Effect of Short-Term 3-Dimensional Schroth Exercises In Adolescent Idiopathic Scoliosis: An Observational Study

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Abstract

Objective: The purpose of this study was to examine how a short-term Schroth exercise camp affects pain intensity, angle of trunk rotation (ATR), postural recovery, trunk muscle endurance, flexibility, dynamic balance, body image, perception of cosmetic deformity, and health-related quality of life in individuals with adolescent idiopathic scoliosis (AIS).

Methods: A single-group pretest−posttest design was conducted. Forty-five individuals between the ages of 10 and 18 years who were diagnosed with AIS were included in the study. ATR with scoliometer, postural symmetry changes with Anterior Trunk Symmetry Index and Posterior Trunk Symmetry Index, trunk muscle endurance with straight plank and side plank durations, dynamic balance with Y Balance Test, cosmetic deformity perceptions with the Walter Reed Visual Assessment Scale, and health-related quality of life with the Scoliosis Research Society 22-item questionnaire. The participants engaged in a short-term Schroth exercise camp involving 4.5 hours of corrective exercises per day for 7 days. Above mentioned assessments were done on the first and last day of the exercise camp.

Results: After the Schroth exercise camp, participants showed decreased ATR, improved postural symmetry ratio, and greater trunk muscle endurance and dynamic balance scores. There were also improvements in cosmetic deformity perception and health-related quality of life ($P < .05$).

Conclusion: This preliminary study suggests that a short-term Schroth exercise camp could have a beneficial effect for adolescents with AIS. Although the results of this study should be considered preliminary, the initial findings seem to be promising and repeatable. (J Manipulative Physiol Ther 2021;44;612-620)

Key Indexing Terms: *Exercise; Scoliosis; Treatment; Balance; Quality of Life*

Introduction

Scoliosis is a 3-dimensional complex spine deformity characterized by lateral deviation of 10 degrees or more in the frontal plane, rotation in the transverse plane, and hypokyphosis in the sagittal plane that can be observed with spinal radiographs.[1] Although there are several different types of scoliosis (eg, congenital, degenerative, neuromuscular, functional), 90% of diagnosed cases are adolescent idiopathic scoliosis (AIS).[2]

The most commonly recommended treatment methods for AIS include observation, exercise, bracing, and surgical interventions. Exercise therapy has been found to yield successful results, especially in low-grade curves where exercises are able to slow or stop progression of the curves.[3]

The American Academy of Orthopedic Surgery has supported the potential efficacy of symmetric and asymmetric mobilizing exercises on the progression of scoliosis.[4] The Schroth method, which is also categorized as scoliosis-specific exercises, was developed by Katharina Schroth in Germany in 1920.[5] The Schroth method aims to train muscle groups that have developed asymmetrically due to the asymmetrical spinal position into a more balanced, symmetrical position with corrections and "rotational breathing." These rotational breathing and correction exercises are planned individually according to the participant's scoliosis curvature and aim to lengthen the spine and correct imbalances in all 3 dimensions.[6] Training also includes building the muscle strength and endurance needed to maintain spinal and postural corrections once they are achieved.[5,7,8]

Exercise studies using the Schroth method have been conducted in clinics providing inpatient and outpatient

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treatment (individual or group sessions) and provided encouraging mid-term results on parameters such as Cobb angle, angle of trunk rotation (ATR), pain, muscular endurance, and quality of life.[7,9] Schroth exercise camps could be an effective additional treatment plan to long-term inpatient rehabilitation programs. However, to the best of our knowledge, there are few studies in the literature investigating the effects of short-term Schroth exercise camps. Studies on the treatment results of short-term scoliosis exercise camp improvements were reported on ATR, Cobb angle, and vital capacity values.[6,10] However, to our knowledge, no study has evaluated changes in balance, quality of life, postural symmetry, and cosmetic deformity perception, which are important factors while evaluating treatment outcomes.[11]

Therefore, the primary aim of this study was to examine the effects of a short-term Schroth exercise camp on ATR, postural symmetry, trunk muscle endurance, dynamic balance, cosmetic deformity perception, and health-related quality of life in this participant group. The secondary aim was to evaluate repeatable outcomes of short-term Schroth exercise camps. The hypothesis of our study was that short-term Schroth exercise camps are effective on ATR, postural symmetry, trunk muscle endurance, dynamic balance, cosmetic deformity perception, and health-related quality of life.

Materials and Methods

Study Design and Ethics

A study using a single-group, pretest−posttest design was conducted. Ethical approval was obtained from the Uskudar University Non-Interventional Ethics Committee (decision number: 61351342/2020-283, dated 27.05.2020). The study was conducted in accordance with the Declaration of Helsinki, and signed informed consent forms were obtained from their parents.

Participants

Participants between 10 and 18 years of age who presented to the Fizyosport Center in Antalya (2 Schroth exercise camps, each with 10 participants) or the Banu Ozel Ustun Exercise Training and Counseling Center in Eskisehir (3 Schroth exercise camps, 1 with 12 participants, and 2 with 7 participants each), which are specialized scoliosis clinics, and were diagnosed as having AIS by a specialist physician were invited to participate in the study. Inclusion criteria were having a diagnosis of AIS and Cobb angles between 10 and 45 degrees for primary and secondary curves. Participants at all levels of skeletal maturity (Risser stage 0-5) were included. Exclusion criteria were the presence of congenital or traumatic scoliosis, spina bifida, osteoporosis, serious cardiopulmonary comorbidity, history of spinal surgery, and lack of written informed consent from a parent to participate in the study.[7]

Sample Size Calculation. Before the study, G*Power 3.1.9.4 software (Heinrich-Heine-Universität Düsseldorf) was used to determine the minimum sample size required based on scoliometer measurements used in a previous study.[10] It was determined that a sample size of 45 people was needed to detect an effect size of 0.5 with a power of 0.95 and an alpha error level of 0.05.

Outcome Measures

Demographic information such as age (years), weight (kg), height (cm), and body mass index (kg/m^2) were recorded, and information pertaining to the participants' Cobb angles (degrees), primary curvature according to the central sacral line and transitional point (TP) side, brace, and insole use (yes/no) was obtained. This was followed by the series of assessments described below.

Angle of trunk rotation. ATR was measured using a special inclinometer, called a scoliometer, during Adam's forward bend test. The reliability of this assessment was demonstrated previously by Amendt et al.[12] Participants were asked to stand upright looking forward, with their feet parallel and adjacent to each other, then bend forward with their hands and feet together until their trunks were parallel to the floor.[12] During the evaluation, the spinous processes were measured by scoliometer (Orthopedics Systems Incorporation) at the cervical, thoracic, and lumbar regions, and changes of 1 degree or more were noted for each region separately.[13] ATR measurement was repeated by the same physiotherapist at the beginning and end of the intervention.

Postural symmetry. The Anterior Trunk Symmetry Index (ATSI) and Posterior Trunk Symmetry Index (POTSI) are reliable tools for documenting postural changes and the corrective effects of treatment.[14] Before evaluation, several points on the participants' bodies (sternal notch center, acromion, bilateral, axillary region, the deepest point of the waist arch bilaterally, the spinous process of the C7, intergluteal cleft) were marked with non-toxic markers. After completing the marking, participants were asked to stand on a cross marked on the floor in front of a blank wall. A camera was positioned 3 m from the participant at a height adjusted to the center of the pelvis. Anterior and posterior images were acquired and uploaded to the SCODIAC program, which automatically calculates ATSI and POTSI values.[14]

Trunk muscle endurance. Basic plank and side plank durations, which have demonstrated validity and reliability, were used to evaluate trunk muscle endurance.[15,16] For basic planks, the maximum time that the participants were able to remain supported on their toes and forearms with their knees, hips, and torso aligned parallel to the floor was recorded. The test was terminated when the participant could not maintain the initial position or the pelvis moved more than 5 cm up or down. The side plank test was performed in the side-lying position, supported by the forearm and feet, with the pelvis in neutral position. The test was repeated for both sides and was terminated when the pelvis began to rotate or moved up or down more than 5 cm. The maximum hold times in both positions were recorded in seconds.[17]

Dynamic balance. The Y Balance Test was used to assess dynamic balance in this study. The test was reported by Shaffer et al to have high reliability.[18] The Y Balance Test kit includes a platform and 3 rails that are attached to the anterior, posteromedial, and posterolateral aspects of the platform. Reach indicators on these rails are pushed as far as possible with 1 foot while balancing on the other leg, and the reach distance is recorded in centimeters. The test was started with the dominant foot, which was determined by asking the participant which foot they would use to kick a ball at a target.[19] Six practice trials were done in each direction with both legs before the test. During the test, the participants were asked to push the indicators as far as possible. After 3 repetitions, the maximum reach distance achieved in each direction was recorded. The values were normalized for each direction using the formula: % maximum reach = maximum reach distance / lower extremity length × 100. The composite score (%) was calculated using the following formula: (total reach in all 3 directions) / (3 × lower extremity length) × 100. The test was terminated when the participant lifted the heel of the stance foot, lost contact between the nonstance foot and distance marker, needed support to maintain balance, or could not return to starting position.[20]

Cosmetic Deformity Perception. The Walter Reed Visual Assessment Scale (WRVAS) enables participants with idiopathic scoliosis to describe their perceptions of their posterior deformity. The Turkish version of the scale was validated by Çolak et al.[21] The tool consists of 7 rows of drawings, each with 5 figures depicting a different aspect of deformity: spinal curvature, rib prominence, flank prominence, trunk deformity, alignment of trunk to midline, shoulder level, and scapular rotation. Each row is scored from no deformity (1 point) to severe deformity (5 points), and all scores are summed to determine a total score ranging from 5 to 35 points.[22]

Health-related quality of life. The Scoliosis Research Society 22-Item questionnaire (SRS-22) was used to assess health-related quality of life in this study. The SRS-22 was translated into Turkish by Alanay et al and consists of 22 questions in 5 domains: pain (5 items), physical activity (5 items), cosmetic appearance (5 items), mental well-being (5 items), and treatment satisfaction (2 items). Response options range from negative (1 point) to positive (5 points). Subscale scores are between 5 and 25 for all domains except treatment satisfaction (range, 2-10). The total score is the sum of all items. Higher scores indicate higher quality of life.[23]

Short-Term Schroth Exercise Camp Procedure

After the pretest assessments performed on the first day of an exercise camp, the Schroth exercise classifications and appropriate exercises were determined by the same responsible physiotherapist at every exercise camp, which was held in scoliosis-specific exercise clinics. During each exercise camp, participants completed 4.5 hours of daily exercise (with 2 breaks of 30 minutes) for 7 days (total of 31.5 hours) in the presence of the responsible and assistive physiotherapists who also had International Schroth 3D Scoliosis Therapy training. One physiotherapist was responsible for a maximum of 3 participants. Target exercises (Table 1) were taught statically and dynamically after aligning the posture to the midline and in all 3 planes with passive support and 3-dimensional corrective movements and breathing (Fig 1). The exercises were repeated until the participants were able to perform them accurately. To be sure that participants have enough time to practice and also the therapist to correct each participant at each exercise module or exercise, each exercise was performed 3 × 5 times and was repeated again on each day. After the accuracy for the exercise was achieved by the participant, the therapist added more challenging positions for each participant; if the participant was unable to control the exercise, the therapist continued with easier tasks or supported them during the exercise. In addition, individuals were informed about their scoliosis and scoliotic according to their exercises. Relaxed

Table 1. *Primary Curves According to the Schroth Classification and Selected Exercises*

	T-Type (Major Thoracic Curvature)	L-Type (Major Lumbar Curvature)
Exercises	Supine shoulder counter-traction on T-side	Supine shoulder counter-traction on L-side
	Sitting weak side stretch	Sitting weak point stretch
	Sideways hang	Side-lying muscle cylinder
	Side-lying shoulder counter-traction	Side-lying psoas synergy
	Sitting shoulder counter-traction	Sitting on a chair/ball
	Between 2 poles	Between 2 poles
	Schroth gait	Schroth gait

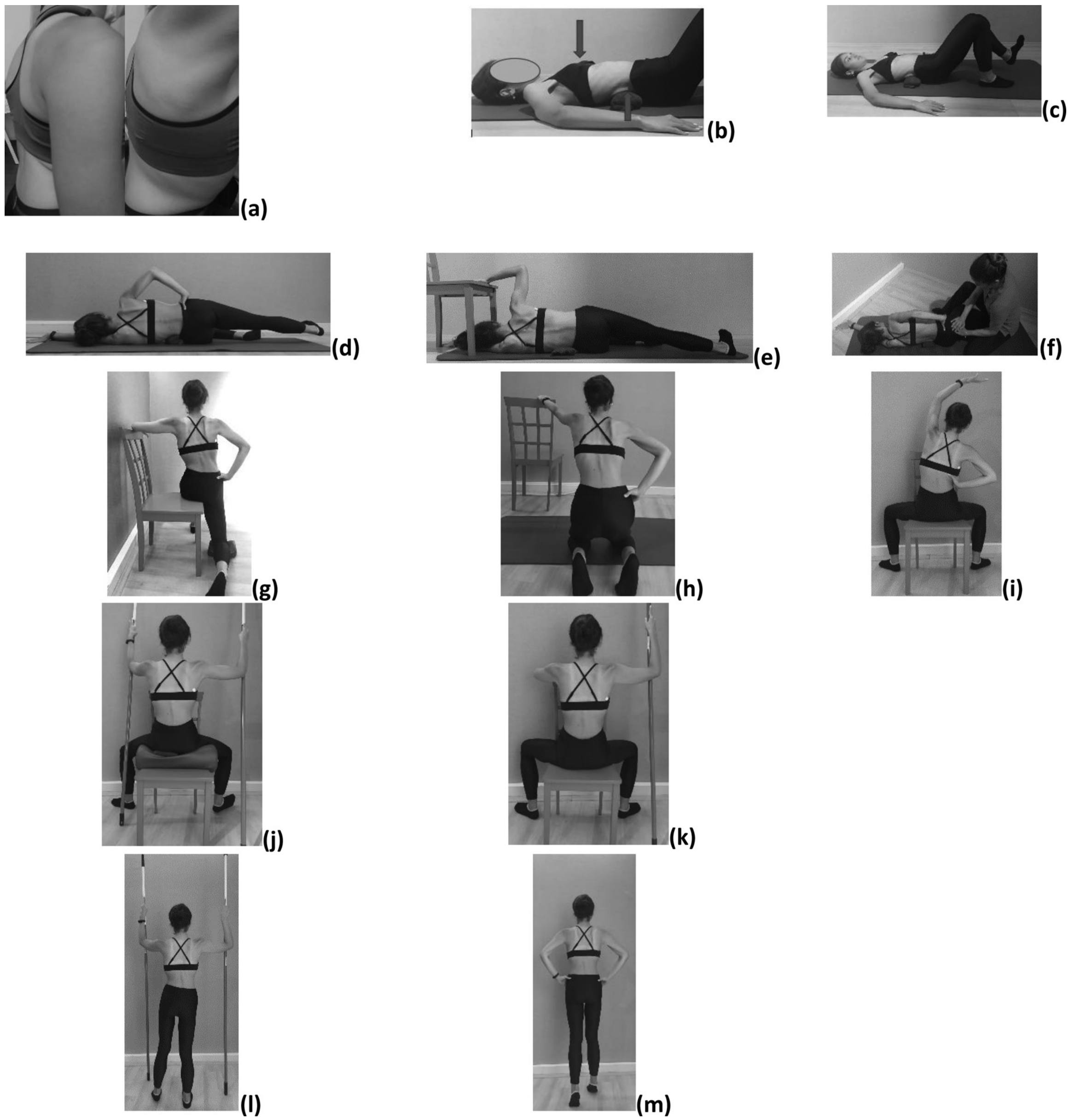

Fig 1. *Schroth exercises. (A) Three-dimensional corrective breathing. (B) Stabilization of the L4-5 segments. (C) Supine shoulder counter-traction on L-side. (D) Side-lying muscle cylinder. (E) Side-lying shoulder counter-traction. (F) Side-lying psoas synergy. (G) Sitting weak point stretch. (H) Sideways hang. (I) Sitting weak side stretch. (J) Sitting on a chair/ball. (K) Sitting shoulder counter-traction. (L) Between 2 poles. (M) Schroth gait.*

posture positions in which gravity is eliminated during rest periods were shown according to each participant's scoliotic curvature. Afterward, individuals were trained on how to use conscious posture during common activities of daily life, such as sitting, standing, and walking.

Statistical Analysis

Statistical analyses were performed using SPSS version 24 software (IBM Corp, New York, NY). Normality of the data distributions was examined using visual (histogram and probability graphs) and analytical methods (Shapiro-Wilk tests). Descriptive statistics were presented as mean and standard deviation for normally distributed variables and as number and percentage for nominal variables. Paired-samples *t*-test was used to compare pretest to posttest changes in ATSI, POTSI, basic plank test, side plank test, WRVAS score, and SRS-22 results, while the Wilcoxon signed rank test was used for ATR measurements and Y Balance Test scores, which did not show normal distribution. Statistical significance level was accepted as $P < .05$.

Results

Forty-nine individuals with AIS between the ages of 10 and 18 years were enrolled in the study. Of these, 1 participant was not evaluated because they did not meet the study inclusion criteria, and 2 participants did not agree to participate. As a result, the study was completed with 46 individuals.

Of the participants who agreed to participate in the study, 82.6% (n = 38) were female and 17.4% (n = 8) were male. The participants' mean age was 16.13 ± 2.87 years, mean height was 1.63 ± 0.07 m, mean weight was 51.93 ± 10.57 kg, mean body mass index was 19.41 ± 3.22 kg/m^2, and mean Risser stage was 3.2 ± 1.67. Cobb angles were measured as 5.98° ± 7.49° for the cervical region, 24.33° ± 14.55° for the thoracic region, and 26.05° ± 12.33° for the lumbar region (Table 2).

The comparison of scoliosis type according to the central sacral line and TP sides of individuals with AIS included in the study is given in Table 3. According to the results, it was observed that the rate of L-type scoliosis type was statistically higher in participants to the left of the central sacral line, which indicates a major lumbar curvature (Table 3).

Individuals with AIS who used a brace constituted 32.6% of all individuals (Table 4). Brace usage time of individuals was found to be 20.05 ± 1.96 hours. Individuals with AIS using insoles constituted 15.2% of all individuals (Table 4).

Comparison of pretest and posttest data revealed statistically significant improvements in mean ATR values for the cervical, thoracic, and lumbar regions, ATSI and POTSI values, trunk muscle endurance, and Y Balance Test results in the anterior, posteromedial, and posterolateral directions ($P < .05$). There was also a significant decrease in mean WRVAS scores and a significant increase in SRS-22 scores in the post-test compared to pretest values ($P < .05$) (Table 3).

Table 2. *Demographic Characteristics of the AIS Participants Included in the Study (N = 46)*

Demographic Characteristics	Mean ± SD	Minimum-Maximum
Age (y)	16.13 ± 2.87	10-23
Height (m)	1.63 ± 0.07	1.49-1.8
Weight (kg)	51.93 ± 10.57	33-80
BMI (kg/m^2)	19.41 ± 3.22	14.29-28.96
Risser stage	3.2 ± 1.67	0-5
Cobb cervical (°)	5.98 ± 7.49	0-28
Cobb thoracic (°)	24.33 ± 15.55	0-64
Cobb lumbar (°)	26.05 ± 12.33	0-51

AIS, adolescent idiopathic scoliosis; *BMI,* Body mass index; *kg,* kilogram; *m,* meter; n, number of participants; *SD,* standard deviation.

Table 3. *Comparison of Scoliosis Type According to TP side of Individuals With AIS Included in the Study (N = 46)*

		AIS Scoliosis Type				X^2	*P*
		T-Type		L-Type			
		n	%	n	%		
TP side	Right side of the CSL	5	50	5	50	15.38	.000
	Left side of the CSL	1	2.8	35	97.2		

$P < .05$.
AIS, adolescent idiopathic scoliosis; *CSL,* central sacral line; *L-Type,* transitional point is on the lumbar convexity side; n, number of participants; *SD,* standard deviation; *TP,* side of the transitional point according to the central sacral line; *T-Type,* transitional point is on the thoracic convexity side; X^2, chi-square analysis; %, percentage.

Discussion

Our study findings demonstrate that a short-term Schroth exercise camp may have positive effects on the ATR, postural symmetry, trunk muscle endurance, dynamic balance, cosmetic deformity perceptions, and health-related quality of life in individuals with AIS Table 5.

Reduction in the amount of rotation at the vertebral level in the transverse plane is reported to be one of the most important parameters when evaluating treatment success in AIS.[3] Decreases in ATR have been observed at the end of 3-, 6-, and 12-month therapy programs, as well as in studies evaluating the results of short-term exercise programs based on the Schroth method.[3,9,10,24-26] At the end of the present study, the decrease in ATR values was consistent with the literature. In our study, our aim was not only to observe the changes in ATR parameters but also to add more parameters like dynamic balance, postural improvement, trunk muscle endurance, cosmetic deformity

Table 4. *Features of Brace and Insoles Use of Individuals With AIS Included in the Study (N = 46)*

AIS		n	(%)
Brace use	Yes	15	32.60
	No	31	67.40
Insole use	Yes	7	15.20
	No	39	84.80

AIS, adolescent idiopathic scoliosis; *m,* meter; *n,* number of participants; (%), percentage.

Table 5. *Comparison of Pretest and Posttest Assessments in Participants With AIS (N = 46)*

	Pretest Mean ± SD	Post-test Mean ± SD	*P*
Angle of trunk rotation			
Cervical (°)	1.15 ± 2.08	0.52 ± 1.13	<.05[a]
Thoracic (°)	6.57 ± 5.34	4.35 ± 4.11	<.001[a]
Lumbar (°)	7.83 ± 5.71	4.54 ± 3.89	<.001[a]
ATSI	30.28 ± 13.49	21.01 ± 9.14	<.001[b]
POTSI	33.15 ± 15.26	19.44 ± 8.5	<.001[b]
Basic plank (s)	38.46 ± 23.02	71.26 ± 35.79	<.001[b]
Side plank, left (s)	32.09 ± 21.58	71.07 ± 33.05	<.001[b]
Side plank, right (s)	37.07 ± 26.31	79.26 ± 34.2	<.001[b]
Y Balance Test, dominant leg			
Anterior maximum Reach (%)	66.02 ± 25.53	72.54 ± 26.53	<.001[b]
Posteromedial maximum reach (%)	55.21 ± 23.82	66.19 ± 23.94	<.001[b]
Posterolateral maximum reach (%)	61.93 ± 26.81	75.16 ± 26.56	<.001[b]
Composite score (%)	61.05 ± 24.13	71.30 ± 24.80	<.001[b]
Y Balance Test, non-dominant leg			
Anterior maximum reach (%)	62.79 ± 28.20	73.25 ± 26.60	<.001[a]
Posteromedial maximum reach (%)	53.35 ± 22.40	65.64 ± 22.17	<.001[a]
Posterolateral maximum reach (%)	64.67 ± 25.30	77.49 ± 26.31	<.001[a]
Composite score (%)	60.27 ± 24.44	72.13 ± 24.14	<.001[a]
WRVAS score	15.07 ± 3.42	12.57 ± 2.77	<.05[b]
SRS-22 total score	3.9 ± 0.46	4.15 ± 0.4	<.001[b]

P < .05.
AIS, adolescent idiopathic scoliosis; *ATSI,* Anterior Trunk Symmetry Index; *n*, number of participants; *POTSI,* Posterior Trunk Symmetry Index; SD, standard deviation; *SRS-22,* Scoliosis Research Society 22-Item Health-Related Quality of Life Questionnaire; *WRVAS,* Walter Reed Visual Assessment Scale.
[a] Wilcoxon test.
[b] Paired *t*-test.

perception, and health-related quality of life before and after a Schroth scoliosis camp, which were evaluated in scoliosis patients in the literature.[11,23,27-29] The exercise camp program consists of intensive training with individualized exercises and corrections to provide ATR control. We believe this promotes optimal muscle contraction of the muscles required for ATR control in accordance with the motor development stages so that the corrections may be more quickly transferred to activities of daily living and possibly resulting in a more rapid decrease in ATR. However, in future studies, we think that it will be beneficial to add control groups to the short-term Schroth exercise camps and compare variables such as age, sex, curve type, and use of braces to further examine the effect of exercise camp on ATR.

It is known that individuals with AIS have postural asymmetries due to scoliotic curves.[1,30,31] In individuals with AIS, the body's center of gravity moves away from the midline, and postural deviations can be seen.[30,32] A decrease in postural asymmetry after therapy can be interpreted as the center of gravity returning to the midline; therefore, frequent evaluation of postural symmetry is recommended during therapies and treatments.[3] Although many different methods for evaluating postural asymmetry have been described in the literature, we used the photography method due to its cost-effectiveness and easy applicability in the clinical setting. Improvements in postural symmetry values have been observed after therapy using the Schroth treatment protocol.[6,33] Chongov et al conducted a 5-day Schroth training with children with different Cobb angles and reported significant decreases in the ATSI and POTSI values after the treatment.[6] Similarly, we detected significant improvements in the postural symmetry of individuals with AIS after a 7-day Schroth exercise camp, regardless of curve type and severity. As postural symmetry can be affected by factors such as age, sex, and spinal flexibility, we think that examining the correlation between these parameters and post-test values could be useful in terms of clarifying the expectations of the individuals participating in such exercise camps and improving the exercise camp program.

We assume that increased trunk muscle endurance is also important in maintaining the acquired postural symmetry. A previous study on the effects of the Schroth method on trunk muscle endurance demonstrated significant improvement in trunk muscle endurance after treatment.[34] According to the literature, trunk muscle endurance develops over 6 to 8 weeks.[35] We attribute the increase in endurance times observed in our study after only 1 week to the trunk muscles approaching their physiological limits and to the activation of the motor units required to reveal optimal muscle strength in the lumbopelvic region. We think that this is related to modulation of the firing rate of the existing active motor units.[36] However, in order to document these physiological changes, electromyographic measurements before and after the exercise camp will provide more objective data regarding the increased duration of trunk muscle endurance due to the exercise camp.

AIS is also described as a motor control disorder in which static and dynamic balance may be affected, including problems with motor adaptation and learning, postural control, and proprioception.[37] The literature data indicate that balance and Schroth exercises are interrelated.[33,38] In our study, we think that the increases seen in the participants' dynamic balance are related to the positive effect of the exercises on the proprioceptive system, which is also emphasized in the literature. We believe that the synergistic contraction of local muscles together with the re-establishment of a healthy relationship with the central nervous system and restoration of lumbopelvic stability during Schroth exercises seems to improve performance in the dynamic balance test.

One of the major problems for individuals with AIS is the cosmetic and quality of life changes resulting from the 3-dimensional pathomechanism.[3,28,39-41] Improvements in the perception of cosmetic deformity in individuals treated with Schroth or other scoliosis-specific exercise programs showed that similar results could be achieved with a short-term Schroth exercise camp lasting 7 days. In the present study, the reduction in WRVAS scores may be related to an increase in postural symmetry and to the patients noticing these results, which heightens their body awareness. Regarding the improvement in the SRS-22 total scores after the short-term Schroth exercise camp, we believe the improvement in quality of life after such a short period may be related to the increase in psychological support and the time spent with other individuals diagnosed with scoliosis.

Limitations

Although our study was planned with 95% power and included a sufficient number of individuals, there are some limitations. Parameters such as the participants' sex, curvature type and degree, and brace use were not taken into account. Furthermore, we did not have a control group for comparison with the intervention group. The final limitation is that we do not have data on the long-term results of the exercise camps. However, our immediate findings suggest a potential benefit of this short-term program and warrant further investigation in larger, randomized controlled trials with longer follow-ups.

Conclusion

The results of this study suggest that a short-term Schroth exercise program might have a positive influence on trunk rotation angle, postural improvement, trunk muscle endurance, dynamic balance, cosmetic deformity perception, and health-related quality of life in adolescents with AIS. Although the results of this study should be considered preliminary, the initial findings seem to be promising and repeatable.

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This project was not funded by any grants or funding agencies. The authors declare no conflicts of interest.

Contributorship Information

Concept development (provided idea for the research): D.A.,Y.E.
Design (planned the methods to generate the results): D.A.,Y.E.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): D.A.,Y.E.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): D.A.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): D.A.,Y.E.
Literature search (performed the literature search): D.A.,Y.E.
Writing (responsible for writing a substantive part of the manuscript): D.A.,Y.E.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): Y.E.

Practical Applications

- Participants in a Schroth exercise camp showed decreased ATR, improved postural symmetry ratio, and greater trunk muscle endurance and dynamic balance scores.
- In this study, we also observed improvements in cosmetic deformity perception and health-related quality of life ($P < 0.05$).
- This preliminary study suggests that a short-term Schroth exercise camp could have a beneficial effect for adolescents with AIS.

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