Article Reprinted from

Physiotherapy, November *1992, vol 78, no 11 page 815-821.*

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RESEARCH REPORT

The Progression of Idiopathic Scoliosis under the Influence of a Physiotherapy Rehabilitation Programme

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Key Words
Treatment of scoliosis, specific exercises, Cobb angle, physiotherapy.

Summary
The purpose of this retrospective study was to show the effectiveness of an intensive in-patient physiotherapy programme - the Schroth technique - on curve progression in a group of idiopathic scoliosis patients.

Records of 118 patients treated between 1984 and 1988 were traced back. The average follow-up period was 31.5 months. Mean initial Cobb angle was 31°. In 16.1% of the cases, a progression of the disease was evident: 68.7% had stabilised and 15.2% showed an improvement of more than 5°. As compared with the natural history of the disease, these results suggest that an increase of the curvature in patients with idiopathic scoliosis can be retarded by means of a specific exercise programme.

Introduction

Although surgical correction of idiopathic scoliosis is currently the treatment of choice in the United Kingdom, in Germany physiotherapy is included in the treatment schedule, and exercise therapy is generally the sole treatment of patients with a curvature (Cobb) angle up to 20° (see figure 1 overleaf).

Specific exercises undertaken during in-patient treatment of patients with unchanged prognosis are: aimed at retarding increase of the curvature, preventing and treating secondary functional impairment (restrictive ventilatory disorder and reduced cardiopulmonary performance due to reduced mobility of the, ribs), reducing pain, and cosmetic improvement. Where the condition has started to progress, intensive in-patient i_t .r treatment is recommended to enable patients to learn specific exercise programme which can be performance at home and monitored at regular intervals by

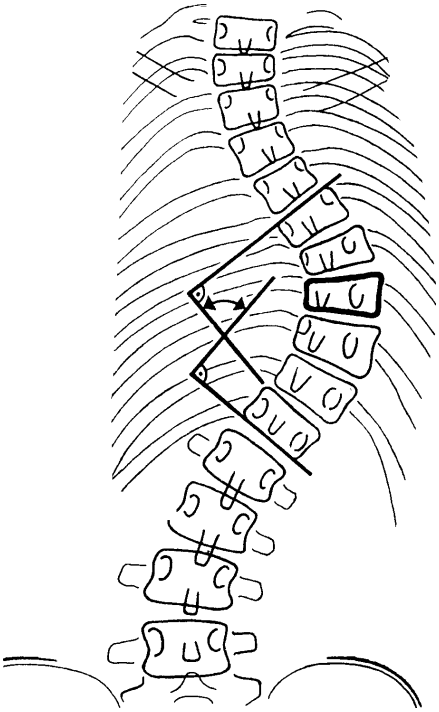

Fig 1: Construction of the **Cobb angle** (modified from Henke, 1982)

physiotherapists in the community. At an angle of more than 20', exercises are usually combined with electrical stimulation or an orthosis.

According to Scheier (1967) systematic physiotherapy may induce an improvement of the curvature with corresponding corrective effects on spinal growth. Duthie (1969) assigned priority within an exercise programme to correction of the deformity and avoidance of further deterioration. Emans (1984) reported benefits from exercise therapy for patients with persistent pain, bad posture and strong trunk imbalance. Cheneau and Gaubert (1988) believed an exercise programme with specific breathing exercise to be as important as the correct fabrication of an adequate orthosis. Caillet (1983) also stressed the importance of specific physiotherapy for scoliosis.

Nowadays, unspecific measures or methods with a purely mechanical effect have been abandoned in favour of methods of physiotherapy with a neurophysiological base. These can be subdivided into those based on developmental kinesiology and reflexes which are mainly used in the treatment of infants (Vojta, 1976) and sensorimotor-kinesthetic methods based on sensorimotor feedback (Lehnert-Schroth, 1991). Other methods, such as those advocated by Weber and Hirsch (1986), are gradually being discontinued because of lack of effectiveness and specificity.

Schroth Three-dimensional Exercise Therapy

Nearly all patients at the Katharina Schroth Spinal Deformities Centre are treated exclusively with the three-dimensional method developed by Katharina Schroth (Lehnert-Schroth, 1991, 19921. Weiss (1988, 1989) has documented evidence of its effectiveness in preventing and treating secondary functional impairment of breathing and scoliosis-related pain. Highly significant increase in vital capacity has been shown as well as highly significant decrease of pain at different sites using standardised pain rating scales.

Schroth's three-dimensional method is based on sensorimotor and kinesthetic principles. The treatment programme consists of correction of the scoliotic posture and breathing pattern with the help of proprioceptive and exteroceptive stimulation and mirror control. During the in-patient treatment programme, patients exercise for six to eight hours a day. They exercise in groups for two hours in the morning and two hours in the afternoon and receive individual training sessions in between. Depending on their individual curve patterns, they are also assigned to specific exercise groups for another two hours a day. Additional individual treatment and massage complete the daily schedule.

Using sensorimotor feedback mechanisms, the patients learn an individual correction routine and corrected breathing pattern. Using only active trunk muscle force, they learn to raise themselves as far as possible from a position of solely passive support by spinal ligaments, which is thought to promote curve progression, and then to maintain the corrected posture in activities of daily living. The correction is supported by `rotational breathing' which is integrated in the corrective routine. By selective contraction of convex areas of the trunk, inspired air is directed to concave areas of the thorax, and ribs are mobilised in these regions.

The exercise programme follows the principles described by Lehnert-Schroth (1991, 1992). The exercises are begun in an asymmetric position in order to maximise the magnitude of correction in an attempt to achieve the maximum possible trunk symmetry. Ordinary household objects, like tables and chairs, can be used as well as wallbars and a horizontal bar. Mirrors enable the patients to monitor their progress and achieve maximum correction. In both individual and group work, the initial assistance given by the physiotherapist is essential. Tactile stimuli, for example, in the concave region of the thorax to indicate the desired direction of breathing, provide the exteroceptive stimulation necessary to achieve the required correction.

At the end of an intensive course of in-patient treatment lasting several weeks, patients should be capable of assuming their personal corrected postural stereotype without the assistance of a physiotherapist and without mirror control and be able to maintain the position during activities of daily living. They are discharged with a short daily exercise routine to perform on their own under the regular supervision of a physiotherapist in the community.

Figures 2 to 7 show patients with scolioses of varying severity which have improved after treatment with the Schroth programme.

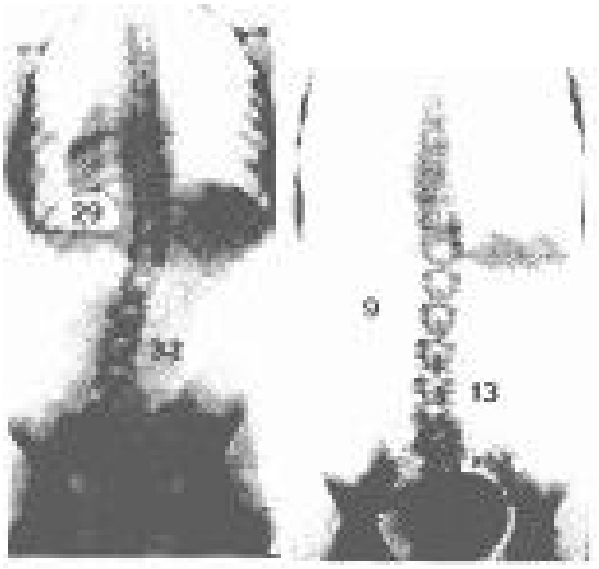

Fig 2: Left: 15-year-old girl with idiopathic scoliosis, prior to initial in-patient treatment: thoracolumbar curve 29°, lumbar curve 32°.
Right: Same girl at age 22: thoracolumbar 9°, lumbar 13°. Treatment consisted of six-week course of intensive treatment at 15 years of age and six weeks in-patient treatment at the Katharina Schroth Spinal Deformities Centre at the age of 17. Between these two treatments, patient continued to exercise at home according to the same method. Numbers indicate Cobb angle (Lehnert-Schroth, 1991)

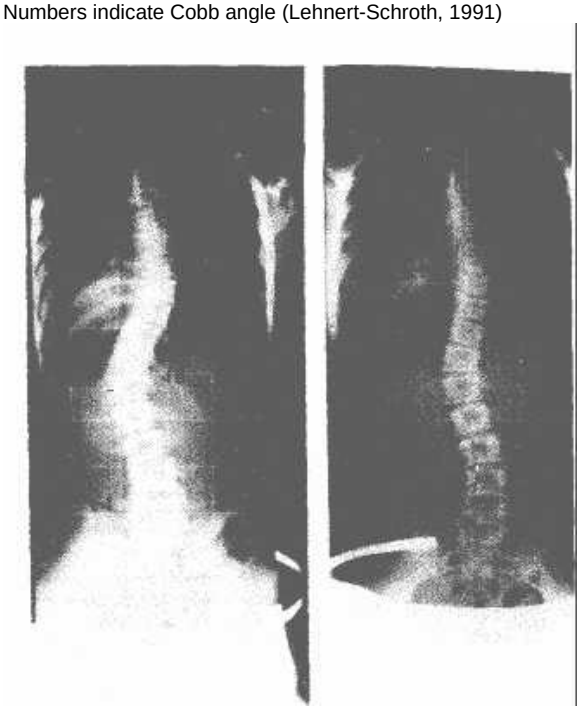

Fig 3: Left: 15-year-old female patient with idiopathic scoliosis and a thoracic curvature of 44°, thoracolumbar 40° and lumbosacral 14°.
Right: Same patient six months later and following an inpatient exercise treatment in the Katharina Schroth Spinal Deformities Centre. Thoracic curvature 28°, thoracolumbar 30° and lumbosacral 20° (Weiss, 1990)

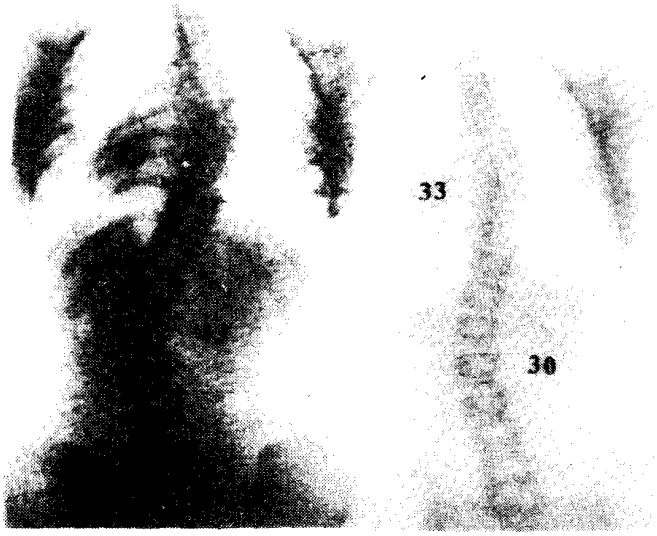

Fig 4: Left: 14-year-old girl before first in-patient exercise treatment with a thoracic and lumbar curvature of 43°.
Right: After two six-week in-patient treatment regimes, thoracic curvature corrected to 33° and lumbar curvature corrected to 30° (Lehnert-Schroth, 1991)

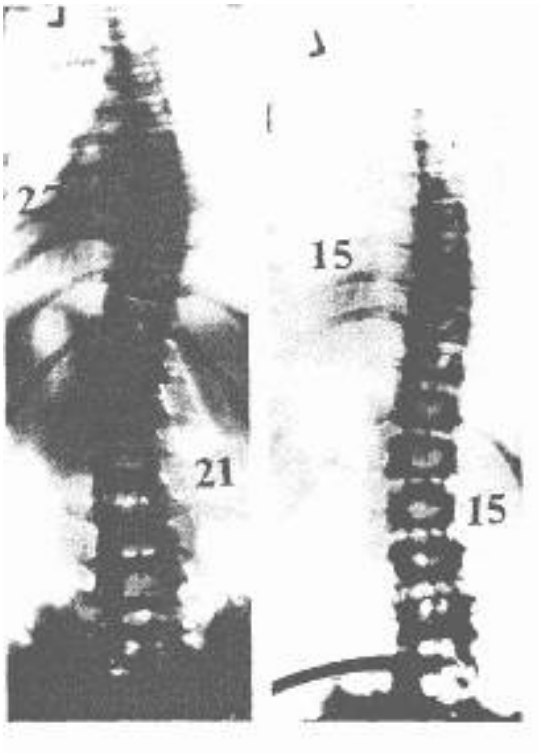

Fig 5: Left: 10-year-old girl with thoracic Cobb angle of 27°, lumbar curve measured 21°.
Right: Nine months later following in-patient treatment, thoracic and lumbar curves measured 15° Cobb angle (Lehnert-Schroth. i99')

All X-rays were previously published in Lehnert-Schroth (1991) **Physiotherapy, November 1992, vol 78, no 11**

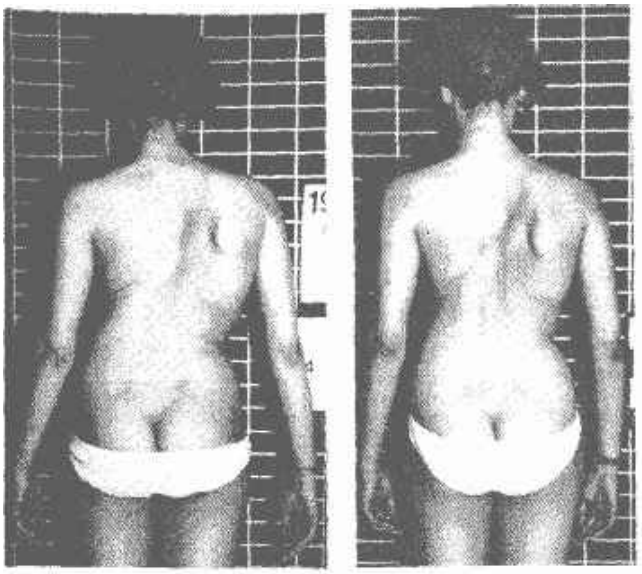

Fig 6: Female patient, left: before treatment, right: after an in-patient exercise treatment at the Katharina Schroth Deformities Centre; postural improvement, surface curvature and rib hump are markedly improved

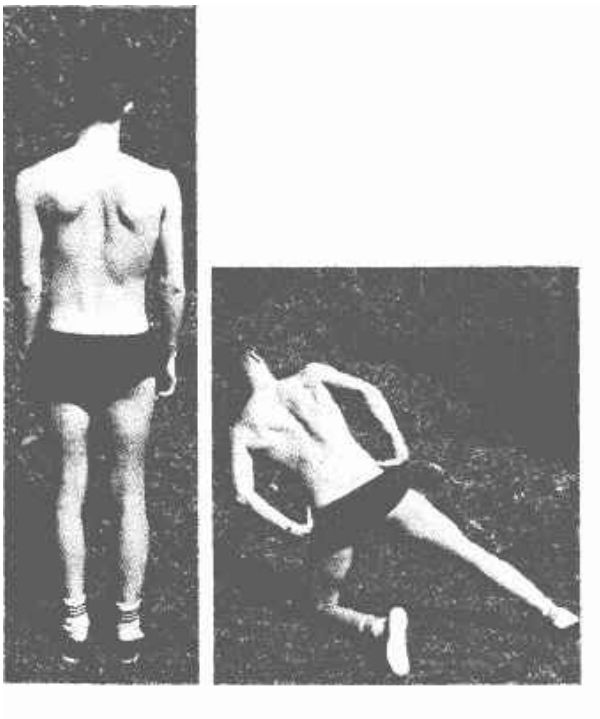

Fig 7: Left: Scoliotic male patient. Right: Same patient during exercise. Notice reduction of curvature of rib hump

Reported Effectiveness of Physiotherapy

Klisic and Nikolic (1982) investigated 150 patients with idiopathic scoliosis; 100 patients received specific physiotherapeutic methods and 50 patients, the control group, did not receive any treatment at all. The average curvature was 15° Cobb angle in the exercise group and 13' Cobb angle in the control group. During a three-year mean follow-up period, 58% of the exercise group improved but only 28% of the patients in the control group. Conversely, 37% of the patients in the exercise group against 64% of the patients in the control group were found to have deteriorated.

Mollon and Rodot (1986) investigated 210 cases. Of these, 160 received physiotherapy and 50 had no treatment at all. The average Cobb angle was 17' in the exercise group and 13° in the control group. The average follow-up period was 4.5 years. In the exercise group 62.5% stabilised or improved, whereas only 20% showed an improvement in the control group.

In a recent study Rigo and colleagues (1991) presented patients regularly treated with the three-dimensional scoliosis Schroth treatment programme. Patients had an average Cobb angle of 19' and an average Risser sign of 2. A curvature increase of more than 5° during the follow-up period was shown in 11.6% of cases, 44.2% of cases had stabilised, and 44.2% of the patients showed improvements of more than 5°. These results are significantly better than the natural history of idiopathic scoliosis reported by both Nachemson *et al* (1982), table 1, and Lonstein and Carlson (1984), table 2.

Table 1: Percentage of patients whose scoliosis progressed, by **magnitude of Cobb angle and age at diagnosis** (from Nachmeson *et al*, 1982)

Cobb angle(O)	*Age (years) 10 - 12*	*13 - 15*	*16*
20-29	60	40	10
30-59	90	70	30
>60	100	90	70

Table 2: Percentages of patients whose scoliosis progressed by age at first observation and Cobb angle (according to Lonstein and Carlson, 1984)

Age (years)	*Cobb angle* 15^0- 19^0	20^0-29^0
<10	45	100
11 and 12	23	61
13 and 14	8	37
>15	4	16

Purpose of Study

A retrospective study of the X-rays of 118 patients was made in order to assess the effectiveness of the Schroth approach in preventing progression of the scoliotic curves of adolescents.

Limitations

Size of Sample and Inclusion Criteria

Of the 1,200 patients per year treated at the centre, more than 500 were identified with no problem other than idiopathic scoliosis and who had been admitted for several courses of in-patient treatment between 1984 and 1988.

Those patients without standard X-rays of the whole body

n the standing position before and after the follow-up period were excluded. As intensive treatment is given for four to six weeks at the centre to patients referred by orthopaedic surgeons, it is difficult to monitor patients for a longitudinal study to evaluate the progress of curves, not least because, in order to limit exposure to X-rays, radiograms are taken during in-patient treatment only when no previous ones exist or were taken over six months previously. A large number of the X-ray pictures taken outside the centre had been taken either in a decubitus position or with corsets on or in extension. Therefore, they could not be compared and no evaluation of progression of scoliosis could be made. Furthermore, a number of patients could not be classified because of the poor quality of radiograms. Consequently, only 118 patients out of over 500 from the period could be included.

Risser Sign (figure 8)

Unfortunately, the Risser classification had not been made in all 118 patients at the beginning of treatment. According to Weinstein (1989), it is only one factor which appears to have an influence on the progression of curvature; and others, such as form and magnitude of curvature, age and sex have been included.

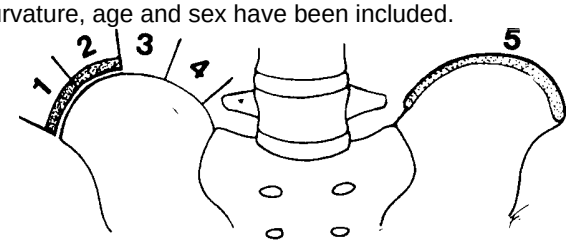

Fig 8: Risser staging: Ossification of epiphysis usually starts at anterior superior iliac spine and progresses posteriorly. Iliac crest is divided into four quarters and excursion or stage of maturity is designated as amount of progression (Lonstein, 1987)

Pre-treatment Evaluation of Progression of Curvature

An attempt was made to evaluate the progression of the curvature of the selected 118 patients before treatment at the centre. Radiograms were not available for 80% of the sample but the X-rays of the other 20% showed an increase of 5% per year.

Procedure

Subjects

A total of 118 adolescent patients with idiopathic scoliosis treated at the Katharina Schroth Centre between 1984 and 1988 whose X-rays were satisfactory and who had not had additional bracing were reviewed.

Data

Progression is defined as curvature increasing by at least 5° per year. All major curvatures increasing by at least 5° per year were included. Minor compensatory curves that deteriorate without causing change in the major curvatures are also termed progressive and were included. Minor compensatory curves that were not progressing were excluded.

Analysis of Data

While statistical manipulation of raw data is generally required in a research paper, the major aim of physiotherapy is to prevent progression of scoliosis and not to decrease the magnitude of the curve. Consequently, although the results have clinical importance for these patients, no significant difference could be demonstrated statistically. A significant result might be shown if a randomised, controlled clinical trial were carried out with a control group who received no physiotherapy. However, in Germany, unlike the United Kingdom, it is unethical to withhold physiotherapy from scoliosis patients for research purposes and, therefore, an untreated control group could not be available. There are no raw data or statistical results available for comparison with those obtained in this study. It is possible only to compare outcome from physiotherapy in general, and Schroth treatment in particular, with studies of the natural history which record only the percentage progression rate of untreated scoliosis.

Results

The female/male ratio was 7.6:1, the average follow-up period was 31.5 months (range 8 to 178 months), the first radiogram was taken an average of 4.5 months before initial in-patient treatment (range 0-23 months) and the average number of in-patient courses of treatment between two usable radiograms was 1.9 (range 1-10).

48.3% of patients had thoracic scolioses, 37.3% had double curves, 12.9% had lumbar scolioses, and 13% had thoraco-lumbar scolioses. The average initial Cobb angle was 31° and the average final angle was 34.6°. 16.1% showed progression of 5° or more per year, 68.7% had stabilised and 15.2% had improved by more than 5° during the follow-up period.

Table 3 shows the magnitude of curvatures related to age and status of the scoliosis and table 4 shows the percentage of 13- to 15-year-olds for each range of progression of Cobb angle.

Table 3: Magnitude of curvatures related to age and status

Curvature (°)	*Progressive*	*Stabilised*	*Improved*
Patients up to 10 years of age (n = 21)			
5-19	2	7	4
20-29	1	2	2
>30	0	2	1
Patients between 11 and 13 years of age (n = 35)			
5-19	1	16	2
20-29	1	5	3
>30	3	4	0
Patients between 13 and 15 years of age (n = 62)			
15-19	1	12	0
20-29	5	16	0
>30	5	17	6

Table 4: Progression of Cobb angle in 13-15-year-old patients, treated according to Schroth

Cobb angle (°)	*No of patients*	*Progressed (%)*	*Improved (%)*
5-19°	13	7.7	0
20-29°	21	23.8	0
>30°	28	17.9	21.4

Figures 9 and 10 show the progressed Cobb angles of patients treated by exercises compared with the natural history (Nachemson *et al,* 1982; Lonstein and Carlson 1984).

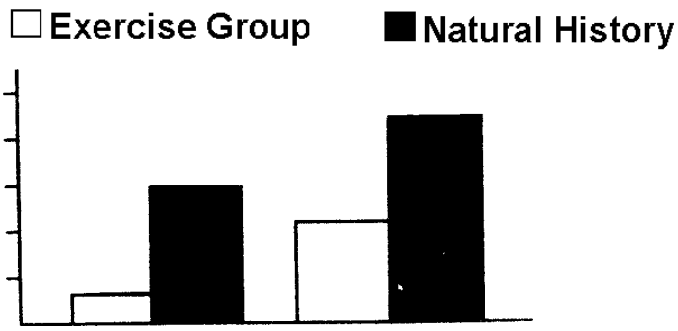

Fig 9: Comparison of Cobb angles of scoliotic patients treated by exercises (age 11-12 years) with natural history (untreated scoliosis) in the same age group.

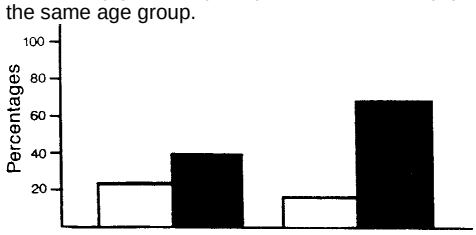

Fig 10: Comparison of Cobb angles of scoliotic patients treated by exercises (age 13-15) with natural history (untreated scoliosis) in the same age group.

Discussion

Prognosis

The subjects of this study appear to have a worse prognosis than both Nachemson *et al (* 1982) and Lonstein and Carlson (1984) reported with respect to curve pattern magnitude related to age and sex. This is reflected in the predominance of thoracic scolioses and double curves in the distribution of curvature patterns. Stagnara and Clarisse (1973) found in their group with idiopathic scoliosis that the highest progression of 67/c was found *it-*, double curves and the lowest progression of scoliosis. Similar results were observed b;: Fustier , 119[1]80' Regain an'! colleagues 11978) found progression in 78.8[1]'c of cases curvatures between 20° and 30°.

Nachemson *et al* (1982) found progression in 25% of the cases of scoliotic patients between 10 and 12 years of age and with Cobb angles below 19°. In patients with a curvature angle between 20° and 29° progression was found in 60% of cases, and in patients with more than 30° progression was found in 90-100% of the cases.

In patients with a bone age of 13 to 15 years, progression was found in 10% of cases below 19°, in 40% of cases between _90` and 29' and in 70-90% of the cases over 30' (see also table 1).

In Lonstein and Carlson's study (1984) only patients with a curvature angle of up to 29' were evaluated. At a curvature angle between 20° and 29°, 100% of patients under the age of ten, 61% of patients between 11 and 12 years, 37% of patients between 13 and 14 years, and 16% of patients over 15 years showed a progression (see also table 2i.

Spontaneous Resolution

10.7% of the untreated patients with a tendency to immaturity and minor curves studied by Lonstein and Carlson (1984) had spontaneously resolving curves. In comparison to the spontaneous course, the study group receiving in-patient Schroth treatment showed better results. This finding is enhanced by the fact that initial X-rays had been taken an average of 4.5 months before starting the in-patient exercise programme during which time the curvature could have increased. This is an unmeasured variable, for reasons already explained. Another unmeasurable variable was the intensity of exercise performed at home between in-patient stays at the centre. Although 30-40 minutes of independent exercises are recommended as a daily home programme, it cannot be known with any certainty how many patients do exercise regularly or for how long.

Age and Progression

Patients between ten and 12 years old are not sufficiently represented in this study and thus are not included when making comparisons within the individual graduations. It is, however, possible to compare outcomes of the 62 patients between the ages of 13 and 15 years with similar patients. In this group there were 28 patients with Cobb angles greater than 30° and who had not undergone brace treatment. These were either cases of non-compliance, meaning patients who could not tolerate a brace, or who refused to undergo an operation.

From the 62 patients within the 13 to 15 age group, 23.8% between 20° and 29° were progressive. Within comparable groups Lonstein and Carlson (1984) found a progression in 37% and Nachemson *et* al (1982) in 40%.

Out of our 28 patients in this age group with a Cobb angle of more than 30°, only 17.9% were found to be progressive. A comparable group investigated by Nachemson *et al* (1982) showed a progression in 70-90%.

Additionally. 21.4% of patients at the Schroth Centre who demonstrated a curvature of over 30° improved by more than 5°. According to Lonstein and Carlson (1984), however; a spontaneously resolving curve is not often seen in scoliosis patients with Cobb angles greater than 30` and growing maturity.

Social Factors

A tentative hypothesis that social factors may influence the curve progression is not supported. Patients with a family history of deformity were equally distributed among those who improved and those who deteriorated. There was a tendency for young patients with greater Cobb angles to have more progressive curves. However, although measurement error is an acknowledged factor in major scoliosis, improvements in Cobb angle were found, for example, from 77` to 70'.

Conclusions and Recommendations

In-patient treatment according to Schroth should be considered more effective than may be assumed from these results. In patients who were X-rayed immediately before and directly after the in-patient exercise programme, more than 4311(of the cases showed an improvement of 5` or more (Weiss, 1992a, b). Comparing this with the reported results, it is assumed that a great part of the successful treatment is lost again during everyday life.

The validity of this study is restricted by some factors. First, a classification according to Risser during initial treatment has not been documented in all patients. This sign, used for classification of skeletal maturity, is a radiological indication of the maturity of the iliac ephiphyses. Second, the majority of radiographs that were evaluated had been taken in other hospitals and, in most cases, several months before the initial treatment at the Schroth Centre.

Nevertheless it is our belief that this study has found evidence that physiotherapy as a sole form of treatment influences the progression of curves as shown by radiological signs. Further prospective studies are necessary to document fully the effectiveness of an exercise programme as the sole form of scoliosis treatment. A number of investigations are currently underway at the Katharina Schroth Centre in support of the preliminary results.

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