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# A PROSPECTIVE PREVALENCE STUDY OF SCOLIOSIS IN SOUTHERN SWEDEN

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In Malmö, Sweden, 17,181 school children born in the years 1961–1965 were screened for scoliosis once a year between the ages of 7 and 16 years, during 1971–1980. Children with clinical signs of scoliosis including a positive forward bending test were admitted to the Department of Orthopedic Surgery for reinvestigation and AP roentgenograms. There were 474 children with a scoliosis measuring 5° or more (prevalence 2.8 per cent). Among the girls this prevalence was 4.3 per cent ($n = 367$) and among the boys 1.2 per cent ($n = 107$). This combined screening test revealed in girls a higher percentage of scoliosis measuring 10–14° than 5–9°, 1.3 and 1.1, respectively. In boys, however, the number of curves measuring 5–9° was almost equal to the number exceeding 9°. Thus, the rotational component of the scoliosis seems to be less pronounced in girls and curves less than 10° can easily be missed in them. Therefore, 10° is recommended as the lower limit when using this screening technique. With 10° as the lower limit, the scoliosis prevalence was 3.2 per cent in girls and 0.5 per cent in boys. Ninety-six of the girls (1.1 per cent) had a scoliosis exceeding 19°, 46 showed a progression of the scoliosis, which indicated brace treatment in 42 cases and surgical treatment in 4 cases.

Among the boys 12 had curves measuring more than 19° (0.14 per cent). Four boys with curves exceeding 24° were treated with a brace.

Thus, the risk of progression was higher in girls as compared with boys; 0.5 per cent of the girls and 0.05 per cent of the boys were treated. Another 0.2 per cent of the girls should also have been treated but, for various reasons, treatment was not carried out.

*Key words:* prevalence study; school screening; scoliosis

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During the last few decades, great progress has been made in the treatment of structural scoliosis. This is true both as regards brace treatment and surgical treatment. Early detection of spinal deformity is, however, essential, so that more cases can be controlled with conservative treatment and several surgical exposures can be prevented. Therefore, interest in scoliosis screening programs and their evaluation has increased markedly during the last few years. A knowledge of the natural history of scoliosis is important in understanding the development of this disorder. However, incidence studies have shown a wide variation. This can be due to different definitions of scoliosis, to different techniques of screening (with or without roentgenograms), to the "know how" of screening or to a true deviation of the frequency of scoliosis in different populations.

The purpose of this study was to analyze the prevalence of scoliosis in a well-defined population in Malmö in Southern Sweden, by using a

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combined clinical and roentgenographical screening technique which was repeated annually at school between the ages of 7 and 16.

## MATERIAL AND METHOD

A prospective study of the incidence of scoliosis was made in the city of Malmö amongst the population born in the years 1961–1965. In all, 17,181 cases have been followed up between 1971 and 1980. There were 8,469 girls and 8,712 boys.

All the children were investigated annually by the school doctors and nurses who had been especially instructed in school screening of scoliosis by one of the authors. Furthermore, from 1978, an especially trained school nurse visited the schools and assisted in the screening. All children between 7 and 16 years of age were screened at school once a year. Those with signs of structural scoliosis in the standing or forward bending positions were admitted to the Department of Orthopedic Surgery, Malmö General Hospital, where they were reinvestigated by the authors and roentgenographed. This follow-up was completed in 1980, when all children had passed the age of the growth spurt and no further scolioses were expected to occur (Brooks et al. 1975, Willner, unpublished data).

### *School screening program*

The child was asked to stand in an erect, relaxed position with equal loading on both legs. Lateral deviation of the spine, asymmetry of the waist line, shoulders and scapulae were registered. The child was then asked to bend forward, holding the arms hanging free with the palms opposed. The back was studied from the head of the child. Asymmetries between the two halves of the back were determined. If an asymmetry of 1 cm or more between the convex and the concave sides was seen, a scoliosis was suspected and the child was admitted to the Department of Orthopedic Surgery for reinvestigation, and A-P roentgenograms on films 100 × 30 cm were obtained in a standing position. Roentgenographically, a curve of 5° or more (according to Cobb 1948) was defined as a structural scoliosis.

## RESULTS

Of 17,181 children screened, a total of 474 cases (2.8 per cent) had roentgenographically a structural scoliosis of 5° or more. There were 367 girls and 107 boys which makes a prevalence of 4.3 per cent and 1.2 per cent, respectively. The male/female ratio was 1:3.6. The distribution of the structural scoliosis, according to the size of the curves, is demonstrated in Table 1. The magnitude of the scoliosis in the non-treated group was registered at the end of growth. In the treated groups, the degree of curvature was determined immediately before treatment was started. The final size of these scolioses, if untreated, was, of course, not known.

The sex ratio for the different sizes of the scoliosis curves is demonstrated in Table 2. The female dominance increases noticeably with increasing size of the scoliosis curve. Ninety-six girls had a scoliosis exceeding 19°, i.e. 1.1 per cent of the entire female material. Of these, 46 (47.2 per cent) demonstrated progression of the curves, indicating brace treatment in 42 cases and surgical treatment in 4 cases. In this material, only one girl had brace treatment starting with a curve less than 25°.

In 24 out of 96 girls (25 per cent) with a

*Table 1. The distribution of the scolioses according to the size of the curves*

| Size of the curves (degrees) | Girls | | | | Ratio girls/boys | Boys | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Non-treated | | Treated | | | Non-treated | | Treated | |
| | No. | Per cent | No. | Per cent | | No. | Per cent | No. | Per cent |
| 5– 9 | 95 | 1.12 | | | 1.8 | 52 | 0.60 | | |
| 10–14 | 106 | 1.25 | | | 3.8 | 28 | 0.32 | | |
| 15–19 | 70 | 0.82 | | | 4.7 | 15 | 0.17 | | |
| 20–24 | 24 | 0.28 | 1 | 0.01 | 4.2 | 6 | 0.07 | | |
| 25–29 | 12 | 0.14 | 14 | 0.17 | 13 | 2 | 0.02 | | |
| 30–34 | 8 | 0.09 | 8 | 0.09 | 8 | | | 2 | 0.02 |
| 35–39 | 4 | 0.05 | 8 | 0.09 | 12 | | | 1 | 0.01 |
| 40–49 | 1 | 0.01 | 7 | 0.08 | 17 | | | 1 | 0.01 |
| >49 | 1 | 0.01 | 8 | 0.09 | | | | | |

*Table 2. Distribution of the size of the scoliosis curves in 107 boys and 367 girls with scolioses exceeding 5°*

| Size of curves (degrees) | Boys (per cent) | Girls (per cent) |
|---|---|---|
| 5– 9 | 48.2 | 25.9 |
| 10–19 | 40.2 | 47.9 |
| 20–29 | 7.5 | 13.9 |
| 30–39 | 2.8 | 7.6 |
| >40 | 0.9 | 4.6 |

scoliosis measuring more than 19°, the progression of the curve ceased spontaneously before the curve reached 25°. In another 12 girls (12.5 per cent), the progression came to an end between 25–29° without treatment. Of the male population, only 12 cases were found to have curves of more than 19° (0.14 per cent). Four boys (33 per cent) with curves exceeding 24° were treated with a brace.

Totally, 0.5 per cent of all girls and 0.05 per cent of all boys were treated. The distribution of the apex of the scoliosis in boys and girls is demonstrated in Table 3. The scolioses were divided into thoracic curves with apex between D 2 and D 11, thoracolumbar curves between D 12 and L 1 and lumbar curves between L 2 and L 5. In double curves, the difference between the curves did not exceed 5°.

*Table 3. Distribution of the convexity in boys and girls according to the level and size of the curves*

| | 5–9 degrees | | 10–19 degrees | | 20–29 degrees | |
|---|---|---|---|---|---|---|
| | Boys $n=52$ (per cent) | Girls $n=95$ (per cent) | Boys $n=43$ (per cent) | Girls $n=176$ (per cent) | Boys $n=8$ (per cent) | Girls $n=51$ (per cent) |
| Thoracic | 46.5 | 43 | 35.7 | 46.0 | 50 | 45 |
| convexity right | 75 | 75 | 73.3 | 89 | 100 | 87 |
| left | 25 | 25 | 26.7 | 11 | | 13 |
| Thoracolumbar | 32.5 | 32.3 | 38 | 30.1 | 50 | 23.5 |
| convexity right | 43 | 37 | 44 | 35 | 50 | 42 |
| left | 57 | 63 | 56 | 65 | 50 | 58 |
| Lumbar | 14.0 | 16.1 | 7 | 10.4 | | 19.6 |
| convexity right | 17 | 13 | | 23.5 | | 50 |
| left | 83 | 87 | 100 | 76.5 | | 50 |
| Double curves | | | | | | 19.9 |
| convexity right/left | 7 | 8.6 | 19.0 | 13.5 | | 100 |
| left/right | 0 | 0 | 0 | 0 | | |

| | 30–39 degrees | | >40 degrees | |
|---|---|---|---|---|
| | Boys $n=3$ (per cent) | Girls $n=28$ (per cent) | Boys $n=1$ (per cent) | Girls $n=17$ (per cent) |
| Thoracic | 33.3 | 42.9 | 100 | 70.5 |
| convexity right | | 92 | 100 | 100 |
| left | 100 | 8 | | |
| Thoracolumbar | 33.3 | 32.1 | | 11.8 |
| convexity right | | 33 | | 50 |
| left | 100 | 66 | | 50 |
| Lumbar | | 7.1 | | 11.8 |
| convexity right | | | | |
| left | | 100 | | 100 |
| Double curves | 33.3 | 17.9 | | 5.9 |
| convexity right/left | 100 | 100 | | 100 |
| left/right | | | | |

## DISCUSSION

During the last few decades interest has increased in prevalence studies of scoliosis. A wide variation has, however, been observed. Percentages ranging between 13 (Brooks et al. 1975) and 0.35 (Hensinger et al. 1975) have been reported. There are many reasons for these differences. The definition of the minimum curve size varies. A minimum curve size of 5 degrees has been suggested by many authors, among others by Lonstein (1977). During last few years, however, a 10° lower limit has been discussed (Brooks 1980). One reason for the great variation observed could be the difficulty in making a clinical diagnosis of the majority of smaller curves, less than 10°. The study emphasizes this difficulty; our combined clinical and roentgenographical screening program shows in girls a higher frequency of scoliosis between 10–14° than between 5–9° (1.3 and 1.1 per cent, respectively). In boys, however, the number of curves between 5–9° was almost equal to the number above 10°, which means that the rotational component of the scoliosis seems to be more predominant in boys as compared with girls, and that scoliosis in boys is easier to detect in a clinical screening program based on a forward bending test. Thus, curves measuring less than 10° may be missed in girls. We therefore agree with the members of the Prevalence Committee of the Scoliosis Research Society that 10° should be the lower limit for a spinal curve which will be defined as structural scoliosis when using this technique of screening.

It is always important that the school doctors and nurses should be familiar with the screening program. This can best be achieved by close cooperation between the school doctors and the orthopedic surgeons responsible for the scoliosis treatment in their area. Repeated information regarding the screening program and understanding of the scoliotic disorder is of great importance. In Malmö, a specially trained school nurse also visits the different schools once a year and assists in the scoliosis screening. The school children with a clinically diagnosed scoliosis were sent to the authors for reinvestigation. Cases with signs of structural scoliosis including rotational deformity in the forward bending position were roentgenographed. By repeating this screening annually, between 7 and 16 years of age, all scolioses with a curve of at least 10° could be expected to be diagnosed and the prevalence of scoliosis determined in this population up to at least the age of 16. After this age, new cases are not expected (Brooks et al. 1975, Willner, unpublished data).

Variations of prevalences of scoliosis in different populations have been suspected. The problem is, however, that different screening techniques cannot be compared. In a few studies, different groups of people have been compared with the same screening methods. Skogland & Miller (1978) noted in Norway a different prevalence of scoliosis among Lapps and non-Lapps (0.5 per cent and 1.3 per cent, respectively) when studying microfilms. Segil (1974) observed different prevalences of scoliosis among Caucasians (2.5 per cent) and Africans (0.03 per cent) in South Africa. Finally, Smyrnis et al. (1980) also reported a different prevalence in the populations of three islands in Greece (7.7 per cent, 4.1 per cent and 3.3 per cent, respectively).

In this urban population of Malmö there was a total scoliotic incidence of 4.3 per cent in girls and 1.2 per cent in boys (a curve of 5° or more). However, if we accepted 10° as the lower limit for scoliosis screening, the scoliosis prevalence would be 3.2 per cent in girls and 0.5 per cent in boys. In the present material, 1.1 per cent of the girls and 0.14 per cent of the boys developed curves during their growth exceeding 20°, i.e. in 1:3.0 of the girls with a scoliosis exceeding 10° there will be a further progression to at least double this size. In boys, the corresponding ratio was 1:3.6.

Out of 96 girls, with a scoliosis exceeding 19°, 45 deteriorated further and developed a scoliosis exceeding 29° and furthermore 15 girls were treated with a brace (Table 1) so we do not know what the degree would have been if they had been untreated. This means that the risk ratio for progression in these girls is between 1:1.6–1:2.1. The corresponding figure for boys with scoliosis exceeding 19°, is 1:3.0 (4/12; Table 1). The risk of progression seems therefore to be greater in girls than in boys. Of those scolioses that reached more than 19°, 25 per cent stopped before the curve reached 25°, which means that 75 per cent

of these curves above 20° can be expected to progress further during the growth period. If 25° is accepted as the lower limit for brace treatment, 0.8 per cent of the girls and 0.05 per cent of the boys should be treated with braces. In our material, however, only 0.5 per cent have been braced or operated on, but at the end of growth there were 14 girls with a scoliosis above 30° who should perhaps have been treated. The reason for their not being treated was that some of them were diagnosed too late (less than 1 year of the expected growth period remained) and some other patients refused treatment for various reasons.

The most important purpose of the brace treatment is to prevent progression of the scoliosis so that it does not reach 40–50° and thereby compel an operation.

The lower limit for brace treatment is in our department, as in many other scoliosis centres, 25° in patients with at least 1 year of the growth period remaining. This means that patients will be treated unnecessarily, since some of them will never progress significantly even when not treated. On the other hand, curves exceeding 35–40° are, in our opinion, difficult to handle with a brace.

The sex ratio in the different size groups of scoliosis also supports the statement made earlier, viz. that the female population faces a greater risk of further progression of the scoliosis than do the males.

When dividing the material into the levels of the apex of the curve, the thoracic scolioses dominate with 44 per cent. Less common are thoracolumbar curves, 32 per cent, in contrast to the findings of Brooks et al. (1975). More than 70 per cent of the scolioses were in the thoracolumbar junction in the latter study. Double curves and lumbar curves, on the other hand, constituted less than 20 per cent, which is in agreement with other studies.

In the present study, groups with different scoliosis sizes had a similar apex distribution. Thus, our study does not support the opinion that lumbar curves have a relatively better prognosis than other scolioses (Clarisse 1974, James 1976). From Table 3 it can be suspected that dextroconvex curves in the thoracic spine are more prone to deteriorate and that the same is true of sinistroconvex curves in the lumbar spine.

## REFERENCES


Brooks, H. L., Azen, S. P., Gerberg, E., Brooks, R. N. & Chan, L. (1975) Scoliosis: a prospective epidemiological study. *J. Bone Joint Surg.* **57**-A, 968–972.

Brooks, H. L. (1980) Current incidence of scoliosis in California. *Scoliosis* (Ed. Zorab, P. A. & Siegler, D.) p. 7–12. Academic Press, London.

Clarisse, P. (1974) Prognostic evolutif des scolioses idiopathiques mineures de 10° to 29° en periode de croissance. Doctoral thesis, Univ. Claude Bernard, Lyon.

Cobb, J. R. (1948) Outline for the study of scoliosis. American Academy of Orthopaedic Surgeons. Instructional Course Lectures. Vol. **5**, 261–275, The C. V. Mosby Company, St. Louis.

Hensinger, R. N., Cowell, R. H., MacEwen, G. D., Shands, A. R. & Cronis, S. (1975) Orthopaedic screening of school age children. *Orthop. Rev.* **4**, 23.

James, J. I. P. (1976) *Scoliosis.* 2nd ed. Churchill Livingstone, Edinburgh, London and New York.

Lonstein, J. E. (1977) Screening for spinal deformities in Minnesota schools. *Clin. Orthop.* **126**, 33–42.

Segil, C. M. (1974) The incidence of idiopathic scoliosis in the Bantu and white population groups of Johannesburg. *J. Bone Joint Surg.* **56**-B, 393.

Skogland, L. B. & Miller, J. A. A. (1978) The incidence of scoliosis in Northern Norway. A preliminary report. *Acta Orthop. Scand.* **49**, 635.

Smyrnis, P. N., Valavanis, J. Voutsinas, S. Alexopoulos, A. & Ierodiaconou, M. (1980) Current incidence of scoliosis in California. *Scoliosis* (Ed. Zorab, P. A. & Siegler, D.) p. 13–18. Academic Press, London.


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