TREATMENT REPORT

Introduction to the Three-dimensional Scoliosis Treatment According to Schroth

Christa Lehnert-Schroth

Key Words

Scoliosis, physiotherapy, exercise programme, Schroth.

Summary

The author gives an introduction to the basic principles of the three-dimensional scoliosis treatment according to Schroth, which is a physiotherapeutic approach to spinal deformity. The development of this specific treatment method by Katharina Schroth is described briefly. The paper gives a short review of the treatment methods as well as referring to aetiological and biomechanical aspects.

Introduction

To deal with her own scoliosis, my mother Katharina Schroth conceived a three-dimensional approach to treatment and designed an exercise programme to treat the various deformities and static changes of the scoliotic trunk additional to the curved spine. The method is taught to patients and physiotherapists at the Katharina Schroth Spinal Deformities Centre, Sobernheim, Germany. About 1,200 patients attend every year for an intensive course of in-patient physiotherapy lasting from four to six weeks depending on the referral from the consultant orthopaedic physician. They range in age from eight to 70 years, but children under ten years are treated only when accompanied by a person they know very well. The ratio of females to males is 7:1.

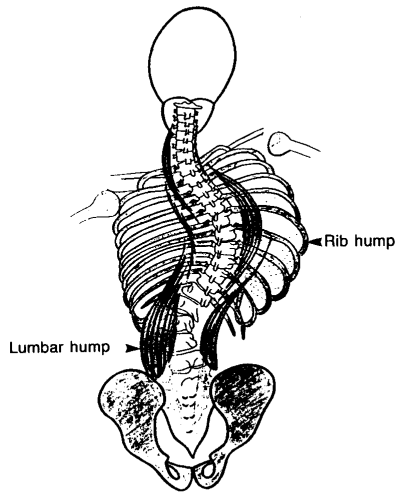


Fig 1: Scoliosis skeleton. The drawing shows the erector spinae muscle with varying thickness, shape and lateral asymmetry

Scoliosis

Definition and Description

Scoliosis (fig 1) is defined as a partly-fixed lateral curvature of the spine (Heine and Meister, 1972; Weinstein, 1989). Its origin may lie in paralysis, hereditary and genetic diseases, or other identifiable causes, but 80% of cases are idiopathic and, although researchers have investigated the aetiology (Moe and Byrd, 1987), no conclusive evidence as to cause has been documented. Of patients at the Katharina Schroth Spinal Deformities Rehabilitation Centre, 80% to 90% have idiopathic scoliosis. The deformity can, therefore, only be treated symptomatically.

A lateral curvature of the spine causes compensatory curves which may be much smaller but cannot be ignored in planning physiotherapy. A functional three-curve scoliosis can be observed in most scoliotic people, as illustrated in figure 2. The ribs are rotated anteriorly on the concave side of the scoliotic curve and posteriorly on the convex side. Consequently, (a) there is a costal depression (rib valley) on the concave side and a thoracic gibbus (hump) on the convex side (fig 2b); there is a lumbar hump below the rib valley and a concavity below the thoracic hump (fig 2c); and (c) the shoulder girdle is drawn posteriorly above the rib valley and anteriorly above the costal convexity (fig 2d). Other symptoms include decreased spinal mobility on the convexity of the curve, back pain, psychological problems associated with the deformity, and cardio-respiratory dysfunction.

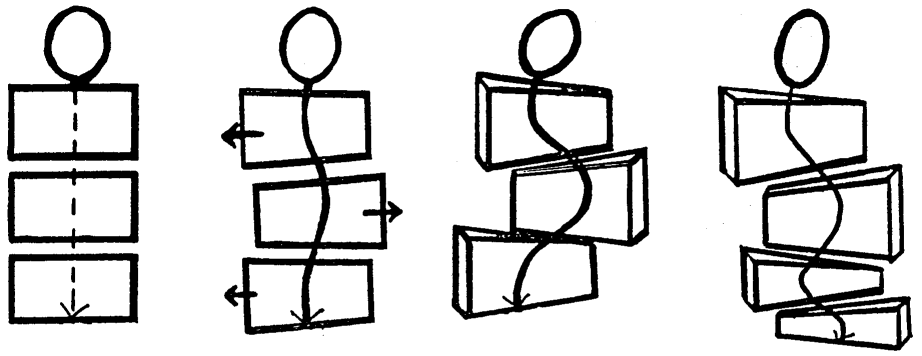
Posture and Scoliosis

Scoliosis must be seen as a multiplicity of postural disorders. The term 'posture' itself indicates more than a passive procedure or a permanent status but, to date, it has not been satisfactorily defined (Rizzi, 1979). Some authors define it as an act of balance (Basmajian, 1967; Tucker, 1969) without reference to an essential description. Taillard (1964) states that a good posture consumes minimal energy and does not stress musculature and connective tissue. A 'poor' posture may very easily change into a postural disorder, such as kyphosis, lordosis and scoliosis.

Diagnosis

If a patient bends forwards to touch his toes, slight dorsal asymmetries become evident (fig 3). The greater the rib prominence, the greater the torsion of corresponding vertebrae as ribs and musculature move with the rotation and develop dorsal elevations (humping of ribs, lumbar hump, 'elevated shoulder') or depressions (concavities of the back). X-ray assessment of the spinal curvature to determine the extent of the curve and to eliminate other possible causes (eg tumours) is generally carried out on the first visit.

2: Block diagrams of trunk



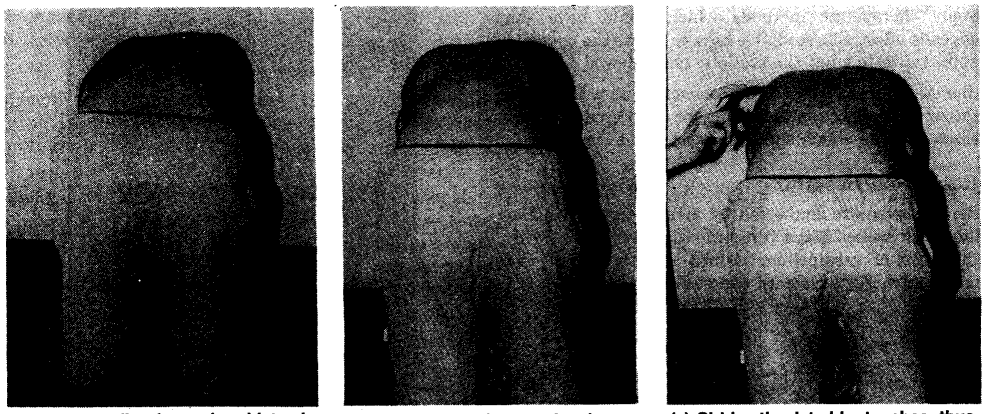
(a) Subdivision into three rectangular superimposed blocks (pelvic girdle, rib cage, shoulder girdle)

(b) In scoliosis, three blocks of trunk deviate from vertical axis. This results in lateral shifting of spine

(c) The three blocks develop 'wedge-like' form, depending on severity of scoliosis, and rotate against each other around vertical axis. Ribs and spine follow these distortions. Scoliotic torsion is created

(d) Additional lumbosacral counter curvature. This pattern demands additional special pelvic corrections in order to influence existing pelvic torsion, explanations of which would go far beyond this paper

3: Eleven-year-old girl with idiopathic scoliosis



(a) Trunk bending forward; uni-lateral elevation of back on right side is clearly visible

(b) Patient practising rotational breathing according to Schroth with left ribs. Left concave side of back is filled, resulting in visible levelling

(c) Girl is stimulated by touches, thus provoking more effective exercise

Prognosis

The so-called thoracic 'hump' and the protrusion of a part of the hip result from progressive scoliosis and increased rotation with lateral deviation of the trunk. In infantile idiopathic scoliosis this often leads to deformities of the rib cage with restriction of the respiratory, circulatory and cardiac function. The cardio-respiratory prognosis is not so bleak with adolescents and they do not usually suffer from major cardio-pulmonary restrictions in later life.

The prognosis of the scoliosis itself depends upon various factors, especially the age of onset of a curvature angle and its magnitude. The greatest danger in idiopathic scoliosis occurs during the growing period of the adolescent years.

Development of a Gibbus

The presence of a hump may also lead to numerous psychological problems. Katharina Schroth is famous for her phrase: 'There is no hump, only torsioned ribs.' This is especially true for a scoliosis in the early stage of development. If nothing is done to counteract it, one lateral half of the back may quickly enlarge, because a gibbus develops as a consequence of imbalance of muscles and forces — mainly shifted ribs and associated muscles being pressed into the wrong direction, partly anteriorly and partly posteriorly and/or laterally. This results automatically in better ventilation of the pulmonary half on the side of the rib hump, whereas the other side — the concave (depressed) side — is less well ventilated. The shifting of the centre of gravity leads to a static imbalance.

Treatment

Development of the Schroth Method

The treatment method was developed by Katharina Schroth in her youth. In the beginning, she intended only to correct her own appearance with her exercises and to normalise the scoliotic posture of her body. She used no talent but that of perception. She shaped her own body and then the bodies of her patients with her hands, guiding them with words. Doing this, she awoke in her patients a new awareness of body image for an imbalanced posture as well as for a balanced posture. By stimulation, she showed them where the narrowed rib segments were. She made her patients feel where to 'guide' their breath. She asked them to imagine or visualise forces and encouraged them to improve their performance gradually.

In a mirror, the patients could see how the scoliotic posture changed into a more favourable appearance and how the imbalance of skeleton and musculature was gradually transformed into an upright posture. By 'going over the middle' she initiated new movement patterns in her patients, as people with postural disorders perceive themselves as having an upright posture.

Step by step, Katharina Schroth formulated 'laws' according to which scoliosis increases and tried to apply therapeutic methods which would have the opposite effect. She said: 'We have to create the opposite appearance to what the scoliotic body shows.'

She used ribs as long lever arms acting on a torsioned thorax by anterior rotation. Thus she discovered and used the technique which she called 'rotational breathing'.

Rotational Breathing

Because ribs are connected by articulations with the lateral processes of the vertebrae (fig 4), they can, with the help of respiration, reduce the torsion of the trunk during the Schroth exercises.

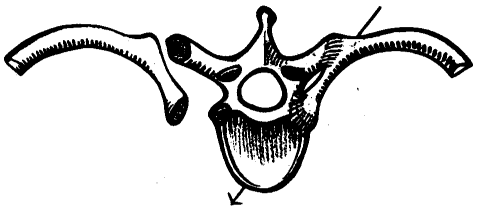


Fig 4: Thoracic vertebra. Left: Rib is dislocated from vertebra. Right: Rib heads and tubercules are connected by articulations with vertebra. By the axis which has been created in this way (see arrow), raising and lowering of ribs during respiration is made possible (after Mollier, 1938)

It is unwise to depress the prominent trunk sections before there is enough space to accommodate them. On the depressed (concave) side the ribs which have sunk inwards and downwards need to be widened from the inside by specific respiratory exercises. Following the idea of doing exactly the opposite of what the body shape presents, they have to be lifted to the outside (laterally) and upwards (cephally). By doing so, a wider space is created which allows the ribs to be moved backwards. This is effected by a 'respiratory thoracic movement' along the sides of an imaginary right-angle: laterally + cephally + posteriorly = three-dimensionally. The counterpart of the posterior rib hump is the narrowed anterior thorax, as it is the same ribs which are rotated posteriorly that cause the anterior compression.

In the Schroth treatment, these ribs are moved anteriorly and upwards and rotated forwards and inwards or three-dimensionally with the help of respiration ('rotational breathing'). At the same time the subject is always urged to think about lowering the diaphragm.

Scoliotic Statics due to Postural Disorder

Katharina Schroth could see the scoliotic statics of the body especially in cases of major scolioses — in nearly every case a postural disorder is present in the sagittal (anterior-posterior) plane with an anterior protrusion of the pelvis. Thus, the trunk deviates posteriorly from the lumbar region. The head swings again over the centre of gravity. This is due to the body equilibrium, which develops into an imbalanced state and finally adapts to the acquired scoliotic static. This is true for scoliotic patients when seen from the rib hump side (fig 5).

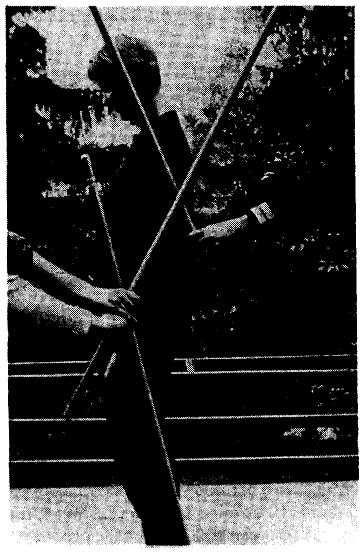
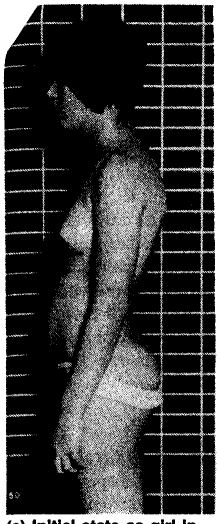


Fig 5: 19-year-old girl convinced she has an upright posture. Bars however prove scoliotic posture. Beginning from the feet, pelvis is carried anteriorly. For reason of balance, body leans posteriorly beginning from lumbar region. The head swings again anteriorly over the centre of gravity. Body forms 'double broken line'

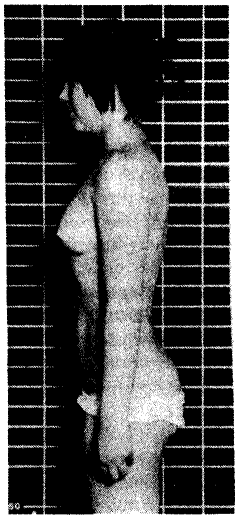
For this reason, postural disorder is first corrected by skeletal correction: pelvis backwards, trunk forwards, 'creating the opposite shape' (fig 6). The same principle is followed when correcting the scoliotic static in the frontal plane with the lateral displacement of the individual body sections. The pelvis which is unilaterally protuding is taken in towards the line of gravity (figs 7, 8). This results automatically in making the trunk more erect. Only this change in posture makes it possible to use rotational breathing effectively. When

. 15-year-old girl

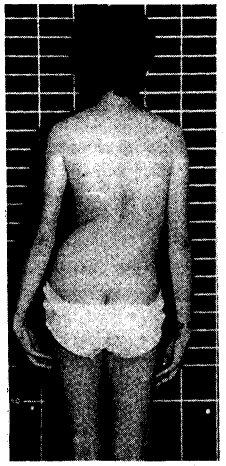
Fig 7: 15-year-old girl with idiopathic scoliosis.



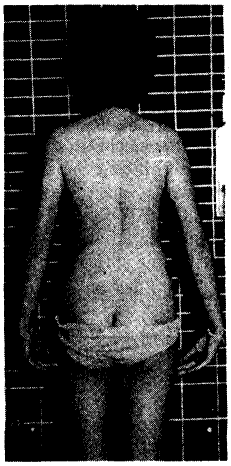
(a) Initial state as girl in fi[illegible] with postural di[illegible]der in sagittal plane



(b) After four weeks intensive treatment according to Schroth, showing postural correction



(a) Shifting and torsion of three blocks of trunk against each other, changing body statics



(b) Same girl at the end of six-week therapy. Three blocks of trunk have largely been realigned vertically, eliminating scoliotic body statics and improving personal appearance

trunk and spine have reached their optimal length, the trunk sections which are rotated against each other are able to move without mutual interference.

Often children and adolescents bring along their braces which have been adapted at home and which should be worn while they are not exercising. There are some exceptions which make it necessary to exercise in a brace, such as when it has to be worn 23 hours a day. Nowadays several good braces exist, such as the Chêneau and Boston braces, which work in conjunction with the Schroth programme and do not inconvenience the patient. They are of tremendous benefit and help in supporting the obtained corrections.

Working Principles According to Schroth

After Katharina Schroth had worked with patients by shaping and forming their bodies, she discovered the 'laws' according to which she was working. She acquired a great deal of practical experience before she wrote about her theory. Gradually, she improved her theoretical knowledge so that it could be taught to others.

Katharina Schroth divided the trunk into three blocks which can be shifted against each other (fig 8). She recognised that the pelvic and the shoulder girdles are rotated into the same direction and that the middle block, the rib cage, is oriented in the opposite direction — in the sagittal plane as well as in the frontal plane. The more these blocks shift against each other, ie the more they deviate from a vertical line, the more they rotate also in the transverse plane (about the vertical body axis). The body becomes less and less upright and 'crumbles', because all parts of the body which deviate from the vertical line are drawn downwards by gravity. For this reason, active extension is a pre-requisite of successful

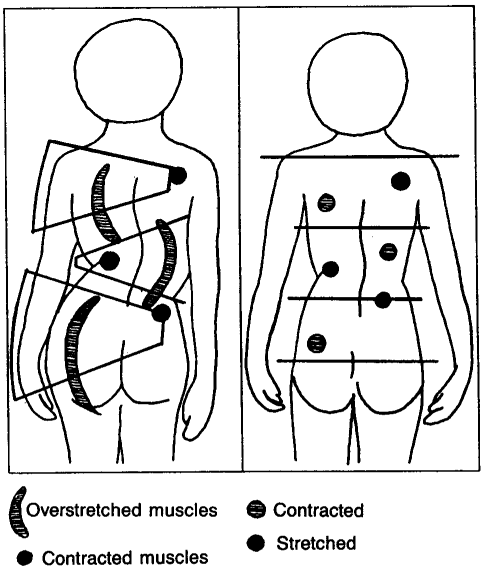


Fig 8: Diagram of girl in fig 7. Overstretched muscles are shortened, contracted muscles extended. Scoliotic body statics are largely corrected (from Lehnert-Schroth, 1991)

exercising. The elongation is connected to active curve correction and realignment of the trunk segments which have deviated laterally. This is completed by active derotation of the three trunk segments rotated against each other. This is achieved by appropriate starting positions for orthopaedic exercises as well as by rotational breathing.

It has been shown that this rotational breathing leads to a significant increase in rib mobility and thus vital capacity (Weiss, 1991a), and in sagittal respiratory excursion (Weiss, 1991b) which is of great importance in improving a flat back. Each exercise is connected with the feeling of the new movement pattern which aims at achieving normality. This is a facilitation process, ie the starting of a mental re-education by consciously repeated derotative exercises which are finally recognised by the patient's subconscious mind and then carried out automatically. The subject establishes a balance between what he sees in the mirror and what he feels. The continuous muscular training results in a re-education of the scoliotic posture into a corrected upright posture, so that new movement patterns are mentally accepted and the patient is capable of adopting a corrective posture at any time on her own.

The new postural pattern is the basis for learning a new movement pattern, ie patients also need to integrate acquired body and corrective perception into activities of daily living. So that the good results from exercise can later develop into a good body shape, active stabilisation is necessary. According to Schroth, this is performed during the expiration phase in the form of isometric tension exercises of the muscle layer so that changed muscle tension in the correction becomes perceptible to the patient. Previously inactive muscles are reactivated. On the 'thick' side, the muscles are overstretched (overstrained) and weak; on the narrowed side, muscles are contracted. They have lost their natural muscle tone and are no longer ready to work. This is counteracted by stretching the shortened muscles with appropriate exercises in suitable starting positions and when they start to work again in a tensioned state. This automatically gives the elongated muscles a contractive stimulus.

These points are essentially connected. Moreover, each exercise must begin with the feeling of the correct movement and the conscious capability of transferring this movement into a corrected body posture. The new posture finally becomes established and leads to a confirmation of the patient's new self-image.

Outcomes

Cosmetic Improvement

An additional advantage of this treatment is improvement in appearance. Patients are photographed, naked, from all four sides at the beginning and end of their six-week therapy. By means of these photographs it is possible to explain scoliotic statics to them. The photographs are an important tool during the exercises. They encourage subjects to exercise alone at home, especially if step-by-step success is apparent. For the patients, the degrees of angle of the spine which can be measured with the help of the roentgenogram are largely of secondary importance. Cosmetic results matter more to them; they want to see that their 'hump back' becomes smaller, because that is what troubles them most.

Motivation to Exercise Alone

The explanations which are always given to patients develop their self-confidence and convince them of the usefulness of the procedure, which also enhances their motivation to do the exercises. Each scoliotic person has to exercise throughout his life. During the first period of therapy, they exercise five to six hours daily. At home, they can reduce intensive daily exercise initially to 90 minutes or an hour. We have met patients again decades later and upon questioning they answered that they still exercise according to the Schroth method for ten minutes a day. That is motivation! In any case, the patients must comply with the treatment because this is essential for its success.

Reduction of Pain

Older patients in particular suffer from pain as a result of the scoliotic posture. The development of spinal curves leads to a uni-lateral tensioning or contusion of the nerves as well as to multiple joint dysfunction. This creates pain. According to our records, this pain improves or disappears in 85% of the patients, sometimes after only a few weeks of therapy, which thus helps to improve the quality of life.

Improvement in Pulmonary Function

Vital capacity increases measureably in about 95% of the patients (Lehnert-Schroth, 1991): 22% obtained an improvement of up to 600 ml vital capacity after six weeks and 11% obtained an improvement of up to 800 ml in the same period. There were also patients who showed an increase of more than 1,000 ml vital capacity within the six-week therapy. This represents an enormous improvement in health which also benefits from exercising in the open air if weather permits.

Cardiac-circulatory Training

Cardiac and circulatory functions are improved not only by a specific respiratory therapy but also by intensive muscle training. In bad weather, exercises are conducted in large halls equipped with suitable appliances for specific group exercises, which are complemented by individual exercises.

Conclusion

The Schroth technique is a scoliosis-specific back school. In the treatment programme, all possibilities for postural correction, including respiration, are used in order to enable the patients to help themselves. The patients learn to acquire a certain feeling which helps them to see and understand the different stages they must go through until they reach the best possible correction. In this way, they learn to accept that treatment will be long-term. The procedure also enables them to avoid behaviour during everyday activities which could increase progression of their scoliosis. Only the maintenance of postural correction during everyday activities can prevent progression in the long run.

Courses for physiotherapists are held in Sobernheim so

that scoliosis patients can be treated according to the Schroth method in their home towns or close to them. In some cases, where patients have already undergone surgery, it is possible to improve pulmonary function and maintain surgical results. Although surgery fuses the spine there is some loss of curve correction over time. To date most surgical techniques do not reduce the rib hump and thus specific physiotherapeutic exercises are aimed at maintaining surgical results. After a therapeutic course at the Katharina Schroth Spinal Deformities Centre, patients revisit the orthopaedic surgeons in their home towns, continue therapy and thus increase stabilisation of the acquired new postural feeling.

The three-dimensional scoliosis treatment according to Schroth has been taught since 1958 at the School of Kinesitherapy in Brussels. It is also taught in Spain, Austria, France, Switzerland, Germany and Brazil.

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RESEARCH REPORT

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

Hans Rudolf Weiss

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 cardio-pulmonary performance due to reduced mobility of the ribs), reducing pain, and cosmetic improvement. Where the condition has started to progress, intensive in-patient treatment is recommended to enable patients to learn a specific exercise programme which can be performed at home and monitored at regular intervals by licensed

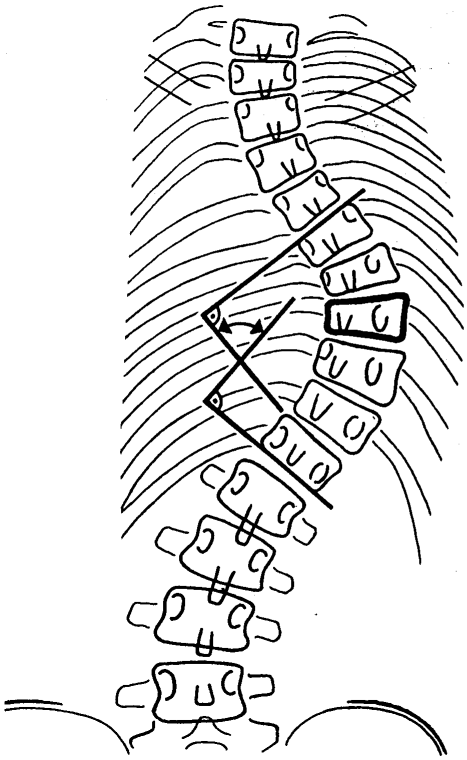

Fig 1: Construction of the Cobb angle (modified from Henke, 1982)

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. Chêneau 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, 1992). 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.

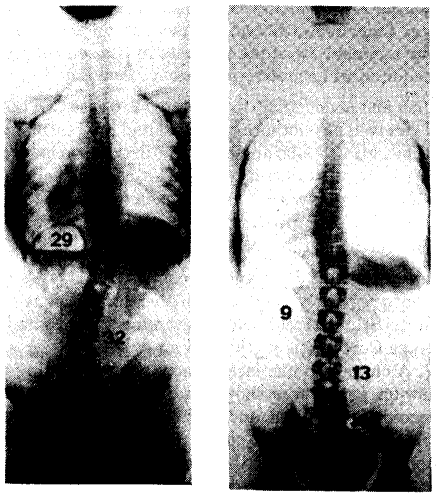

Fig 2: Left: 15-year-old girl with idiopathic scoliosis, prior to initial in-patient treatment: thoracolumbar curve 29°, lumbar curve 32°.
Right: Same girl at age 22: thoracolumbar 9°, lumbar 13°. Treatment consisted of six-week course of intensive treatment at 15 years of age and six weeks in-patient 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)

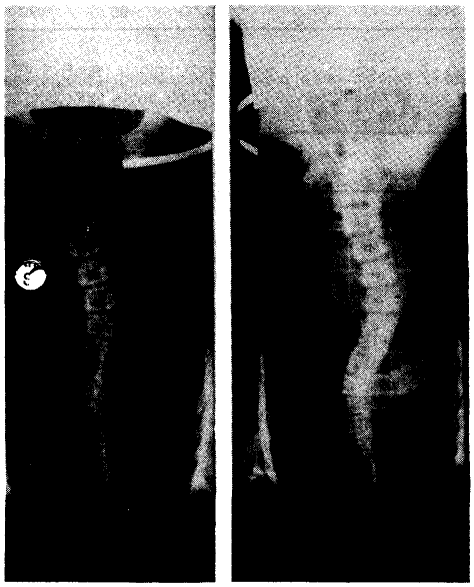

Fig 3: Left: 15-year-old female patient with idiopathic scoliosis and a thoracic curvature of 44°, thoracolumbar 40° and lumbosacral 14°.
Right: Same patient six months later and following an in-patient exercise treatment in the Katharina Schroth Spinal Deformities Centre. Thoracic curvature 28°, thoracolumbar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

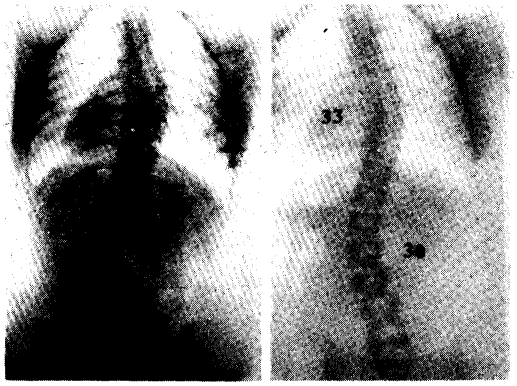

Fig 4: Left: 14-year-old girl before first in-patient exercise treatment with a thoracic and lumbar curvature of 43°.
Right: After two six-week in-patient treatment regimes, thoracic curvature corrected to 33° and lumbar curvature corrected to 30° (Lehnert-Schroth, 1991)

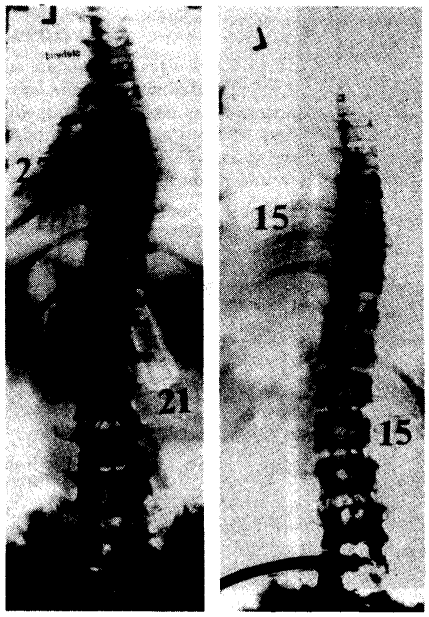

Fig 5: Left: 10-year-old girl with thoracic Cobb angle of 27°, lumbar curve measured 21°.
Right: Nine months later following in-patient treatment, thoracic and lumbar curves measured 15° Cobb angle (Lehnert-Schroth, 1991)

All X-rays were previously published in Lehnert-Schroth (1991)

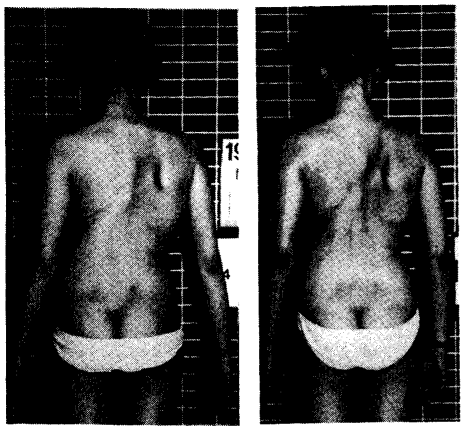

Fig 6: Female patient, left: before treatment, right: after an in-patient exercise treatment at the Katharina Schroth Deformities Centre; postural improvement, surface curvature and rib hump are markedly improved

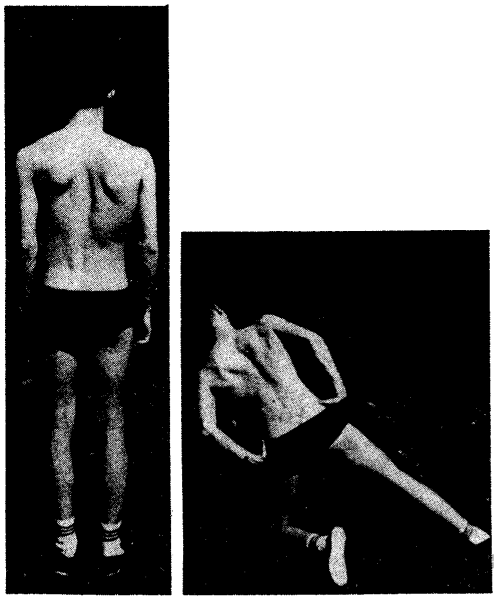

Fig 7: Left: Scoliotic male patient. Right: Same patient during exercise. Notice reduction of curvature of rib hump

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(°)	*Age (years)* *10 – 12*	*13 – 15*	*16*
<19	25	10	0
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° – 19°*	*20° – 29°*
<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

in 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.

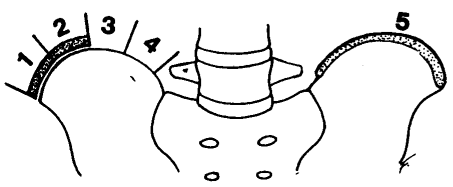

Fig 8: Risser staging: Ossification of epiphysis usually starts at anterior superior iliac spine and progresses posteriorly. Iliac crest is divided into four quarters and excursion or stage of maturity is designated as amount of progression (Lonstein, 1987)

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).

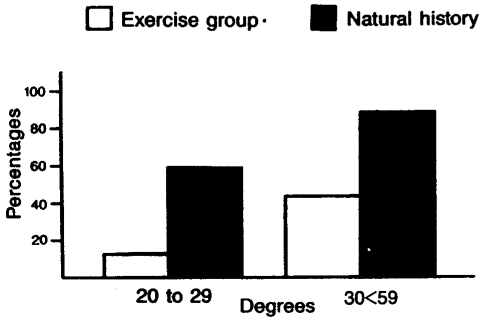

Fig 9: Comparison of Cobb angles of scoliotic patients treated by exercises (age 11-12 years) with natural history (untreated scoliosis) in the same age group

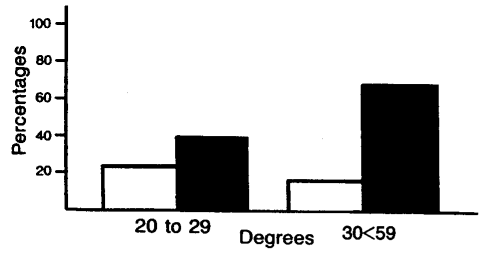

Fig 10: Comparison of Cobb angles of scoliotic patients treated by exercises (age 13-15) with natural history (untreated scoliosis) in the same age group

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% was found in double curves and the lowest progression of 12% in lumbar scoliosis. Similar results were observed by Fustier (1980). Rogola and colleagues (1978) found progression in 78.8% of cases with 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 20° 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 2).

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 43% 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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