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The efficacy of three-dimensional Schroth exercises in adolescent idiopathic scoliosis: A randomised controlled clinical trial

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Abstract

Objective: To compare the efficacy of three-dimensional (3D) Schroth exercises in patients with adolescent idiopathic scoliosis.
Design: A randomised-controlled study.
Setting: An outpatient exercise-unit and in a home setting.
Subjects: Fifty-one patients with adolescent idiopathic scoliosis.
Interventions: Forty-five patients with adolescent idiopathic scoliosis meeting the inclusion criteria were divided into three groups. Schroth's 3D exercises were applied to the first group in the clinic and were given as a home program for the second group; the third group was the control.
Main Measures: Scoliosis angle (Cobb method), angle of rotation (scoliometer), waist asymmetry (waist – elbow distance), maximum hump height of the patients and quality of life (QoL) (SRS-23) were assessed pre-treatment and, at the 6th, 12th and 24th weeks.
Results: The Cobb (-2.53°; *P*=0.003) and rotation angles (-4.23°; *P*=0.000) significantly decreased, which indicated an improvement in the clinic exercise group compared to the other groups. The gibbosity (-68.66mm; *P*=0.000) and waist asymmetry improved only in the clinic exercise group, whereas the results of the other groups worsened. QoL did not change significantly in either group.
Conclusion: According to the results of this study the Schroth exercise program applied in the clinic under physiotherapist supervision was superior to the home exercise and control groups; additionally, we observed that scoliosis progressed in the control group, which received no treatment.

Keywords

Adolescent idiopathic scoliosis, exercise, Schroth method

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Introduction

Various treatment approaches have been proposed for adolescent idiopathic scoliosis, including exercise, surgery, traction, bracing, casting, biofeedback and simple observation to correct, prevent or stop the progression of the deformity.[1-5] Conservative treatment methods including physiotherapy and bracing are accepted in Central Europe.[6] There are different types of exercise techniques for scoliosis, including the Schroth method.[2,4,7] The Schroth method is a physiotherapeutic approach that uses isometrics and other exercises to strengthen or lengthen the asymmetrical muscles. The treatment program consists of scoliotic posture correction and a breathing pattern with the help of proprioceptive and exteroceptive stimulations and mirror control.[4,7] Patients learn an individual correction routine using sensorimotor feedback mechanism and corrective breathing patterns called "rotational breathing". In this breathing pattern, the inspired air is directed to the concave areas of the thorax, and the ribs are mobilised in these regions by selective contraction of the convex area of the trunk.[7-9]

Studies have documented the effects of Schroth therapy in scoliosis.[4,7,8] The Schroth method helps patients halt curve progression, reverse abnormal curves, reduce pain, increase vital capacity, improve posture and appearance, maintain improved posture and avoid surgery.[3,6-9] However, studies showing the effects of Schroth's technique are fairly limited. Romano et al. reported recently in a systematic review a lack of high-quality evidence to recommend the use of scoliosis-specific exercises for adolescent idiopathic scoliosis.[10] We conducted the present study to determine the effects of Schroth's method on the Cobb angle, rib hump, vertebral rotation, waist asymmetry and quality of life in patients with adolescent idiopathic scoliosis. Our hypothesis, based on our clinical experience, has been that "Schroth exercises are effective in patients with adolescent idiopathic scoliosis, and it is more effective to perform the exercises under the guidance of a physiotherapist in the clinic rather than at home".

Methods

Adolescent idiopathic scoliosis patients who applied to the Division of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Istanbul University, between November 2010-December 2011 participated in this study. Ethical approval was obtained from the Istanbul Medical Faculty's Ethical Committee. A parent of each child signed an informed consent form.

The inclusion criteria were as follows: having a diagnosis of adolescent idiopathic scoliosis, age range of 10-18 years, a Cobb angle of 10 to 60 degrees, a Risser sign of 0-3, and, no other treatment which might affect scoliosis. The exclusion criteria were as follows: having contraindications to exercise, accompanying mental problems, neurological-muscular or rheumatic diseases, a previous spinal operation, and non-idiopathic scoliosis.

Each patient selected a number in a closed envelope, which was sorted via the 'Research Randomiser' program[11] for the randomisation process, and the patients were separated into the following three groups; the Schroth clinical exercise program under physiotherapist supervision (the exercise group), the Schroth home exercise program (the home group) and the control group.

Before the study, the entire spinal column of each patient was x-rayed in the anterior-posterior direction in a standing position. The Cobb method was used to measure the degree of scoliosis.[12]

The Risser sign grading was assessed on the anteroposterior radiograph, and the Tanner stage assessment was performed for each child. Some children might be shy during the Tanner assessment, and, in that situation, we asked them to select the figure consistent with their grade by self-assessment from the Tanner stage chart.[13-15]

The angle of trunk rotation was measured with a Scoliometer™,[16] and the readings were obtained at standing forward bending position (the maximum angle of trunk rotation was recorded).

The Adams forward bend test was used to check for prominence of the ribs or changes in the spine. The maximum height of the hump was measured using two rigid rulers. One of the rulers was placed horizontally on the highest point of the hump, and

another ruler was placed perpendicularly to the first ruler to measure the hump height. The average value of the measurements, repeated three times to ensure the accuracy, was recorded.[17]

The waist asymmetry was assessed in the standing position, the distance between the trunk and arm was measured on the same horizontal line at the midpoint of each waist concavity with a rigid ruler. The final asymmetry was calculated by subtracting one side from the other.

The "Scoliosis Research Society-23 (SRS-23)" questionnaire assesses the health-related quality of life specific to scoliosis and has five domains (function, pain, mental health, self-image and satisfaction). It has 23 items and the score ranges from 0 (worst) to 5 (best) for each item. The SRS-23 and SRS-22 have 22 identical items; however the SRS-23 has an additional question including body image.[18,19] The questionnaire was completed by the subjects.

Our treatment regimens lasted for six weeks (18 sessions) as an outpatient or home program. The patients in the Schroth exercise group started their exercise program under physiotherapist supervision for 1.5 hours a day, three days per week. The Schroth exercises were performed in an asymmetric position to maximise correction to achieve trunk symmetry. These exercises include spinal elongation, de-rotation, de-flexion, stretching, strengthening and rotational breathing exercises to maintain vertebral alignment.[7,9]

This program was taught to their caregivers as well, because after the six-week program was completed, they performed the same program at home. Additionally, the exercises were checked in the assessment sessions. During this period, the subjects were asked to combine these exercises with their daily living activities. In the second group, the Schroth exercises were taught to the subjects under the supervision and guidance of a physiotherapist, and these patients were asked to perform the exercises at home. To check the compliance, we asked the care givers if the exercises were regularly performed at home. The third group was the control group and these patients were under simple observation. The subjects were examined once every six weeks for a six-month period. All the assessments, which were conducted at the beginning of the study, were repeated at the 6th, 12th, and 24th week, and results were compared among the three groups.

The SPSS 15.00 software package was used for the statistical analysis. A value of P less than 0.05 was considered to be statistically significant for a two-tailed test. The chi-square test was used to compare the gender among the groups. Normality was analysed by the Shapiro-Wilks test.

Baseline and 24th week Cobb angle values were compared using the Wilcoxon signed-rank test, and the differences among the groups were analysed with the Kruskal Wallis test. A one-way ANOVA test was conducted to identify whether there were significant differences in the baseline demographics and the angle of trunk rotation values as well as the repeated measures of angle of trunk rotation in the group analysis. A paired-samples t-test was used to compare the means of two different assessments of the angle of trunk rotation for each group in the within group analysis. A Tukey's post hoc multiple comparison test was performed to detect the differences among the groups. The baseline SRS-23, and gibbosity and waist asymmetry variables as well as the, 6th, 12th and 24th week mean values were analysed with Friedman's test and the Kruskal-Wallis was performed on the group analysis for these variables. Kruskal-Wallis and Mann Whitney U tests were used to compare the differences in the changes among the three groups. The amount of the differences (found by subtracting the values obtained at different time frames from one another) among the changes between the baseline, 6th, 12th and 24th week results were analysed with a Wilcoxon signed-rank test for the within group analysis.

Results

Fifty-one patients with adolescent idiopathic scoliosis applied to the department, and 45 (39 females, 6 males) of them participated in this study (shown in the flow diagram, Figure 1). After the randomisation process, the patient distributions were as follows: the exercise group (n=15), the home group (n=15) and the control group (n=15). These 45 patients were able to complete the study and assessments.

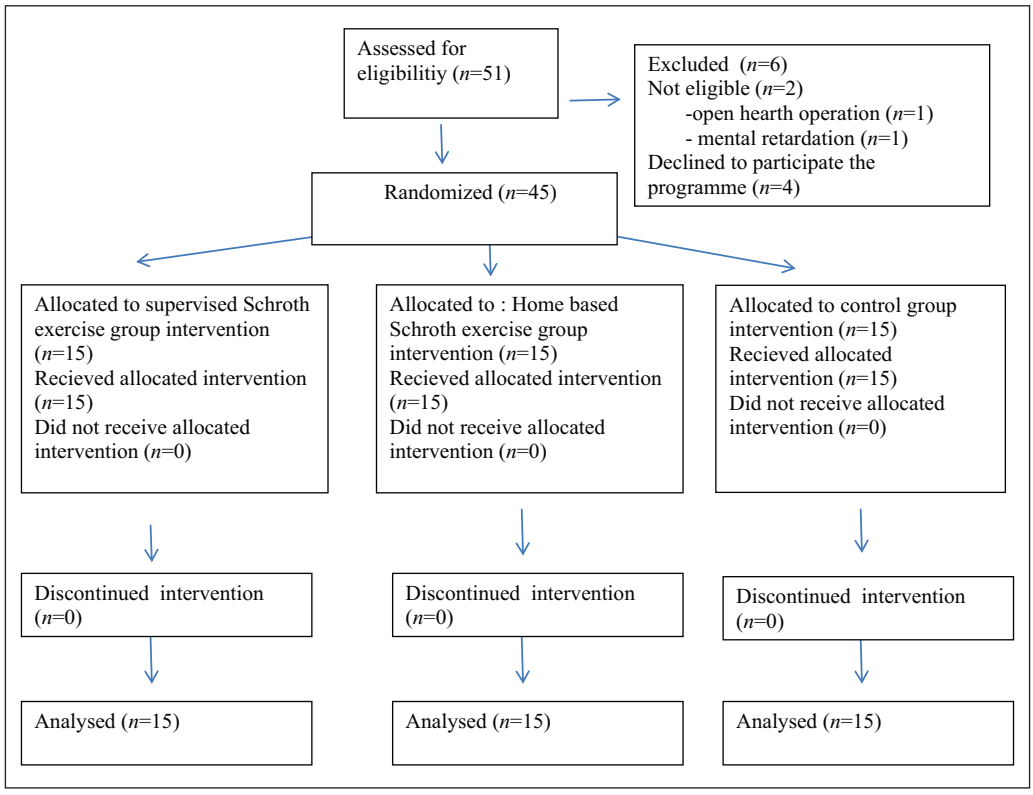

Figure 1. Flow diagram of the participants.

The comparison of the demographic and baseline clinical characteristics of the groups and the repeated measurement results are shown in Table 1. The assessment of the baseline comparability showed no significant differences among the three groups regarding the demographic characteristics, gender, Risser sign, and Tanner stage; the baseline clinical characteristics including the Cobb angle, angle of trunk rotation, height of the hump and waist asymmetry as well as the SRS-23 total score were similar among the groups. No patient wore a brace.

In a comparison of the groups in terms of the Cobb angle changes, there were significant differences among the three groups (P=0.003) (Table 2). The amount of the Cobb angle change amount in the exercise group was different from the results in the other groups, which indicated the superiority of the exercise group in showing an improvement.

The Cobb angle change amount in the exercise group indicates better improvement and was different from the Cobb angle change amounts in the two other groups, which was the reason for this significant difference.

There were statistically significant differences in the comparison of the angle of trunk rotation changes among the three groups between the 1st – 6th week (baseline to week 6) and 1st – 24th week assessments (Table 2). There were significant differences among the exercise group and the other groups in the paired group analysis when the groups were compared separately.

The changes in the height of the hump were compared among the three groups, and there were statistically significant differences in all the assessment results (Table 2). There were significant differences among the exercise group and the other groups in the paired group analysis.

Table 1. Baseline characteristics and measurement results at 6th,12th 24th weeks.

Parameter	Time	Supervised exercise group (*n*=15)	Home exercise group (*n*=15)	Control group (*n*=15)	*P* value
		Mean ± SD or median (min–max)	Mean ± SD or median (min–max)	Mean ± SD or median (min–max)	
Gender (Female/Male)	**Baseline**	14 / 1	12 / 3	13 / 2	0.562
Age (years)	**Baseline**	12.9 ± 1.4	13.1 ± 1.7	12.8 ± 1.2	0.797
Height (m)	**Baseline**	152.9 ± 10.7	157.9 ± 10.5	154.8 ± 10.9	0.483
Weight (kg)	**Baseline**	44.1 ± 8.6	50.6 ± 10.0	43.4 ± 8.4	0.228
BMI (kg/m²)	**Baseline**	18.8 ± 3.2	20.3 ± 3.4	18.0 ± 2.2	0.119
Risser Sign	**Baseline**	1.5 ± 1.3	1.4 ± 1.4	1.0 ± 1.2	0.555
Tanner Stage	**Baseline**	2.9 ± 0.9	3.1 ± 1.0	2.6 ± 1.1	0.480
Cobb angle	**Baseline**	33.4 ± 8.9	30.3± 7.6	30.3 ± 6.6	0.397
		32.0 (20.0 – 50.0)	30.0 (20.0 – 40.0)	28.0 (20.0 – 45.0)	
	24th week	32 (20 – 45)	35 (20 – 45)	32 (22–46)	
Angle of trunk rotation	**Baseline**	11.9 ± 5.2 (3.0 – 20.0)	9.6 ± 4.5 (3.0 – 20.0)	8.4 ± 2.9 (4.0 –19.0)	0.106
	6th week	7.40 ± 4.65	10.16 ± 5.10	9.16 ± 2.96	
	12th week	7.60 ± 5.03	10.53 ± 5.31	9.80 ± 3.20	
	24th week	7.66 ± 5.24	11.66 ± 5.92	10.50 ± 4.21	
Maximum height of the hump (mm)	**Baseline**	216.0 ± 116.4	156.7 ± 92.8	158.7 ± 95.7	0.235
		250.0 (20.0 – 430.0)	120.0 (30.0 – 350.0)	140.0 (40.0 – 400.0)	
	6th week	180.0 (20.0 – 370.0)	150.0 (30.0 – 370.0)	130.00 (40.00 – 430.00)	
	12th week	160.0 (20.0 – 340.0)	170.0 (30.0 – 350.0)	160.00 (40.00 – 410.00)	
	24th week	150.0 (20.0 – 310.0)	200.0 (30.0 – 450.0)	160.00 (40.00 – 450.00)	
Waist asymmetry (cm)	**Baseline**	2.2 ± 0.9	1.9 ± 1.1	1.5 ± 0.9	0.226
		2.0 (1.0 – 4.5)	1.8 (0.5 – 4.0)	1.3 (0.5 – 3.5)	
	6th week	1.5 (1.0 – 4.0)	1.5 (0.3 – 4.0)	1.3 (0.5 – 3.5)	
	12th week	1.5 (0.5 – 3.0)	1.5 (0.2 – 4.0)	1.6 (0.6 – 3.6)	
	24th week	1.5 (0.5 – 2.5)	1.5 (0.2 – 5.2)	1.5 (0.6 – 3.8)	
SRS–23 Total Score	**Baseline**	3.9 ± 0.6	3.9 ± 0.4	4.1 ± 0.4	0.452
		4.2 (2.7 – 4.7)	4.0 (3.2 – 4.5)	4.1 (3.3 – 4.6)	
	6th week	4.2 (3.3 – 4.7)	4.0 (3.3 – 4.7)	4.2 (3.3 – 4.6)	
	12th week	4.3 (3.3 – 4.8)	4.1 (3.5 – 4.8)	4.0 (3.5 – 4.7)	
	24th week	4.4 (3.5 – 5.0)	3.9 (3.9 – 4.7)	4.1 (3.0 – 4.7)	

Baseline: baseline assessment, 6: assessment at 6th week, 12: assessment at 12th week, 24: assessment at 24th.

Statistically significant differences were observed in the comparison of the waist asymmetry changes among the three groups in different assessment sessions. According to the measurements, the exercise under supervision group result was superior to that of the other groups for each assessment; the home group results showed a significant difference in the changes, indicating a decrease in the waist asymmetry compared to that of the control group for the baseline-6th week and 6th-12th week measurements (Table 2).

There were statistically significant differences in the amount of the changes observed between the 1st – 6th week (baseline to week 6) and 1st – 24th week assessments regarding the SRS-23 scores (Table 3). When the paired group comparisons were made separately, statistically significant differences were obtained between the home exercise and the control groups in terms of the 1st – 6th week (baseline to week 6) and 1st – 24th week assessments.

Discussion

Our study results, which appear to be consistent with the study hypothesis, indicate that the Schroth exercise program applied in the clinic under

Table 2. Mean change in Cobb angle, angle of trunk rotation, waist asymmetry at baseline, 6th,12th 24th week in three groups.

Mean change		Supervised exercise group (*n*=15) Mean ± SD	Home exercise group (*n*=15) Mean ± SD	Control group (*n*=15) Mean ± SD	*P* value G1-G2-G3	*P* value G1-G2 G1-G3 G2-G3
Cobb angle	C4	−2.53	3.33	3.13	**0.003**	**0.005** **0.006** 0.907
Angle of trunk rotation	C1	−4.50 ± 3.42	0.50 ± 1.23	0.73 ± 0.97	0.000	0.000 0.000 0.606
	C2	0.20 ± 1.74	0.36 ± 1.20	0.63 ± 1.40	0.652	
	C3	0.26 ± 0.88	1.13 ± 1.84	0.70 ± 1.36	0.199	
	C4	−4.23 ± 4.78	2.00 ± 2.39	2.06 ± 2.09	**0.000**	**0.001** **0.000** 0.833
Height of gibbosity (mm)	C1	−42.00 ± 30.75	7.33 ± 20.51	9.33 ± 21.86	**0.000**	**0.000** **0.000** 0.685
	C2	−16.00 ± 15.49	21.33 ± 35.22	9.00 ± 15.79	**0.000**	**0.000** **0.000** 0.360
	C3	10.66 ± 13.87	24.00 ± 43.55	9.33 ± 13.34	**0.000**	**0.001** **0.000** 0.652
	C4	−68.66 ± 47.48	52.66 ± 91.21	28.00 ± 38.39	**0.000**	**0.000** **0.000** 0.815
Waist asymmetry (cm)	C1	−0.37 ± 0.32	−0.13 ± 0.26	0.02 ± 0.07	**0.001**	**0.031** **0.012** **0.002**
	C2	−0.19 ± 0.36	−0.04 ± 0.11	0.13 ± 0.20	**0.028**	0.078 **0.019** **0.035**
	C3	−0.16 ± 0.20	0.14 ± 0.36	0.02 ± 0.20	**0.038**	**0.019** 0.056 0.564
	C4	−0.72 ± 0.68	0.02 ± 0.38	0.18 ± 0.32	**0.000**	**0.001** **0.015** **0.000**

C1: Mean change from baseline to week 6, C2: mean change from week 6 to week 12, C3: mean change from week 12 to week 24, C4: mean change from baseline to week 24. G1: Group 1 (supervised exercise), G2: group 2 (home exercise), G3: group 3 (control).

supervision of a physiotherapist is effective and essential to slow or stop the progression of scoliosis, decrease the Cobb and rotation angles and improve the cosmetic appearance.

The physiotherapist-supervised Schroth exercise program is superior to the home exercise program and no treatment, and scoliosis showed progression in the home exercise program and control groups.

Table 3. Mean change in total SRS-23 scores at baseline 6th,12th 24th week in three groups.

Mean change		Supervised exercise group (*n*=15) Mean ± SD	Home exercise group (*n*=15) Mean ± SD	Control group (*n*=15) Mean ± SD	*P* value G1-G2-G3
SRS-23 Total Scores	C1	0.16 ± 0.18	0.05 ± 0.28	−0.04 ± 0.13	0.111
	C2	0.08 ± 0.24	0.11 ± 0.18	0.02 ± 0.13	0.464
	C3	0.08 ± 0.13	0.08 ± 0.27	−0.09 ± 0.22	0.175
	C4	0.33 ± 0.34	0.08 ± 0.37	−0.03 ± 0.23	0.131

C1: Mean change from baseline to week 6, C2: mean change from week 6 to week 12, C3: mean change from week 12 to week 24, C4: mean change from baseline to week 24; G1: Group 1 (supervised exercise), G2: group 2 (home exercise), G3: group 3 (control).

Our study is important because of its randomised controlled design for the non-surgical treatment of adolescent idiopathic scoliosis; there is a lack of this type of study investigating a specialised exercise program effect that includes many dimensions such as quality of life and other objectively measured parameters.

Follow up measurements of the adolescents with idiopathic scoliosis is recommended until bone maturity is completed, and we measured our patients at baseline and at the 6th and 12th weeks. We obtained our latest results at the sixth month and do not have longer-term results yet, which could be considered a limitation of our study. Our small sample size is another limitation that could be related to this study. Further studies are needed that include larger sample sizes and longer term results in randomised controlled designs as well as a comparison of different types of specific exercises for scoliosis.

For many years, the effectiveness of different types of exercises in scoliosis treatment was not investigated in the literature.[20,21] In natural course studies, patients who perform exercises are classified in the non-therapy group by surgeons.[21] The methodology and supervision of and compliance with the exercises as well as the length of the follow up or the duration of the treatment period have not been well described in studies. Conclusions regarding these data in the studies is difficult.[20,21] Solberg suggested that judging the therapeutic effect of exercise on scoliosis is not advisable without close supervision and monitoring of performance.[20]

Exercise therapy is important in the treatment of adolescent idiopathic scoliosis because loss of spinal flexibility is a structural deformity of the spine, which might become rigid. If the curvature is sufficiently mobile and the patient is able to change posture, the condition could be defined as non-structural or functional scoliosis, which is a situation in which we might be more effective with conservative treatment of scoliosis and expect much better improvements than in scoliosis cases presented with a rigid spine. Regarding this knowledge, and as Hawes indicated, therapy methods based on exercises that increase and protect the flexibility of the spine might be useful in the treatment of scoliosis without surgery or bracing.[21]

Specific exercises for scoliosis are being practiced with different intensities and durations.[6,22,23] A review that investigated the role of exercise therapy in idiopathic scoliosis reports that an exercise session frequently lasts approximately 45-60 minutes, and 2-3 sessions are performed per week.[24] In our study, the individual exercise therapy sessions were performed for 1.5 hours, 3 times/week (18 sessions) for six weeks in the Schroth exercise group.

The capability of each child for correcting the curve and learning the exercises is different. According to our clinical observations in this study, some of the children learned the exercises properly at the first session, and most of them performed the exercises correctly at the second session; some children needed to relearn their exercises. Regarding the different learning capabilities of children, some children might need a longer time

with the physiotherapist to learn the Schroth exercises effectively. Comparing the duration, intensity and number of exercise sessions might be specific subjects for future investigations.

In Otman's study, the Cobb angle was decreased by 6.85° after six months and by 8.25° after one year following the Schroth exercise therapy.[22] In our results, the mean Cobb angle decreased 2.53° in the exercise group whereas it increased 3.33° in the home group and 3.13° in the control group. These change amounts were significant compared to one another because scoliosis is a progressive disease; avoiding an increase of the curvature angle by having better results in the exercise group than in the home exercise and control groups is a success.

Negrini et al. reported in their study that the angle of trunk rotation decreased 0.33° in their scoliosis specific exercise group and increased 0.15° in their control group (traditional physiotherapy).[23] In another study, the angle of trunk rotation decreased an average of 0.98° after treatment in patients who had only Schroth exercise therapy for three months.[25] Our results are consistent with these previous literature findings showing that the angle of trunk rotation decreased in the exercise group whereas it increased in the home exercise and control groups (Table 1). These changes were significant when compared to one another in showing the superiority of the results of the exercise group.

The height of the hump decreased in the patients who perform exercises.[25] Romano et al. found that the height of the hump decreased in the exercise group; however, it increased in the patients who were non-compliant with the exercises and in the control group.[26] This study showed that the height of the hump decreased in the exercise group and increased in the home exercise and control groups, and these changes indicated the superiority of the Schroth exercise group over the other groups.

There are insufficient data regarding the waist asymmetry measurement in the literature. Only Watanabe et al. have published a study evaluating and scoring waist asymmetry.[27] Regarding our waist asymmetry measurements, we concluded that exercising under supervision is more effective for achieving a better cosmetic appearance in children; we detected that the waist asymmetry changes showed better improvement in the exercise group than in the home and control groups after the first six weeks and at the 24th-week follow up. Additionally, we found that home exercises could be effective for changing the cosmetic appearance for lateral asymmetry. Exercising at home might correct frontal plane changes in scoliosis. However, this change is not reflected in the rotational deformity or Cobb angle. This type of measurement lacks reliability and validity, and a definite conclusion is difficult.

Scoliosis might lead to several physical and psychosocial problems and negatively affect the quality of life, depending on the severity of the curve.[28] In the literature, children diagnosed with adolescent idiopathic scoliosis and treated conservatively showed quality of life improvement.[29] Another study, which assessed the quality of life in adolescents with the SRS-22, reported that there was no change in the quality of life scores of the control groups after a six-month follow up and that the only change was improved cosmetic appearance scores in the exercise group compared to those of the control group.[30] In this study, we could not conclude that Schroth exercises under supervision or home exercises improve the quality of life based on the SRS-23 total score comparison among the groups. The results showing the amount of change were similar in all the assessments, and no superiority among the groups was noted according to the SRS-23 results or the SRS-22 total results.

Based on our clinical observation in this study, adolescents do not like intensive exercise programs and might have trouble focusing on exercise as well as becoming distracted. Based on our clinical experience with children, brief and low-intensity exercise programs might provide greater satisfaction and result in better compliance. Providing different names for the exercises, using various materials that relatively increase the enjoyment of exercising or attempting group exercises might improve compliance.

Teaching the Schroth method to patients requires a significant amount of time, and physiotherapists should have special training and experience.

The patients in our study have not completed bone maturation, which might an advantage because

of spine flexibility; the lack of bone maturation might confer a disadvantage because of the risk of scoliosis progression. In this study, the Schroth exercises were performed under physiotherapist supervision by children with a progression risk, and the Cobb angle, angle of trunk rotation, height of the hump measurement and waist asymmetry improved, compared to the results of the other groups. The results of the home and control groups were similar, and the supervised group results were superior to the results of the home and control groups.

Clinical messages

- A program of well-planned individualised Schroth exercises under physiotherapist supervision is an effective method for improving regression or stopping progression of idiopathic scoliosis in adolescents.
- A home exercise program including Schroth exercises without supervision is not an effective treatment method for adolescent idiopathic scoliosis.
- Curvature progression is inevitable for most children with idiopathic scoliosis if they are not treated by exercise, bracing or surgery.

Conflict of interest

The authors declare that there is no conflict of interest.

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