In: Research into spinal deformities 4, TB Grivas, (Ed), IOS Press, Amsterdam 2002, pp. 25-31. ISBN I 58603 289 5 (IOS Press), ISBN 4 274 90552 7 C3047 (Ohmsha), ISSN 0926-9630.
Stud Health Technol Inform, 2002: 91: 25-31

Lateral spinal profile in school-screening referrals with and without late onset idiopathic scoliosis 10°-20°.

Theodoros B GRIVAS, Spyros DANGAS, Panagiotis SAMELIS, Christina MAZIOTOU, Konstandinos KANDRIS.
Scoliosis Clinic, Orthopaedic Department, "Thriasio" General Hospital
G. Genimata Avenue, Magula, 19600 Greece
E-mail: grivastb@vodafone.net.gr

Abstract: *Introduction.* The aim of this report is a) to study the lateral spinal profile, (LSP), in school-screening referrals with and without late onset idiopathic scoliosis of small curves 10°-20° Cobb angle and b) to validate LSP's aetiological importance in idiopathic scoliosis pathobiomechanics.
Methods and Material. The spinal radiographs of 133 children, 47 boys and 86 girls with a mean age of 13.28 and 13.39 years respectively and Axial Trunk Inclination (ATI) ≥ 7°, were examined. The Cobb angle was appraised from the anteroposterior standing radiographs and the segmental spinal profile was assessed. A line was drawn down the posterior surface of each vertebral body from T1 to L5 on lateral standing radiographs, and the angle of this line from the vertical was recorded. Intervertebral values for LSP, (ILSP), that is the result of the subtraction of two consecutive spinal levels LSP, were also calculated. The data were then statistically analyzed.
Results. The statistical descriptives of LSP and intervertebral LSP are presented for several groups of children, namely in those: 1) with straight spines, 2) with spinal curvature having a Cobb angle less than 10°, and 3) in scoliotic children with a) thoracic, b) thoracolumbar and c) lumbar curves 10°-20°. A correlation of the LSP with Cobb angle for the various types of curves for boys and girls is also presented. It is shown that the kyphotic segmental angulation is slightly less and the lordotic one almost normal in scoliotics, compared with the values of normal children. It is interesting to note that the LSP correlated with Cobb angle shows: a) a positive correlation pattern at T6, T7, T8 and T9 for thoracic curves of scoliotic boys and b) a negative correlation pattern at T3, T4 and T5 spinal levels of lumbar curves for scoliotic girls.
Discussion. The observed differences of the LSP are mainly located at the lumbar spine, suggesting that factors acting on the lumbar spine in sagittal plane, contribute to the development of AIS. The minor hypokyphosis of the thoracic spine and its minimal differences observed in the studied small curves with nonscoliotics in this report add to the view that the reduced kyphosis, by facilitating axial rotation, could be viewed as being permissive, rather than as aetiological, in the pathogenesis of idiopathic scoliosis.

1. Introduction

The aim of this report is dual a) to study the lateral spinal profile (LSP) in school-screening referrals with and without commencing late onset idiopathic scoliosis, who had small curves (Cobb angle of 10°-20°) and b) to validate LSP's aetiological importance in idiopathic scoliosis pathobiomechanics.

2. Material and Method

2.1 The examined children. 133 school-screened for scoliosis and referred children, 47 boys (35.3%) with a mean age 13.28 years (range 9-18), and 86 girls (64.7%) with a mean age 13.39 years (7-18) were included in the study. All these children had an Axial Trunk Inclination (ATI) ≥ 7°. The statistical analysis showed no difference of the age between the boys and girls, thus the studied sample contains homogenous aged population, (independent Samples T-test). The children were separated in the following groups: 1) with straight spine, 2) with curves measuring Cobb angle less than 10°, which is not considered as a scoliosis according to SRS, 3) in children with i) thoracic ii) thoracolumbar and iii) lumbar curves.

2.2 The measurements. The Cobb angle was assessed on the standing posteroanterior and the segmental LSP, on the lateral spinal radiographs. The LSP was measured as following: A line was drawn down the posterior surface of each vertebral body from T1 to L5 on lateral standing radiographs, and the angle of this line from the vertical was recorded [8]. Intervertebral LSP values, that is the result of two successive LSP level values subtraction, were also calculated.

When measuring the LSP, the forward tilt of a vertebra from the vertical is conventionally termed proclivity and it is deemed positively (+), while the backward tilt of a vertebra against the vertical it is termed declivity and it is deemed negatively (-) [8].

There are three component angles of sagittal spinal curves - upper proclive, declive and lower proclive angles. The *kyphosis angle* is a compound measure of sagittal shape - declive angle plus upper proclive angle. The *lordosis angle* is a compound measure of declive angle and lower proclive angle [2,3].

The point, where the the upper proclive angle is turned into the declive angle is considered as the *first transitional zone* of the LSP of the thoracic kyphosis, while the *second transitional zone* is located at the lumbar or lumbrosacral spine, where the declive angle is turned into the lower proclive angle.

2.3 The statistical analysis. The techniques used included frequencies, descriptives, Kruskal-Wallis test, Pearson Correlation Coefficient and independent Samples T-test, (SPSS).

3. Results

The LSP is presented in the following groups of children: 1) with straight spine, 2) with curves measuring Cobb angle less than 10°, which is not considered as a scoliosis according to SRS, 3) in children with i) thoracic ii) thoracolumbar and iii) lumbar curves.

Statistics (independent Samples T-test) showed that segmental LSP do not differ between boys and girls of the examined population apart from T10; thereby the findings for both sexes are reported together.

In the *first group* (straight spines) 27 children were included, 12 boys [44.4%] and 15 girls [55.6%]. The mean kyphosis (the T4 – T12 Cobb angle reading on lateral spinal radiographs) is 27.1 degrees, and the mean lordosis 30.3 dergrees, (the L1 - L5 Cobb angle reading on lateral spinal radiographs).

In the *second group* (curves with a Cobb angle less than 10°), 13 children were included, 6 boys [46.2%] and 7 girls [53.8%]. The mean kyphosis was 24°, and the mean lordosis 30°.

In the *third group* of children with:

i) Thoracic curves with a Cobb angle 10°-20°, 47 children were included, 17 boys [36,2%] and 30 girls [63.8%]. The mean kyphosis was 31°, and the mean lordosis 35.8°.

ii) Thoracolumbar curves with a Cobb angle 10°-20°, 14 children were included (4 boys [28.6%] and 10 girls [71.4%]. The mean kyphosis was 28° and the mean lordosis 32.2°.

iii) Lumbar curves with a Cobb angle 10°-20°, 28 children were included 7 boys [25%] and 21girls [75%]. The mean kyphosis was 28.7°, and the mean lordosis 32.6°.

The statistical analysis of the LSP's of children with thoracic, thoracolumbar and lumbar curves, using the Kruskal-Wallis non-parametric test, showed no differences among them, apart from L2 and L3 spinal levels and only for girls.

Comparing the children's LSP between groups, using Mann-Whitney test, it was shown that: Between the *first (straight spines)* and the *second group (0°-9° Cobb angle)*, no statistical difference was noticed.

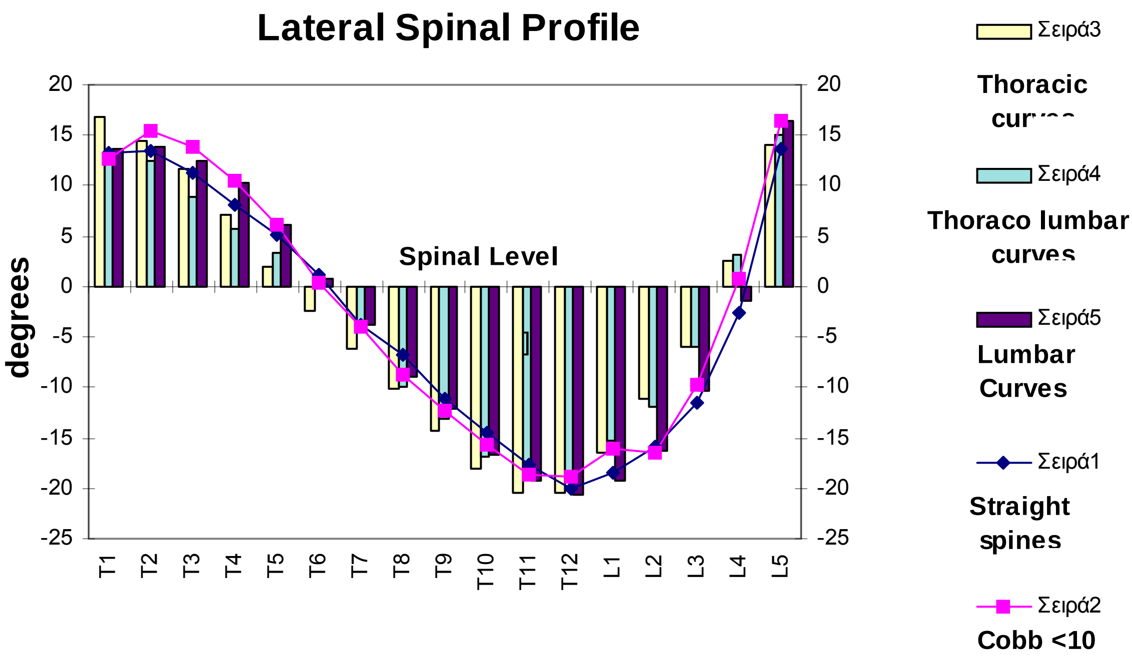

Figure 1. The Lateral Spinal Profile for the various groups of children, boys and girls. Yellow bars = thoracic curves, azure bars = Thoracolumbar curves, mauve bars = lumbar curves, line with blue diamonds = straight spines, line with red rectangles = curves with Cobb < 10 dergees.

Between the *first* and the *third group* with *thoracic curves*, a difference was found on the T6 level, ($p< 0.05$). Between the *first* and the *third group* with *thoracolumbar curves*, a difference was found on the L3 level, ($p< 0.02$). Between the *first* and the *third group* with *lumbar curves*, a difference was shown on the T4 and L2 level, ($p< 0.04$ and $p< 0.03$ respectively). Between the *second group* of children and the *third group* with *thoracic curves,* a statistical difference was shown on the spinal levels T4, ($p< 0.02$), L2 ($p< 0.048$) and L3 ($p< 0.035$). Between the *second group* and the *third group* with *thoracolumbar curves*, a difference was found on the L2 ($p< 0.027$) and L3 ($p< 0.018$), spinal levels. Between the *second group* of children and the *third group* with *lumbar curves*, a difference was found on the T4 and L2 spinal levels, ($p< 0.04$ and $p< 0.017$ respectively).

From the above comparisons it is ascertained that some distinct differences are focused mainly at the lumbar spine.

The spinal levels where the first and the second transitional zone appears, relating to the inclination of the LSP (proclive – declive angle) and the maximum value of the above angles are presented in *Table 1*.

In the *children* of the *first group* the declive angle from T5-T6 to the T12-L1 is greater than that in the remaining groups of children. The children of the *third group*, were presenting declive angles from L1-L2-L3 greater than the non-scoliotics, (first and second group), in the contrary at T5-T6 to T12 the declive angle was smaller than in the non-scoliotics.

Study of the intervertebral LSP (ILSP). In the *first group* the larger intervertebral difference of 5.1° in the LSP appears at the T4-T5 level (intervertebral disc), while in the lumbar spine, 11.8°, at the L4-L5 level. In the *second group* the larger intervertebral difference of 4.5° in the LSP appears at the T3-T4 level and then at T7-T8, while in the lumbar spine, 11.8°, at the L4-L5 level. In the *third group* with thoracic curves the larger intervertebral difference of 5.2° in the LSP appears at the T5-T6 level, while in the lumbar spine, 16.9°, at the L4-L5 level.

In the *third group* with thoracolumbar curves the larger intervertebral difference of 4.85° in the LSP appears at the T6-T7 level, while in the lumbar spine, 15.3°, at the L4-L5 level. In the *third group* with lumbar curves the larger intervertebral difference of 6.1° appears at the T5-T6 level, while in the lumbar spine, 15.7°, at the L4-L5 level.

Table 1

Groups of children	First transitional zone * Spinal level	Spinal level and maximum value of declive angle	Second transitional zone ** Spinal level	Spinal level and maximum value of proclive angle
First group	T5-T6	T12 (-20.4°)	L3-L4	L5 (14°)
Second group (Curves < 10° Cobb)	T6-T7	T12 (-18.46°)	L3-L4	L5 (15°)
Third group Thoracic curves	T6-T7	T12 (-20.7°)	L4-L5	L5 (16.5°)
Third group Thoracolumbar curves	T6-T7	T12 (-20.0°)	L4-L5	L5 (15.7°)
Third group Lumbar curves	T6-T7	T12 (-18.7°)	L3-L4	L5 (16.5°)

*First transitional zone = conversion of proclive into declive angle, **Second transitional zone = = conversion of declive into proclive angle

Table 1: The spinal levels where the first and the second transitional zone, relating to the inclination of the LSP (proclive – declive angle) appears and the maximum value of the above angles, (numbers in parenthesis)

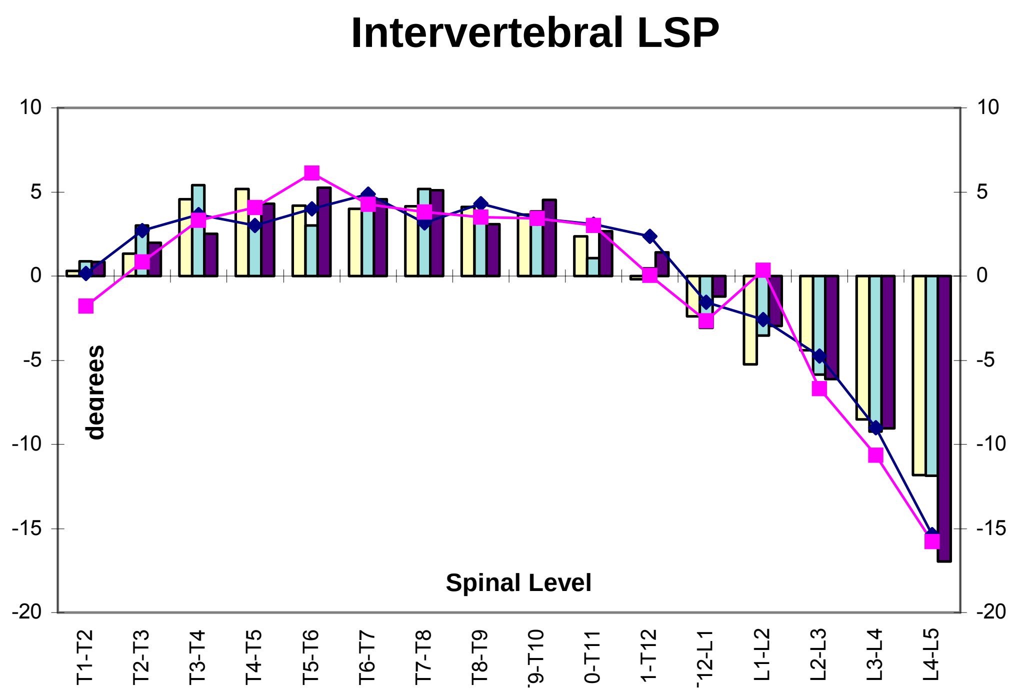

Figure 2. The intervertebral LSP of the various groups of children. Yellow bars = thoracic curves, azure bars = Thoracolumbar curves, mauve bars = lumbar curves, line with blue diamonds = straight spines, line with red rectangles = curves with Cobb < 10 dergees.

Comparison of the segmental intervertebral LSP (ILSP) of the third with the first and second group. Mann-Whitney test showed that ILSP of children in *group one* compared with that of

"*thoracic" group three* was no different, with "*thoracolumbar" group three* was statistically different at T4-5 (p< 0.02) and T11-12 (p< 0.042), and with "*lumbar" group three* was statistically different at T5-6 (p< 0.045). Similarly the comparison of *group two* children's ILSP with that of "*thoracic" group 3* was statistically different at T3-4 (p<0.003) and L4-5 (p< 0.042), with "*thoracolumbar" group 3* was different at T11-12 (p< 0.042), and with "*lumbar" group 3* was different at T5-6 (p< 0.008).
Correlation of LSP with Cobb angle for girls and boys. For the girls there is no correlation pattern found for the thoracic and thoracolumbar curves, but only for the lumbar curves at T3, T4 and T5 levels (r = -.532/p< 0.02, r = -.500/ p< 0.02 and r = -.479/ p< 0.03 respectively), where r represents the *correlation coefficient* and p the statistical significance. For the boys there is no correlation pattern found for the lumbar and thoracolumbar curves, but only for the thoracic curves at T6, T7, T8 and T9 levels (r = 0.595/ p< 0.01, r = 0.618/p< 0.01, r = 0.621/p< 0.01, r = 0.671/p< 0.003, respectively), where r represents the correlation coefficient and p the statistical significance, with the stronger correlation at T9.
The readings for ILSP for lumbar spine is consistently more pronounced at the L4-L5 level for all groups with values ranging from 11.8˚ – 16.5˚; for the thoracic region the greader readings for ILSP are traced higher for the healthy children (T3-T4, T4-T5) and somewhat lower for the scoliotics (T5-T6, T6-T7) with values ranging from 4.5˚ – 5.2˚.

4. Discussion

Sagittal spinal angulation (Kyphosis, lordosis and segmental LSP and ILSP) in the study groups. It is evident from our results that the kyphosis is a little smaller and the lordosis almost similar compared with the published values for healthy children [7,8]. The segmental LSP is no different among the studied groups for boys; it is different only for the scoliotic girls for L2 and L3 levels.

Correlation of LSP with Cobb angle. It is interesting to note that a) there is a positive correlation pattern at T6, T7, T8 and T9 for thoracic curves of scoliotic boys and b) a negative correlation pattern at T3, T4 and T5 spinal levels for lumbar curves of scoliotic girls. This correlation implies that the LSP or the sagittal angulation is associated or influencing the deformity on the frontal plane at the above spinal levels.

LSP and Scoliosis Pathogenesis. In the literature on the aetiology of scoliosis, hypokyphosis is considered a predisposing factor of a scoliosis [1]. It has also been suggested that a flat thoracolumbar profile predisposes an adolescent to idiopathic scoliosis [6]. But equally, the flat thoracolumbar profile could be secondary to the thoracic scoliosis above it. This scientific dilemma should be resolved by the studies of the lateral spinal profile in school screening referrals [8].

This study is addressing the problem whether the sagittal shape deformity or the lateral spinal curve (scoliosis) comes first. Is evident from this study that hypokyphosis is not a predisposing factor of a commencing or small scoliotic curve because there is no difference of the LSP in these curves with the LSP of the respective curves of their healthy counterparts. The minor hypokyphosis of the thoracic spine and its minimal differences observed in the studied small curves when compared with the non-scoliotics in this report add to the view that the reduced kyphosis, by facilitating axial rotation, could be viewed as being permissive, rather than as aetiological, in the pathogenesis of idiopathic scoliosis [4,5].

References

[1]Bonne, A. J. 1969 On the shape of the human vertebral column. Acta Orthop. Belg., 35: 567-583.

[2]Burwell, R.G., Upadhyay, S.S., Wojcik, A.S., Bacon, N.C.M., Moulton, A. and Webb, J.K. (1988). Ultrasound in evaluating scoliosis. In: Proceedings of the Eighth Phillip Zorab Scoliosis Symposium, 26-28 October 1988, London, pp.48-67 Eds. D. Siegler, D. Harrison and M. Edgar. London: Phillip Zorab Scoliosis Research Fund.

[3]Burwell, R.G., Patterson, J.F., Webb, J.K. and Wojcik, A.S. (1990). School screening for scoliosis - the multiple ATI system of back shape appraisal using the Scoliometer with observations on the sagittal declive angle. In: Surface Topography and Body Deformity. Proceedings of the Fifth International Symposium, 29 September - 1 October 1988, Vienna, Austria Eds. H. Neugebauer and G. Windischbauer, pp.17-23 Stuttgart: Gustav Fischer.

[4]Burwell, R. G., A. A. Cole, T. B. Grivas, A. W. Kiel, A. Moulton, S. S. Upadhyay, J. K. Webb, A. S. Wojcik, and D. J. Wythers 1992 Screening, aetiology and the Nottingham theory for idiopathic scoliosis. In 6th International Symposium on Surface Topography and Spinal Deformity. Hotel Escoril Eden. 19-20 September 1990. A. Alberri, R. Drerup, E. Hierholzer (eds.). Stuttgart: Gustav Fischer Verlag, pp. 136—161.

[5] Burwell, R. G., Cole, A. A., Cook, T. A, Grivas,T B., Kiel, A. W., Moulcon, A., Thirlwall, A. S., Upadhyay, S. S., Webb, J. K. Wemyss-Holden, S. A., Whitwell, D. J., Wojcik, A. S., and Wythers, D. J. (1992) Pathogenesis of idiopathic scoliosis: The Nottingham concept. In Symposium on idiopathic scoliosis. Orthopaedica Belgica, Gent, 20-23 March 1991. D. Uyttendaele (ed.). Acta Orthop Belgica. Vol 58, Suppl. I, 1992, 33-58.

[6]Dickson, R. A., and Archer, I. A. 1984 Scoliosis in the community. In Butterworth's International Medical Reviews, Orthopaedics 2, Management of Spinal Deformities. R. A. Dickson and D. S. Bradford (ed.). London: Butterworths, pp. 77-100.

[7]Grivas TB, Baritaki M, Kalamakis N, Kandris K, Polyzois D, Smyrnis P (1998): Normal spinal profile in a Greek high school population sample. 1st Inter-Balkan Congress on Spinal Diseases – Giannestras / Smyrnis Spinal Meeting, 7-9 May 1998. Athens Greece.

[8]Kiel A.W., R.G. Burwell, A. Moulton, M. Purdue, J.K. Webb, And A. S. Wojcik. (1992): Segmental Patterns of Sagittal Spinal Curvatures in Children Screened for Scoliosis: Kyphotic Angulation at the Thoracolumbar Region and the Mortice Joint. Clinical Anatomy. 5, 353-371.