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A HIGH INCIDENCE OF SPINAL CURVATURE

A Study of 100 Young Female Students

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A hundred adult female students were clinically examined for scoliosis and other spinal abnormalities. Ninety-nine per cent of them participated voluntarily in X-ray examination of the spine. Of the X-rays only 34 per cent were classified into group without spinal curvature. Mild curvature (3–10 degrees) was observed in 51 per cent and a curvature of 11 degrees or more in 15 per cent. The average angle of curvatures was 7.7 degrees. The incidence of 66 per cent of spinal curvatures exceeds what has been observed before. Rotation was observed in spinal X-ray in 86 per cent, but the average of rotation was the same both in spines with curvature or without. In grades of kyphosis and lordosis no difference was observed between the groups with spinal curvature and without. Mild scoliotic curvature and rotation of the spine must be seen as a normal phenomenon at least in females. What makes these curvatures progress during the growth period in idiopathic scoliosis remains to be clarified.

Key words: incidence; scoliosis

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In earlier studies scoliosis has been observed in 3–16 per cent of the population depending on the degree of curvature which has been chosen as the limit of scoliosis and on the age of the subjects (Kane 1977, Lonstein 1977). Of all cases of scoliosis requiring treatment, 90 per cent are females, but mild scoliosis has been observed nearly as frequently in boys as in girls (Drummond et al. 1979). Most scoliosis studies depend on clinical screening or on mini X-rays, which do not give the real incidence of spinal curvatures.

The aim of the study was to find out the incidence of spinal curvatures in adult females by clinical and roentgenological means and to suggest limits of normality for further studies, and try to find out correlations between clinical and roentgenological findings. The results of the clinical study are to be presented in another paper.

MATERIAL AND METHODS

The studies were carried out from 1973 to 1974. A hundred 20–23-year-old female physiotherapist students (two whole year courses) were asked to take part in the study. No requirements concerning height, weight or build had been imposed for beginning their physiotherapist studies. A clinical orthopaedic investigation was made including spinal X-ray. The side film was taken in a recumbent position because of better quality of X-rays and comparability. The antero-posterior film was taken on standing, feet parallel and pelvis 90 degrees to X-ray. Exposure took place at a distance of 250 cm for the ap-film and 100 cm for the side film. Normal radiation protection was used. X-ray examination was voluntary but 99 per cent of the students were willing to have the X-rays because 25 per cent of them had had occasional back pain whilst under physical stress and because the examination was related to their future work. Curvatures and rotation were measured in X-rays according to Cobb (1948). Rotation was expressed as an index of percental displacement of pro-

cessus spinosus from midline to the rim of vertebrae. The measurement was made from the shadow of processus spinosus most clearly seen in X-ray. Seen from behind the rotation was to the left (anti-clockwise rotation) or to the right (clockwise rotation). The kyphosis was measured from the side film as an angle of lines drawn parallel to the second and twelfth thoracic vertebrae. Lumbar lordosis was measured analogously from L I and L V. Congenital anomalies and acquired changes as degeneration of disci, osteochondrosis, retro- or antepositio of the vertebrae, spondylolysis and spondylolisthesis of the spine were registered.

The material was divided into three groups on the basis of X-ray: Grade 0 (curvature < 3 degrees), Grade I (3–10 degrees) and Grade II (≦ 11 degrees). The curvature of three degrees was chosen as a limit, because it was easy to see in X-ray and was repeatedly measurable. The largest curve was seen to be the major curve. The curves were classified into cervicothoracic, thoracic, thoracolumbar and lumbar curves. A statistical analysis of the findings from the spinal X-rays was made between the three groups mentioned above. Student's t-test, χ^2 (chi square) and Fisher's exact probability test were used. *P*-value smaller than 0.05 was regarded as a statistically significant value.

RESULTS

Scoliotic curvatures

In ap-film no curvature was observed in 34 per cent of the students, grade I curvature in 51 per cent and grade II in 15 per cent (Table 1). From the cervicothoracic curves one was to the left, one to the right, from thoracic one to the left, 21 to the right, from thoracolumbar seven to the left, 16 to the right, and from lumbar five to the right, 14 to the left. 65.2 per cent of the curves were right-sided, 34.8 per cent were left-sided (Table 2). The most frequent curve was 8 degrees, and the average was 7.7 degrees (range 3–25) (Fig. 1). A single curve was seen in 48 cases and a double curve in 18 of which 10 were of thoracic right, lumbar left type. The vertebrae most frequently participating in curvatures were L II, L I, L III and Th XII in this succession frequency (Fig. 2). On an average six vertebrae participated in forming the curvature.

Table 1. Types and numbers (%) of 66 major spinal curves

	Gr 0	Gr I	Gr II	Total
Cervicothoracic	–	1	1	2 (3.0%)
Thoracic	–	17	5	22 (33.3%)
Thoracolumbar	–	19	4	23 (34.9%)
Lumbar	–	14	5	19 (28.8%)
No curvature	34	–	–	–
Total	34(%)	51(%)	15(%)	100 (100%)

Table 2. Direction of the major curve in 66 spinal curves

	Right		Left		
	GR I	Gr II	Gr I	GR II	Total
Cervicothoracic	–	1	1	–	2
Thoracic	17	4	–	1	22
Thoracolumbar	14	2	5	2	23
Lumbar	4	1	10	4	19
Total	35 (53.0%)	8 (12.1%)	16 (24.2%)	7 (10.6%)	66 (100%)

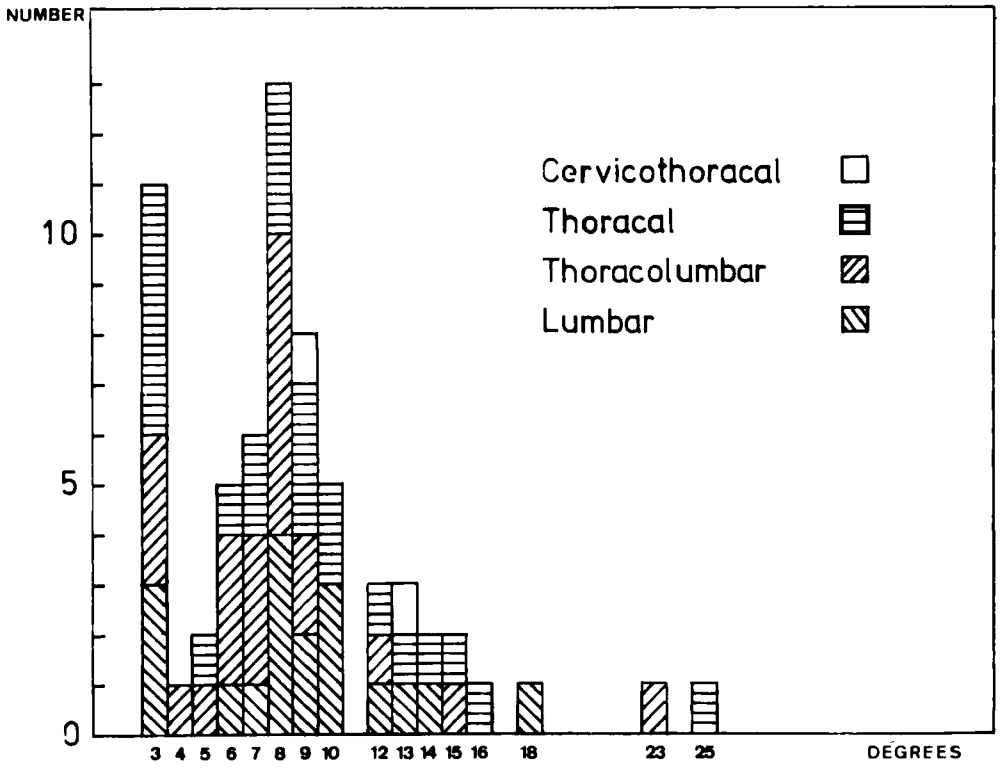

Figure 1. The number of spinal X-rays of different degrees of curvature.

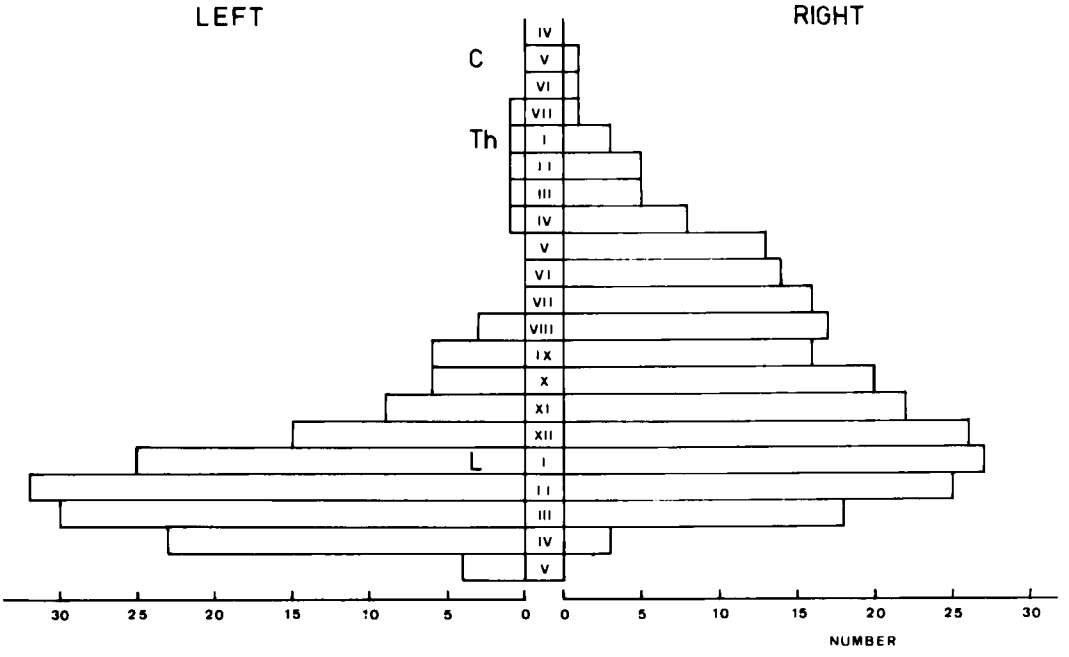

Figure 2. The number of times each vertebrae participated in forming the left- or right-sided major curve.

Rotation

Some degree of rotation was observed in 86 per cent of the ap-films. The average index of rotation was 21 (range 6–52). In the grade II group clockwise rotation (index 32) was greater than anti-clockwise rotation (index 20) ($P < 0.05$). In this respect no difference appeared in other groups. Rotation was not observed in 18 per cent of spines in study group 0, 12 per cent in group I and 13 per cent in group II. The differences were not statistically significant. One maximum of rotation, clockwise or anti-clockwise, was seen in 27 cases, two maximums in 45 and three maximums in four cases. In the thoracic area rotation was 38 times anti-clockwise, 18 times clockwise and five times in both directions. In the lumbar area the figures were 34, 37 and one, respectively. Different modes of rotation are seen in Table 3. Rotation took place in 23 cases to opposite direction at two points but in 16 cases both thoracic and lumbar rotation were to the same direction. Mostly rotation appeared in vertebrae Th I–IV and L II–IV (Fig. 3). In 20 cases rotation was seen without curvature. The position of symphysis in relation to midline could be measured in 77 X-rays. In three fourths of cases it was along the midline and in one fourth to the right or to the left. There were no differences between the study groups.

Kyphosis – lordosis

Thoracic kyphosis was on average 28 degrees (±1 s.e.) and lumbar lordosis 26 degrees (±2). In these respects there was no difference between the study groups.

Anomalies and acquired changes in spinal X-rays

Congenital abnormalities were found in group 0 in 15 per cent of X-rays and in spines with curvatures (grade I + grade II) in 20 per cent and acquired changes respectively in 29 per cent and 44 per cent. The differences were not statistically significant (Table 4).

DISCUSSION

The exact incidence of scoliosis in the adult population is unknown (Kostuik 1980). Most research on prevalence of scoliosis deals with growing children selected by clinical screening. Thus a lot of mild curvatures have remained un-

Table 3. Different models of vertebral rotation

Rotation	Gr 0	Gr I	Gr II	Total
Thoracic right*	3	2	0	5
Thoracic left**	7	1	0	8
Th-right – lumbar left	1	3	1	5
Th-right – lumbar right	1	7	0	8
Th-right – th-left	0	1	0	1
Th-left – lumbar right	5	5	4	14
Th-left – lumbar left	2	11	3	16
Th-left – th-right – lumbar left	1	1	1	3
Th-left – th-right – lumbar right	0	0	1	1
Lumbar right	3	10	1	14
Lumbar left	5	3	2	10
Lumbar left – lumbar right	0	1	0	1
No rotation	6	6	2	14
Total	34	51	15	

* Right, clockwise rotation.
** Left, anti-clockwise rotation.

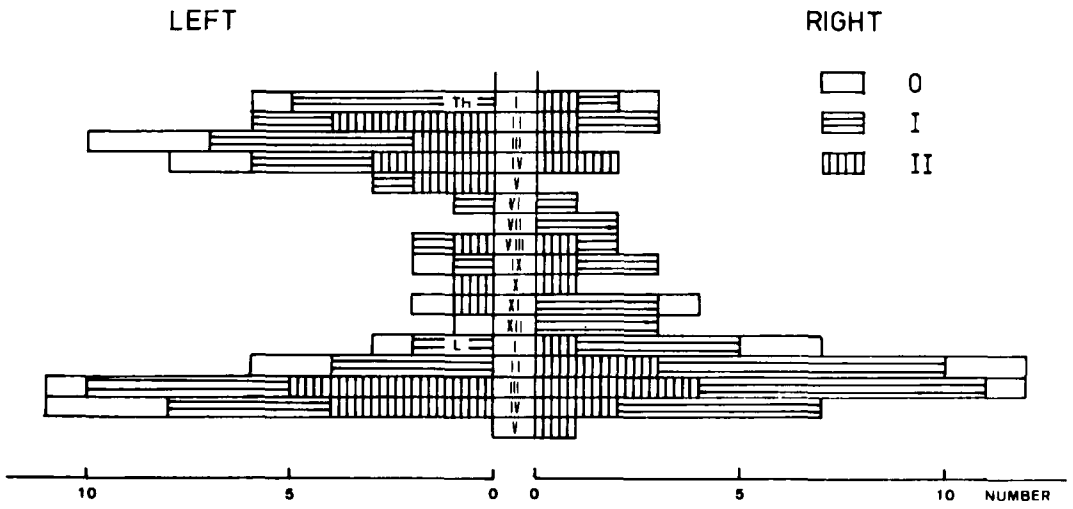

Figure 3. The number of times each vertebra participated in forming the maximum of rotation to the left (anti-clockwise) or to the right (clockwise) in study groups grade 0, grade I and grade II.

noticed, and in minifilm studies lumbar curvatures are not found. The highest frequencies of scoliosis have been found on the basis of clinical screening by Brooks et al. (1975), who discovered scoliosis in 14 per cent of girls with a mean age of 13 years and Newman & De Wald (1977), who found that 21.4 per cent of high school girls had scoliosis. The lower limit of the curve was five degrees in both studies. In minifilm studies scoliosis of 10 degrees or over has been found in 1.9 per cent of girls, 14 years or over (Shands & Eisberg 1955). In the present study of young adult women a much higher frequency of spinal curvature was observed. Curvatures over 10 degrees were found in 15 per cent, five degrees or over in 54 per cent and three degrees or over in 66 per cent. In fact, a completely straight spine was the exception rather than the rule in this material. Part of the above mentioned curvatures apparently were nonstructural, but mild curvatures are impossible to separate into nonstructural and structural curves either clinically or in X-ray. However, the distribution of curves along the spine was the same as in other studies for scoliosis (Newman & De Wald 1977, O'Brien & Van Akkerveeken 1977), roughly one third thoracic, one third thoracolumbar and one third lumbar curves. Also it is highly probable that if one of these mild curvatures had been of progressive type of idiopathic scoliosis it had progressed to the same direction as the present one.

As can seen (Fig. 1) one peak of the curves was at three degrees and the other peak at eight degrees. We expected an even decrease of frequency of curvatures towards higher degrees. The reason for this unexpected finding remains

Table 4. Numbers (%) of congenital and acquired abnormalities in X-rays of 100 spines

Cervical rib	3
Four lumbar vertebrae	5
Six lumbar vertebrae	5
Transitional Th XII	1
Transitional L V	1
Neoarthron L V–S I	3
Spina bifida occulta	5
Lumbar apophyseal nonunion	5
Spondylolysis L V	5
Spondylolisthesis L V	1
Osteochondrosis	20
Retropositio* L I	1
Retropositio L II	2
Retropositio L III	2
Retropositio L IV	9
Degeneratio disci L III–IV	3**
Degeneratio disci L IV–V	3
Degeneratio disci L V–S I	1

* at least 3 mm.
** two cases apophyseal nonunion.

obscure. One might imagine that the high number of three degree curvatures would be explained by error (±2°) of measurement, but this is not the case. For example, all three degree curves in the thoracic area were to the right as were the larger curves and all had had some rotatory component. It would be unfair to exclude minor curvatures when we are searching for the etiology of idiopathic curvatures.

In the present material two thirds of the curves were to the right and one third to the left. In this respect the results are in accordance with the findings of Brooks et al. (1975) but in the study of Newman & De Wald (1977) about one half of the curves were to the right and one half to the left.

Some degree of rotation could be measured in 86 per cent of X-rays. The Cobb method was found suitable for measuring minor degrees of rotation (Mehta 1973). The methods of measuring rotation from the tip of processus spinosus (Cobb 1948) has been criticized (Nash & Moe 1969) as has the pedicle method of Nash & Moe (Benson et al. 1976). The Cobb method was found more suitable in the present study as regards the relative measurements of rotation. The experimental works criticizing the Cobb method have used the tip of processus spinosus. In the present study the tip of processus spinosus was difficult to see in X-ray and therefore the measurements were made from the point of processus spinosus most clearly seen. This means the point is somewhere in the middle of processus spinosus. The errors of detorsion and distorsion were thus minimized. In the lumbar area the rotation was best controlled from the shadows of transverse processes. Rotation per se seems not to be obligatory to spinal curve because in some curves rotation did not appear and the frequency of rotation was the same in all study groups. In some cases rotation was in the same direction at two points. It was interesting that in the thoracic area maximal rotation mostly appeared in vertebrae Th I–IV and overwhelmingly to the left (anticlockwise). It was not secondary to rotation of the thorax when compared to shadows of the medial ends of clavicles. In most thoracic curvatures and additional rotation took place typically clockwise. In the lumbar areas maximal rotation appeared "in a normal way", at the apex of curvature. However, rotation appeared often also without curvature.

In clinical screening of the present material remarkable asymmetry of hip rotation was observed (Avikainen, in manuscript), which may result from the body's compensation of spinal rotation outside the spinal area. On the other hand, in our observations concerning progressive scoliosis the rotation of the hips is predominantly symmetrical (unpublished observation). It is possible that in progressive scoliosis rotation of the body takes place only in the spinal area and may have a bearing on the progression of scoliosis.

Many students when asked complained of previous back pain. In one fourth of spinal X-rays retroposition of vertebrae and mild degenerative changes were observed in the lower lumbar area. Both rotational stress on vertebrae and spinal curvature may have an effect on degenerative changes in the lumbar area.

Thoracic lordosis has been connected with scoliosis (Sommerville 1952, Roaf 1966). In this study the scoliotic curves were quite mild and this may be the reason why no differences were seen in thoracic kyphosis and lumbar lordosis between the curvature and non-curvature groups.

In summary then, a mild curvature of the spine was very common in young, adult females. The eight degree curve was the most frequent one. The distribution of mild curvatures along the spine was the same as in 'real scoliosis'. Rotational deformity was even more common than spinal curvature.

In some cases compensatory rotation of the spine apparently occurred outside the spinal area. The results of the clinical study and the effects of spinal muscle reflex asymmetry on spinal curvature pathology are discussed in another paper.

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