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Summary

Sagittal alignment of the spine alters during the pubertal growth spurt. Using a musculoskeletal model, we simulated these alterations by choosing Thoracic Kyphosis and Sagittal Vertical Alignment as variable parameters. Results indicated that, by increasing these parameters as the posterior inclination of the spine decreases through the growth spurt, the intervertebral compression forces of the thoracolumbar spine increase.

Introduction

Adolescent Idiopathic Scoliosis (AIS) occurs most often in adolescent girls. This is a deformity in the frontal plane. However, this concurs with natural changes in sagittal plane alignment in their spinal pubertal growth. Previous studies indicate that the adolescent spine tends to be more posteriorly inclined earlier in the growth spurt, then Thoracic Kyphosis (TK) and Sagittal Vertical Alignment (SVA) increase in a way that posterior inclination decreases during further pubertal development [1, 2].

Methods

We utilized a recently developed thoracolumbar musculoskeletal model [3] to obtain the variation of normalized intervertebral joint compression (NJC) force caused by alteration of TK and SVA, and then investigate the NJC trend through the growth spurt.

TK is the sagittal Cobb angle between the T4 and T12 vertebrae, and SVA is the horizontal distance between the C7 vertebra and the posterior superior sacrum. Positive SVA means C7 is placed posteriorly to Sacrum. Parameter values during the growth spurt were obtained from previous studies. [1, 2]. In this study, TK and SVA were simulated in the range of 28 to 39 degrees and -20 to 43 mm respectively.

We represented the reclined segment (RS) of the spine by the number of vertebrae that are posteriorly inclined relative to the horizontal plane [1]. This parameter was employed to identify the proper growth direction line on the surface. Typical RS in growth is considered to be 8 to 10 posterior vertebrae, which were illustrated as dashed lines (Figure 1).

We acquired the growth direction line considering that TK and SVA increase and RS decreases, to describe typical TK, SVA and RS development in the growth spurt.

Results and Discussion

We considered the T8-T9 NJC as a function of TK and SVA (Figure 1) because T8 is the most common apical vertebra in AIS. However, the trend was the same for all the lower thoracic and lumbar regions. NJC increased with increasing TK and SVA but NJC is more sensitive to SVA than TK.

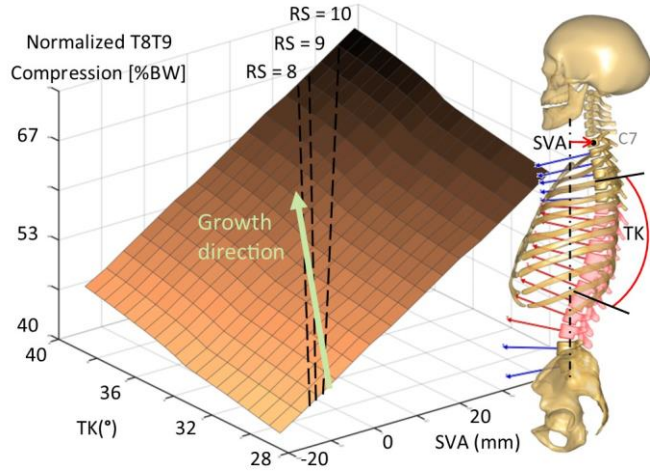

Figure 1: The T8-T9 NJC as a function of TK and SVA. The compression is normalized to body weight [BW]. TK and SVA are defined on the right and the reclined segment (RS) is shown in red. The spine arrows show the inclination of each vertebra. The dashed lines on the surface show constant RS of 8, 9, and 10 reclined vertebrae, which include L3 up to T8, T7, and T6, respectively.

Using the growth direction line, we infer that NJC is higher in the later stages of growth for adolescent girls. Moreover, we found a positive correlation between NJC and RS.

Conclusions

The intervertebral joint compression in T8-T9 increases with TK as well as SVA, and the combination of parameter development typical for the growth spurt causes a net increase of joint compression. It may be speculated that the balance between increasing spinal compression forces and evolving resistance to load in the adolescent spine can play a role in the pathomechanism of AIS. The perspectives of this thoracolumbar musculoskeletal model may contribute to investigating this question in the future.

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