THE ASSOCIATION BETWEEN ATHLETIC TRAINING TIME AND THE SAGITTAL CURVATURE OF THE IMMATURE SPINE

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INTRODUCTION: The normal development of the spine’s sagittal curvature depends upon a complex interaction between heritable growth factors and the mechanical environment in which the spine grows. Sagittal spine curvature is known to be modifiable by altering the loads applied during growth. Studies of the immature rat tail vertebrae have demonstrated that disc height can be modulated by mechanical loading history (1). Excessive spinal compressive loads have also been found to affect normal human spinal development at the apophyses (2). The research question addressed in this study is whether exposure to long hours of athletic training is associated with increases in the sagittal curvature of the immature spine. The primary null hypothesis (Ho) tested was that larger angles of thoracic kyphosis or lumbar lordosis are not associated with increased exposure to athletic training as quantified by the number of annual training hours. Secondary null hypotheses were that the angles of kyphosis or lordosis would not differ by the primary sport of choice, age, or gender.

MATERIALS AND METHODS: 2,270 children (407 females) between the ages of 8 and 18 were studied after obtaining consent from the Institutional Review Board as well as written permission from their parent/guardian. These individuals attended local schools or volunteered from our University’s annual summer athletic training camps between 1989 and 1996. The athletic subject population was recruited by the primary sport declared by the child. An age-matched group of children reporting no sports participation or experience of manual labor was recruited and used as a ‘non-athletic’ control group.

Testing Apparatus: This method used to measure spine curvature was similar to that developed by Druetup and Hierholzer (3,4). A tripod-mounted custom-made 33mm projector, a motor drive Canon F1 35 mm film camera, and a custom-built platform for standardizing subject position and orientation were utilized. Fixed onto the platform were two vertical stanchions, each supporting a fixed array of four light-emitting diodes and a trochanter pad. The LEDs provided fixed points in 3D space for the calibration procedure and thereafter served as permanent fiducial reference points in every image. Adjustable, bilateral cupped trochanter pads served to fix the pelvis within the photographic reference plane.

Testing Protocol: Each subject was interviewed about their sports participation history, work activities, musculoskeletal injuries, and self-reported training programs. Anthropometric and flexibility data was also collected. Photographs of the backs of each subject were obtained to measure the degree of thoracic and lumbar curvature. Surface markers were placed at T1, T10, L2 and S1 landmarks. Films were taken after instructing the subject to stand in a relaxed, upright position. Each 35 mm photograph image was converted to bitmap files and then processed using a sequence of custom computer programs written to quantify the angles of thoracic kyphosis and lumbar lordosis of each subject.

Statistics: Univariate analyses were conducted to provide summary statistics of continuous and discrete variables. Since data followed a Gaussian distribution, ANOVA (for primary hypothesis) with post-hoc t tests with Bonferroni’s correction factor (for secondary hypothesis) were used to determine differences in thoracic and lumbar spine angles between sports. Nonlinear regression was used to explore the relationship between the number of training hours and angle of kyphosis and lordosis.

RESULTS: No significant differences were found between thoracic and lumbar spine sagittal angles and either gender or age. Both thoracic and lumbar angles of curvature increased significantly with the number of annual training hours (p<0.05, Table 1). A nonlinear regression of curvature angle on training time demonstrated coefficients of determination of 0.72 for thoracic kyphosis and 0.69 for lumbar lordosis (Figure 1). A significant difference was found in the thoracic and lumbar spinal curves when adolescents were stratified by their primary sport (Table 1). The non-athletic controls had significantly smaller thoracic and lumbar spine curves compared with each of the athletic groups (p<0.001).

DISCUSSION: The novel finding in this study was the significant increase in spine curvature associated with cumulative training exposure in this sample of children. The finding of significantly smaller thoracic and lumbar angles in the non-athletic controls suggests that a certain amount of physical activity may be required for the development of normal curves. We believe from a musculoskeletal developmental standpoint that physical activity is beneficial for proper bone growth and maturation. Strenuous exercise, however, can have a deleterious effect on immature bone morphology and its mechanical integrity. In highly competitive sports, the spine of the growing athlete appears to be vulnerable. Long-term exposure to such forces appears to correlate with altered spinal development.

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