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Study of the Natural History of the Back Trunk Shape by the use of Scoliometer in Children Aged 5-12 Years

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Abstract. The amount of asymmetry of the back trunk shape, that is the existence of a hump, in the general adolescent population during School-screening for scoliosis constitutes one of the strongest indicators for further referral. The aim of this study is to map the trunk asymmetry in normal Mediterranean children 5-12 years of age and to determine its natural history. Material and Method: The readings of scoliometer in 900 children aged 5-12 years (512 boys and 388 girls) were studied. The children were examined at school, during our School-screening program. The bending test was performed both in standing and sitting forward bending positions using the Pruijs scoliometer, in order to quantify, the existing asymmetry, at three areas of interest: in thoracic, thoracolumbar and lumbar area. The severity of asymmetry was defined in two groups: in the 1^{st} group the scoliometer reading was $1°$- $6°$, right or left, and in the 2^{nd} $\geq 7°$ respectively. Seven age groups of children were defined: years <7; 7≤years<8; 8≤years<9; 9≤years<10; 10≤years<11, 11≤years<12, years≥12.
The existing symmetries and asymmetries are presented at the three areas of interest, in the two severity groups of asymmetry, in the seven age groups, for the boys and girls. Trunk asymmetries are found in normal children with no spinal curve, and they are increasing progressively downwards from the thoracic to the lumbar area. The more frequently found asymmetries are to the left. The asymmetries to the right are more frequently traced by age. It is shown that there are more asymmetries in the standing than in the sitting position. The traced percentage of symmetry is larger in the sitting position, which is after leveling the pelvis and elimination of any leg length inequality effect on back shape. Thus the real trunk asymmetry is revealed. The differences in percentage in asymmetries in the examination in the two positions are probably expressing the existing small leg length inequalities. These leg asymmetries are either equalized during growth or they facilitate the increasing of trunk asymmetry and probably the pathogenesis of scoliosis with the contribution of other mechanisms, according to our hypothesis. Another statement that can be implied from this study is that asymmetries in the form of thoracic or lumbar hump are traced in the thorax or in the loin, without an apparent deformity in the spine (central axis). This means that the deforming forces, which begin the asymmetry, do not initiate at the spine, as it is elsewhere claimed. The findings of this study and the above mentioned hypothesis are compatible with the existing Nottingham theory for pathogenesis of scoliosis. According to our findings we recommend the sitting forward bending position as standard position for examining the rib or loin hump.

1. Introduction

The amount of asymmetry of the back trunk shape, that is the existence of a hump at the thoracic, thoracolumbar or lumbar area in the general adolescent population during School-screening for scoliosis, constitutes one of the strongest indicators for referral and further orthopaedic assessment. The primary aim of this study is to map the trunk asymmetry in a sample of Mediterranean school children, 5-12 years of age, and to determine its natural history using the scoliometer; and secondarily to set the 95% confidence limits of the method in use and to determine the preferred position of examination for asymmetry (that is the standing or the sitting forward bending position).

2. Materials & Methods

The readings of scoliometer in 900 children aged 5-12 years (512 boys and 388 girls) were studied. Seven age groups of children were defined, namely: those with =7 years of age, 7<years<8, 8≤years<9, 9≤years<10, 10≤years<11, 11≤years<12, years≥2 respectively. The children were examined at school, using a particular protocol that involved assessment of height and weight among several measurements. *The scoliometer.* The Pruijs (1991) scoliometer was used in order to quantify, in degrees, the existing asymmetry (rotation of the turso - hump). Orthomet-Surgeyplant B.V. Postbus 483, 5140 AL Waalwijl, Netherlands supplied the instrument. *The bending test.* The bending test was performed in standing and sitting forward bending position. *The standing forward bending position.* The student was asked to bend forward looking down, keeping the feet approximately 15 cm apart, knees braced back, shoulders loose and hands positioned in front of knees or shins with elbows straight and palms opposed. Any leg length inequality was not corrected. The scoliometer was used by one observer (TBG) at three areas of interest: at thoracic (T7-8), thoracolumbar (T12) and at the lumbar area (L3-4). *The sitting forward bending position.* The student was seated on a chair (40 cm high) and was asked to bend forwards and place the head between the knees with the shoulders loose elbows straight and hands positioned between knees. The scoliometer readings were obtained successively at the same three areas of interest as in standing forward bending position. *The severity of asymmetry.* The severity of trunk asymmetry was defined into two groups: in the 1st group the scoliometer reading was between 1° to 6°right or left, and in the 2nd group ≥ 7° respectively. *Leg length inequality.* Leg length inequality measurements were not obtained during school screening examination. This measurement is obtained regularly in referrals, in our scoliosis clinic, using a tape. *Reliability study for Pruijs's scoliometer readings.* The Pruijs's scoliometer readings were obtained in the described above three areas of interest, in 7 school children, aged within the range of the study population. One observer (TBG) twice obtained the readings on each child. Then the difference for each pair of readings was calculated. Finally, the intra-observer error was calculated at 95% confidence limits using the formula:

$$\text{Intra-observer error} = \frac{SD}{\sqrt{2}} \times 2$$

The inter-observer error was calculated using the first set of TBG readings and those of another observer (BE), using the same formula. The findings are shown in Table 1.

Table 1. Reliability study for Pruijs's scoliometer readings

scoliometer readings	intra-observer error in degrees	inter-observer error in degrees
standing forward bending test		
thoracic (T7-8)	1.82	2.63
thoracolumbar (T12)	3.24	3.33
lumbar (L3-4)	4.04	4.29
sitting forward bending test		
thoracic (T7-8)	2.15	3.73
thoracolumbar (T12)	2.55	2.13
lumbar (L3-4)	4.09	4.10

Statistical analysis. The SPSS PC package was used. Statistical techniques included frequencies, descriptives, Mann-Whitney, Wilcoxon and Kruskal-Wallis tests, cross-tabulation and scatterplots.

3. Findings

The existing symmetries/asymmetries from scoliometer readings are presented using bar charts, at the three areas of interest, in the two groups of asymmetry severity, in the seven age groups, for boys and girls.

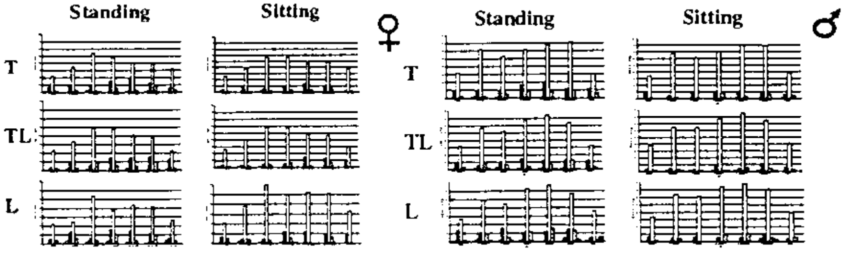

Fig 1. The existing symmetries and asymmetries from scoliometer readings T = thoracic: TL = thoracolumbar: L = lumbar. At each set of bars the 2 left (right) small bars represent left (right) asymmetries in the 2 severity groups of trunkal asymmetry. The middle bar represents symmetry. x axis represent age groups, y axis represent the number of children.

Cumulatively, the findings are presented as percentages in Tables 2 & 3.

Table 2 Symmetries in boys and girls

	STANDING FORWARD BENDING		SITTING FORWARD BENDING	
	Boys	*Girls*	*boys*	*girls*
thoracic	73.57%	70.70%	83.68%	81.32%
thoracolumbar	73.77%	66.67%	86.90%	79.35%
lumbar	67.10%	64.22%	82.20%	77.80%

Table 3 Asymmetries in boys and girls

	STANDING FORWARD BENDING		SITTING FORWARD BENDING	
	boys	*Girls*	*boys*	*girls*
thoracic	26.43%	29.30%	16.32%	18.68%
thoracolumbar	26.23%	33.33%	13.10%	20.65%
lumbar	32.90%	35.78%	18.80%	22.20%

Asymmetries in group 2 (scoliometer reading > 7°) are shown in Table 4. These asymmetries are reflecting the percentage of small curves in the study population.

Table 4 Scoliometer reading > 7° (group 2)

	STANDING FORWARD BENDING		SITTING FORWARD BENDING	
	boys	*Girls*	*boys*	*girls*
thoracic	0.97%	4.63%	0.58%	0.58%
thoracolumbar	2.92%	3.34%	1.75%	1.28%
lumbar	5.07%	5.41%	1.95%	1.28%
total	8.96%	13.38%	4.28%	3.15%

Crosstabulating the trunkal asymmetry with right or left handed children (laterality), it was shown that there is no statistical significance for the boys but there is for girls for the sitting forward bending position at the thoracolumbar and, more, at the lumbar area (Pearson p = 0.0027 and 0.0000 respectively, in right hand children left trunkal asymmetry). Scatterplots of children Body Mass Index (BMI: body weight in kg/height in m^2) by asymmetry showed no correlation. Analysing our reliability study for Pruijs's scoliometer readings we observe that maximal variability is shown at the lumbar and minimal at the thoracic region. Scoliometer readings are reported to have a variability of ±2° to ±4° (Mubarak et al. 1984, Upadhyay 1987, and Pruijs 1992).

4. Discussion-Conclusions

Trunkal asymmetries are found in normal children with no spinal curves, as it is shown in this and other reports (Burwell et al 1983). The asymmetries are increasing progressively from thoracic to the lumbar area. Even though no statistical significance was found (Mann-Whitney, Wilcoxon and Kruscal Wallis tests), arithmetically the more frequently found asymmetries are those to the left. The right-sided asymmetries are more frequently traced by age. In healthy children a physiological shortening of one leg (1-2 cm) is associated with a contralateral hump on the back in forward flexion (Burwell et al 1983). It is shown that the comparison of the standing and sitting forward bending position asymmetries is in favor of the standing one. The percentage of symmetry is larger in the sitting position, after leveling the pelvis and eliminating any effect of leg length inequality on back shape. Then the real trunkal asymmetry is revealed. The differences in percentage of various asymmetries in the examination in the two positions are probably expressing the existing small leg length inequalities, or in scoliotics the coupling phenomenon between «hump rotation» and forward flexion in lumbar lateral curves (Upadhyay et al 1987). These leg asymmetries in normal children are either equalized during growth, or with the contribution of other mechanisms, according to our hypothesis, facilitate the increase of trunkal asymmetry and probably the pathogenesis of scoliosis. We are recommending, according to our findings, the sitting forward bending position as a standard one for examining the rib or loin hump. Another statement that can be implied from this study is that asymmetries in the form of thoracic or lumbar hump are earlier traced in the thorax, or in the loin, without any apparent deformity in the spine (central axis This means that the deforming forces that begin the asymmetry do not start within the spine (Dickson et al 1984) but elsewhere. These findings are compatible with the existing Nottingham theory for pathogenesis of scoliosis (Burwell et al 1992). Finally, the asymmetries reflecting the percentage of small curves in our study, see Table 4, are similar to other Greek school screening findings (Smyrnis et al 1979, Soucacos et al 1997).

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