal plane alignment influence the spine biomechanical environment and thus risk of vertebral fracture. More specifically, we sought to determine the effect of increasing amounts of thoracic kyphosis (TK) on the magnitude of vertebral compressive loading during two different standing activities, and to examine how three different posture conditions (uncompensated, compensated, and congruent) interact with the TK angle to modulate this effect on loading.

METHODS

We used a static musculoskeletal model of the spine 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. For each activity, we examined three different posture conditions: 1) an uncompensated increase in TK; 2) increasing TK with a compensatory postural adjustment, in this case tilting the pelvis posteriorly; and 3) increasing TK concomitantly with lumbar lordosis to maintain congruity, 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 15°-75° while all other spinopelvic parameters remained fixed at their baseline values. For the compensated posture condition, pelvic tilt was varied (2° to 15.31° in 0.23° increments) concomitantly with the T1-T12 Cobb angle (15° 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 (30.3° to 52.1° in 0.36° increments) concomitantly with the T1-T12 Cobb angle (15° to 75° in 1° increments) to maintain the sagittal alignment of the head and neck directly above the hip joint.

RESULTS

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 TK 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. The figure to the right shows the increase in compressive force per degree increase in TK for each of the conditions.

DISCUSSION AND CONCLUSIONS

Vertebral fractures are the most common type of osteoporotic fracture in the elderly, and a source of significant morbidity and mortality. In addition, the lumbar spine is a focal point for bone loss in astronauts and may be at heightened risk for fracture upon returning to earth after long duration spaceflight, or in an operational EVA setting. Understanding the contribution of spinal curvature and postural alignment to spinal loading is important for fracture prevention and treatment in these two at risk populations.

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