Differences in Male and Female Spino-pelvic Alignment in Asymptomatic Young Adults and its Relation to Spinal Deformities - A Three-dimensional Analysis using Upright low-dose Digital Biplanar X-rays

INTRODUCTION

Sagittal spino-pelvic alignment plays a very important role in spinal biomechanics. As biomechanical overloading of the spine is known to cause and worsens several spinal disorders, sagittal spino-pelvic alignment has been studied extensively in the past two decades and referential values are described in both asymptomatic adults and children. Given the fact that some spinal disorders, such as idiopathic scoliosis and Scheuermann’s disease, have strong sex-related prevalence rates, it is surprising that only a few studies have analyzed differences in the normal spino-pelvic alignment between the sexes. Furthermore, most of these studies only obtained two-dimensional (2-D) referential values using standing upright sagittal radiographs, hereby simplifying a complex three-dimensional (3-D) construct.

With an innovative low-dose digital biplanar X-ray system (EOS imaging system, Biospace Instruments, Paris) we are able to make 3-D reconstructions of the spine and pelvis with the accuracy of 3-D reconstruction from a CT scan. However, with 800 to 1000 times less dose then is needed for a 3-D reconstruction from a CT scan. Most importantly, this can be done in a fully freestanding upright position.

Purpose of this study was to analyze in depth the differences in sagittal spino-pelvic alignment in a group of asymptomatic young adult males and females.

MATERIALS AND METHODS

After approval by the local ethics committee, sixty healthy young adults without prior known spinal disease or pelvic abnormality were enrolled in this prospective study. The cohort consisted of thirty males and thirty females, all of European heritage. Prior to radiography, informed consent was obtained and weight and height were measured.

Positioning. Care was taken to obtain the most natural position of each subject as possible, forced positioning was avoided. Each subject was asked to stand upright in a relaxed manner and look forward. The fingertips of both hands were placed at the ipsilateral temple to prevent overcontraction of the arms over the thoracic spine. (Fig. 1)

Radiography. Subsequently, simultaneous biplanar radiographs (PA and lateral) from head to feet were obtained using the EOS imaging system (Biospace Instruments, Paris). This system provides high-definition digital radiographs, with an 8 to 10 times lower radiation dose than is needed in conventional imaging.

Reconstruction. Two observers made a 3-D reconstruction of vertebrae (T1 to L5), sacrum and pelvis, using the PA and lateral radiograph with in-house developed reconstruction software. (Fig. 2) Measurements. Values were calculated for T4-T12 thoracic kyphosis (TK), T12-L5 lumbar lordosis (LL), total and regional lumbopelvic lordosis (PRT12, PRL2, PRL4, PRL5), sagittal plumb line of T1, T4 and T9 (HAT1, HAT4, HAT9), sagittal spinal inclination, total and sagittal offset, pelvic parameters (pelvic tilt, sacral slope and pelvic incidence). In addition, vertebral inclination in the sagittal plane of each vertebra was measured.

Statistical analysis. The independent samples t test was used to test differences in the spinal and pelvic parameters between the sexes. Before testing, normality of distribution was examined and equality of variances was tested. Intra and inter observer intraclass correlation coefficients (ICCs) were calculated for all parameters. A P value of < 0.05 was considered to be statistically significant.

RESULTS

The mean age was 27 years (range, 21-49) for males and 26 years (range, 20-42) for females. No statistical differences were found in BMI between the groups. In the following parameters statistical differences were found between the sexes: LL was larger in females (54˚ vs 49˚; P = 0.042), female spine was more dorsally inclined (11° vs 8°; P = 0.003) and the high thoracic and thoracolumbar vertebrae were significantly more dorsally inclined in women than in men. (Fig. 3) TK, regional lumbopelvic lordosis, sagittal plumb lines, T9 sagittal offset and pelvic parameters were not statistically different between the sexes. Intra and inter observer reliability were both excellent (mean ICCs > 0.93).

DISCUSSION AND CONCLUSION

The results of our present study indicate that the female spine is not just a scaled down version of a male spine. The female spine as a whole, as well as individual vertebrae in certain regions are more backwardly inclined. To our best knowledge this has never been previously described. An important biomechanical consequence of this finding is that these spinal regions are more subjected to dorsally directed shear loads.[1] Whereas the basic anatomy of the spine makes it well suited to resist axial load and anterior shear, dorsally directed shear loads make spinal segments less rotationally stable.[2] In conclusion, this is the first accurate 3-D analysis of differences in the spino-pelvic alignment including vertebral inclination between the sexes. Our main results signify that certain spinal regions are less rotationally stable in females than in males. This may explain why progressive idiopathic scoliosis occurs more in the female sex.

REFERENCES