RESEARCH ARTICLE

Outcomes of 12 Weeks of Schroth and Asymmetric Spinal Stabilization Exercises on Cobb Angle, Angle of Trunk Rotation, and Quality of Life in Adolescent Boys with Idiopathic Scoliosis: A Randomized-controlled Trial

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Abstract

Objectives: The available evidence on the efficiency of well-known Schroth's exercises (SE) for correcting adolescent idiopathic scoliosis (AIS) is limited, especially in combination with the asymmetric spinal stabilization exercises (ASSE) method. Therefore, we hypothesized that, first, there is no difference in the efficiency of the combined exercises (SE+ASSE) and SE alone in improving Cobb angle, angle of trunk rotation (ATR), and quality of life (QoL) in AIS. Second, there is no difference in the efficiency of SE and no intervention on corresponding variables in treating AIS.

Methods: This randomized controlled trial (RCT) consisted of 40 patients with mild AIS (10-18-year-old boys) divided into three groups: SE (n=15), SE+ASSE (n=15), and a waitlist control group (n=10). For 12 weeks (three days a week), both experimental groups performed SE, the combined group additionally received ASSE, and the control group received no intervention. The assessment included Cobb angle (photogrammetry), ATR (Adam's test), and QoL (Scoliosis Research Society-22 questionnaire).

Results: It was found that Cobb angle, ATR, and QoL improved significantly in the combined SE+ASSE group (Cobb=16.45° to 9.01°; ATR=4.93° to 1.33°) compared to the SE group (P<.001). In addition, the SE group showed significant amelioration in the mentioned variables (Cobb=15.09° to 9.77°; ATR=4.23° to 2.17°) compared to the control group (P<.001), whereas the control group remained almost unchanged.

Conclusion: Based on the obtained results, the combination of SE and ASSE provided more benefits than SE alone, and the SE results were efficient compared to the no-intervention group regarding the correction of scoliosis and related problems. However, patients with moderate to severe scoliosis should also be investigated in longer treatment periods in future.

Level of evidence: I

Keywords: Cobb angle, Exercise therapy, Quality of life, Schroth, Scoliosis

Introduction

Scoliosis (Cobb angle of ≥10) is an illness described by three-dimensional spinal deformation set apart by misshaping in the frontal (lateral curvature), transverse (vertebral rotation), and sagittal planes (thoracic lordosis).[1] Adolescent idiopathic scoliosis (AIS), with a prevalence of 0.47-5.2%, is the most common type of this illness (about 80%).[2]

While the main cause of AIS is not confidently known, some potential causes have been found to influence the rate of this deformity, including genetics, hormonal dysfunction, abnormal platelet calmodulin levels, bone density change, and central nervous system abnormalities.[3,4] Scoliosis can cause several complications such as body asymmetry, respiratory disorders,[5] mental and psychological disorders,

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poor quality of life (QoL),[6] back pain,[7] and even osteoporosis,[3] Failure to pay attention to corrective and therapeutic strategies, especially in the growth spurt age, can lead to the severity of scoliosis and its problems.[8] For this reason, various invasive (surgery) and non-invasive (usually therapeutic exercises and braces) strategies have been proposed to treat and control its progression.[9]

Due to the likely dangers of surgery as an invasive strategy, it causes dread and anxiety in AIS patients.[1] Additionally, non-invasive treatments such as wearing braces for long periods of time can cause flat back, muscle weakness, inflexibility, negative self-esteem,[10] impaired lung function,[5] and even foster reluctance in the adolescents regarding their will to proceed with the treatment process.[10]

Here, the role of therapeutic exercise becomes prominent.[11] While different exercise methods have been provided by therapists and specialists,[9,12] Schroth's exercises (SE) have become more prominent due to promising results and have attracted the attention of many researchers and experts in this field.[13-15]

However, while the SE approach is generally utilized in AIS treatment, the number of space randomized controlled studies on the matter and its effectiveness is limited.[1,15,16] Furthermore, two recent systematic review studies pointed the possibility of more positive effects of the SE method in combination with other exercise methods,[13,14] however, limited evidence exists supporting this hypothesis.[14,17-19]

Electromyography studies indicate muscle imbalance in the spine of idiopathic scoliosis patients (especially paraspinal muscle weakness on the concave side).[20-22] For this reason, asymmetric spinal stabilization exercises (ASSE) were designed to improve muscle imbalance, Cobb angle, and angle of trunk rotation (ATR), etc.[20]

To this date, although the efficiency of combining most exercise methods (such as pilates, core stabilization, respiratory muscle, etc.) with the SE method has been investigated, the benefits of combining SE and ASSE have not yet been tested.[18,19,23]

Unfortunately, because access to AIS is limited and their treatment process is difficult, the majority of previous studies could not correctly distinguish between the effects of braces and those of exercises.[17,18,23,24] In addition, the lack of randomized controlled studies is another gap in the literature.

These gaps have been mentioned in several recent systematic reviews, and the need for more studies with better methodological quality has been addressed to determine the best exercise intervention to correct AIS.[1,13-15] Therefore, the present study was conducted to alleviate the mentioned issues in the literature.

The primary null hypothesis of this research is that there is no difference in the effectiveness of combined exercises (SE+ASSE) and SE alone on improving Cobb angle, ATR, and QoL in AIS. Secondarily, it hypothesized that there is no difference in the effectiveness of SE and no intervention (or control group) on corresponding variables in treating AIS patients.

Materials and Methods

Study design

The study design was a randomized controlled trial (RCT) and was conducted (between January 2022 and March 2023) at the Department of Corrective Exercises, Red Crescent Rehabilitation Center in Tehran, Iran. The study protocol was approved by the Ethics Committee of the Research Institute of Sports Sciences in Tehran, Iran (approval ID: IR.SSRC.REC.1400.108), based on the Declaration of Helsinki.[25] Before the study, informed consent was obtained from all participants and their parents. Due to an error of omission, the study was registered retrospectively on December 15, 2021, in the Iranian Registry of Clinical Trials (IRCT Identifier: IRCT20180727040609N1).

Participants

The participants of this study included 40 boys with mild AIS (Cobb angle 10˚-30˚),[9] and Lenke curve type 1 and 5,[26] who were diagnosed by a physician and referred to the Red Crescent Rehabilitation Center in Tehran, Iran, to receive therapeutic and corrective exercise services. Simple randomization was used to group the participants.[27] For this purpose, every patient chose a number in a shut envelope, which was arranged by means of the "Research Randomizer" website program for the allocation, concealment, and randomization cycle.[28] These patients were then divided into the following three groups: the SE+ASSE (n=15), the SE (n=15), and the waitlist control group (n=10) groups [Figure 1]. G*Power 3.1 software was used to calculate the sample with a power of 80%, an alpha of 0.05, and an effect size of 0.88 (statistical test; ANCOVA: fixed effects, main effects, and interactions).[29] The sample size of 30 participants was placed in groups (10 in each). Therefore, this RCT included 15 participants in the experimental groups to calculate the dropout rate, and the control group consisted of 10 participants.

Inclusion criteria

The inclusion criteria consisted of diagnosis of AIS (only boys) aged 10-18 years old, having Cobb angles between 10˚ to 30˚,[11] Lenke curve type 1 and 5,[26] and not receiving any other treatment (e.g., brace) that could affect scoliosis.[1]

Exclusion criteria

The exclusion criteria included patients with a Cobb angle greater than 30°,[9] non-idiopathic scoliosis, neurological or neuromuscular problems, mental problems, trauma-related diseases, leg discrepancy, congenital anomalies, or previous spinal surgery.[30] Furthermore, the patients who had been prescribed braces or medicine and were reluctant to continue the exercises or unable to participate were excluded from the study.[24,31]

Interventions

The participants of both intervention groups performed the exercises for 50-70 min, three times per week, for 12 weeks in the clinic under the supervision of specialists. While the participants of the third group (the control group) received no therapeutic intervention during the research period, and due to ethical considerations, they were placed on the waiting list for 12 weeks before receiving the delayed intervention and were monitored during this period.

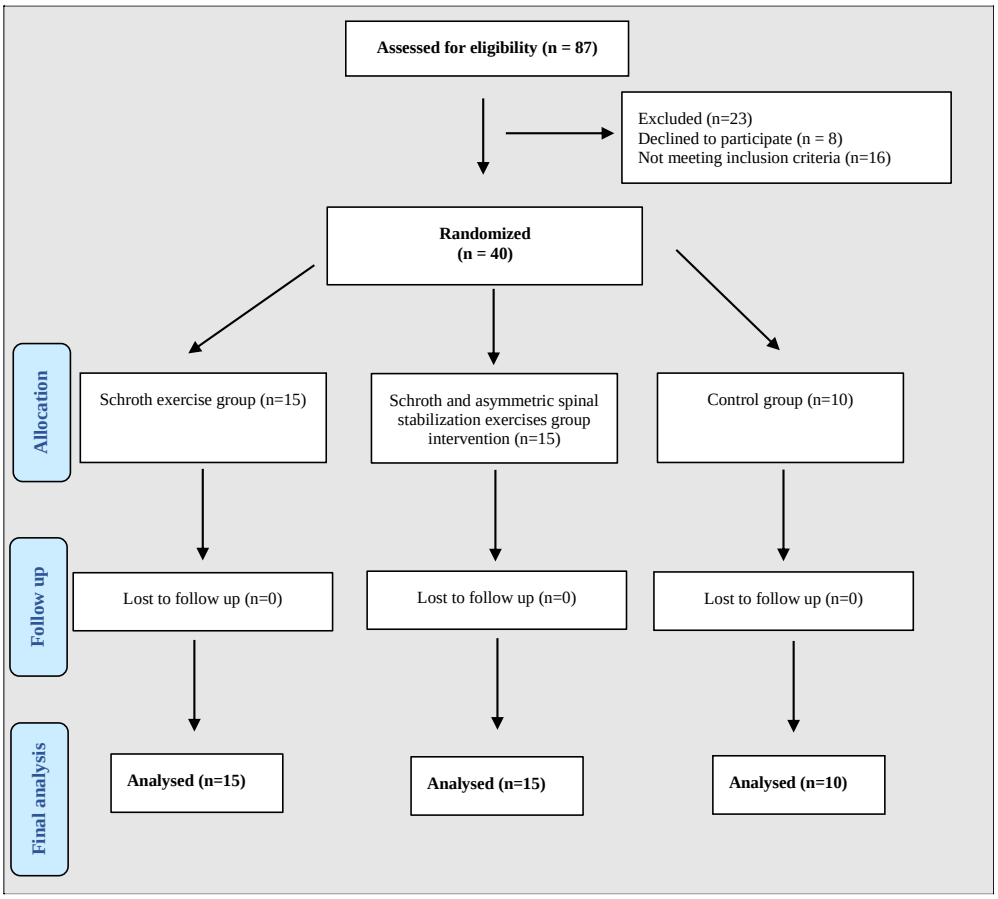

Figure 1. Flow diagram of the participants

The exercises consisted of warm-up (10 min), the main exercise (40-55 min), and cool down (5 min). Both experimental groups received SE, while the combined exercise group additionally received ASSE [Figure 2 and 3]. The exercises were designed based on the results obtained from the evaluation and diagnosis of the type and area of curvatures of AIS patients.

The exercise programs in both experimental groups were developed based on the principle of FITT (frequency, intensity, time, and type).[32] Schroth's exercises progressed from more to less feedback, from more to less passive support, and from lying down to sitting and standing exercises based on the patient's ability (4-6 sets × 5-8 repetitions, progressing from the beginning to the last weeks of treatment) [Figure 2].

Asymmetric spinal stabilization exercises were given in three phases of progress. The first phase consisted of motor training and activation of core extensor muscles (such as gluteal, multifidus, and paraspinal muscles) to improve muscle coordination and proprioception in spinal areas in static positions or isometric contraction (4 sets × 10 to 15 seconds). In the second and third phases, more intense exercises were performed to improve stability and eliminate muscle imbalances in dynamic positions or isotonic contraction (4 sets × 6 to 12 repetitions) [Figure 3].

Schroth exercises

Schroth exercises (SE) include de-rotation, spinal elongation, de-flexion, strengthening, and rotational breathing stretching exercises to maintain vertebral alignment. The following exercises were selected from the SE method.[24]

First, the SE for AIS patients with thoracic scoliosis included correcting the thoracic region [Figure 2A], hanging [Figure 2E], stretching the concave side (weak side) [Figure 2H], strengthening the posterior trunk muscles [Figure 2J], and sitting on the Swiss ball [Figure 2I]. Second, the SE for those with lumbar spine scoliosis included lumbar area correction [Figure 2B], hanging techniques [Figure 2E], side bridge (lateral hip lifting) [Figure 2G], concave or weak side stretching [Figure 2H], and strengthening of the posterior trunk muscles [Figure 2J]. Third, for those with thoracolumbar curvature (lumbar and thoracic scoliosis), the SE consisted of correction of the thoracolumbar spine area [Figure 2F], basic correction sitting [Figure 2C], hanging techniques [Figure 2E], self-correction in front of the mirror [Figure 2D], stretching of the concave or weak side, and strengthening of the posterior trunk muscles [Figure 2J].

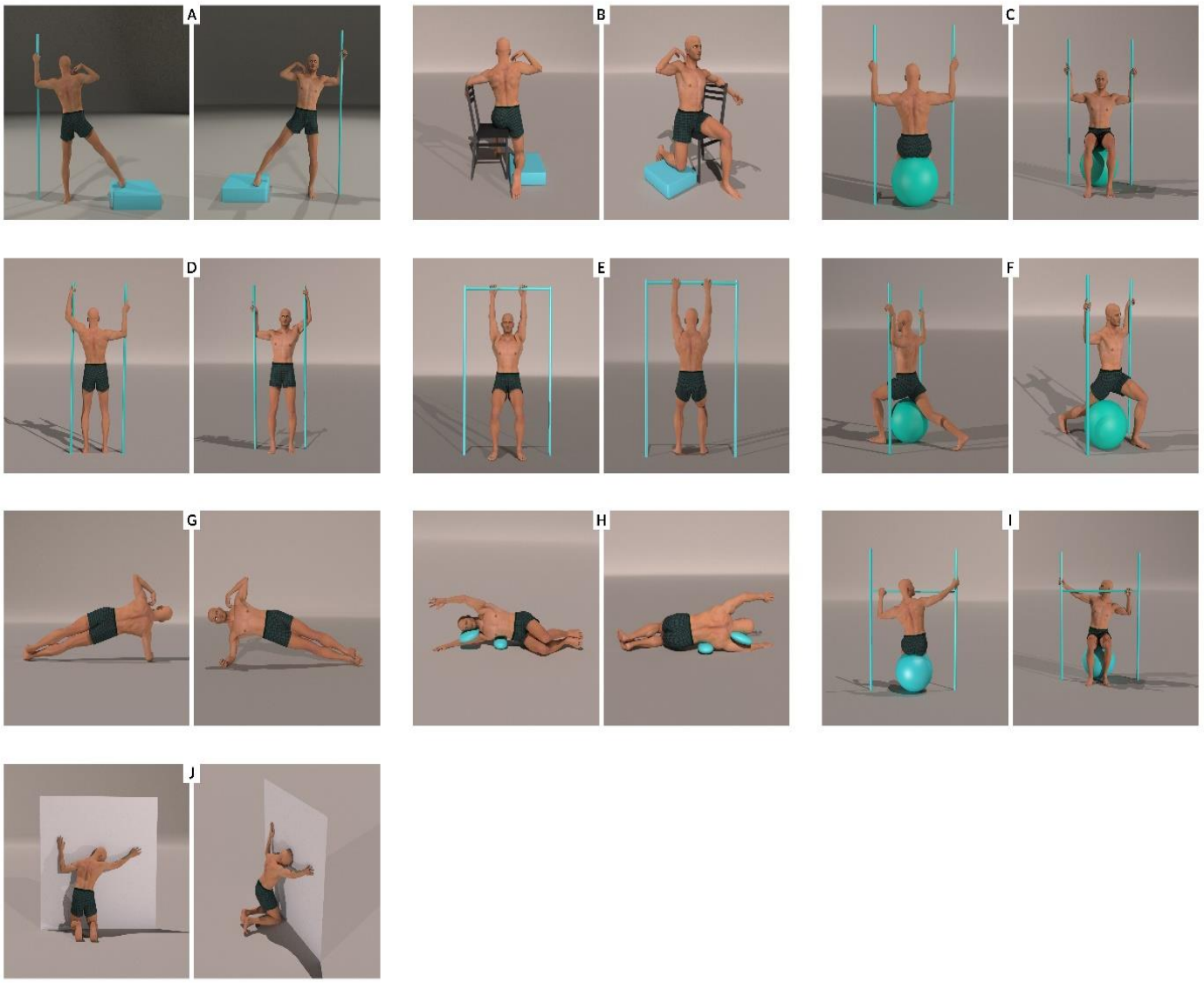

Figure 2. Schroth exercises: correction of the thoracic region (A), correction of the lumbar region (B), basic correction of sitting (C), self-correction correction with a mirror (D), hanging techniques (E), correction of thoracolumbar region (F), side bridge (G), weak side traction (H), correction of the thoracic region sitting on a Swiss ball (I), stretching the side and strengthening the back muscles (J)

Asymmetric spinal stabilization exercises

Asymmetric spinal stabilization exercises (ASSE) were categorized into the following three types (a total of 8 movements): prone position (4 movements), quadruped position (3 movements), and a side bridging exercise [Figure 3].[20] These movements were classified into the following categories:

First, for the patients with the right (Rt; convex) proximal thoracic (apex in T9-T12) scoliosis, left (Lt) hand up [Figure 3A], Rt leg up [Figure 3C], both Lt hand and Rt leg up in quadruped position [Figure 3D], Lt side bridge [Figure 3H], and both legs and hands up in the prone position [Figure 3I] were included. Second, for the patients with Rt distal thoracic scoliosis (apex in T6-T8) consisted of Lt hand up [Figure 3A], both Lt hand and Rt leg up in quadruped position [Figure 3D], Lt hand up [Figure 3E], Lt hand and Rt leg up [Figure 3G], and both legs and hands up in prone position [Figure 3I]. Third, for the patients with Rt lumbar or thoracolumbar scoliosis consisted of Lt leg up in quadruped position [Figure 3B], Lt leg up in prone position [Figure 3F], Lt side bridge [Figure 3H], and both legs and hands up in the prone position [Figure 3I]. It should be noted that all the movements were performed in the opposite direction in AIS patients with convexity to the left.

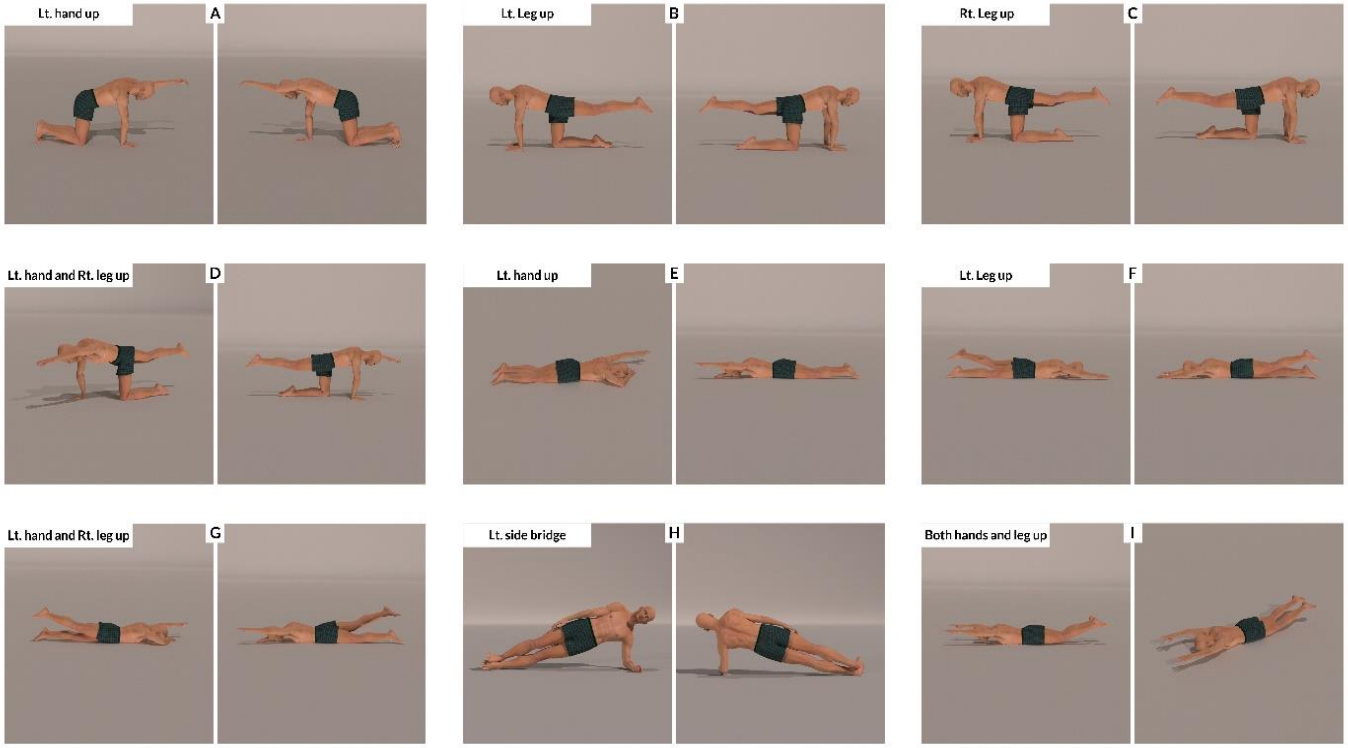

Figure 3. Asymmetric spinal stabilization exercises: Quadruped; Left hand up (A), Left leg up (B), Right leg up (C), Left and Right leg up (D), Prone: Left hand up (E), Left leg up (F), Left hand and Right leg up (G), both hands and legs up (I); Left side bridge (H)

Measurement

Cobb angle

The photogrammetric method was used to calculate the Cobb angle. For this reason, anatomical landmarks (C7, T12, and S2) were palpated and identified with a marker by the examiner while the participant was standing from behind with bare feet at a distance of 2 meters from the camera, and the photogrammetry process was performed in the frontal plane. Then, two lines were drawn on the inferior and superior limit vertebrae (vertebrae close to the midline) to the apical vertebra (the furthest vertebra from the midline) and the angle between them was considered as the Cobb angle (the obtained angle was subtracted from 180°) [Figure 4].[33] Photogrammetry is considered as a method without adverse effects in adolescents and with validity and test-retest reliability in measuring the Cobb angle of patients with scoliosis.[33] A semi-automatic software named SCODIAC was used for ease of measurement [free download link; https://www.ortotika.cz/download/SetupSCODIAC_Full.zip].

Angle of trunk rotation

The angle of trunk rotation (ATR) was assessed by Bunnell's scoliometer and Adam's forward bend test. For this purpose, the patient was asked to bend forward, and then the center point of the scoliometer was placed on the apical vertebra parallel to the horizontal plane. The angle observed on the scoliometer was recorded as the ATR. This tool has high reliability and validity and can be used in evaluating the ATR of scoliosis patients.[34]

Quality of life

Quality of life (QoL) was evaluated by the Scoliosis Research Society-22 (SRS-22) questionnaire. It consists of five domains: function, pain, mental health, self-image (five questions each), and satisfaction with treatment (two questions). To answer each of the 22 items of this questionnaire, scores between 1 (worst) to 5 (best) were considered, and the average of the five domains was recorded as the patient's final score. It has been introduced as a validity and test-retest reliability tool in examining the QoL of scoliosis patients.[35] All of these variables were evaluated at both pre- and post-treatment stages.

Statistical analyses

The Kolmogorov-Smirnov (K-S) test was used to examine the normal distribution of data. Analyses of covariance (ANOCOVA) and Bonferroni post-hoc tests were used to determine the differences between the groups (group effect). Data was analyzed with IBM SPSS software (version 23; IBM Corporation, Armonk, NY, USA), and a $P \leq 0.05$ was considered statistically significant.

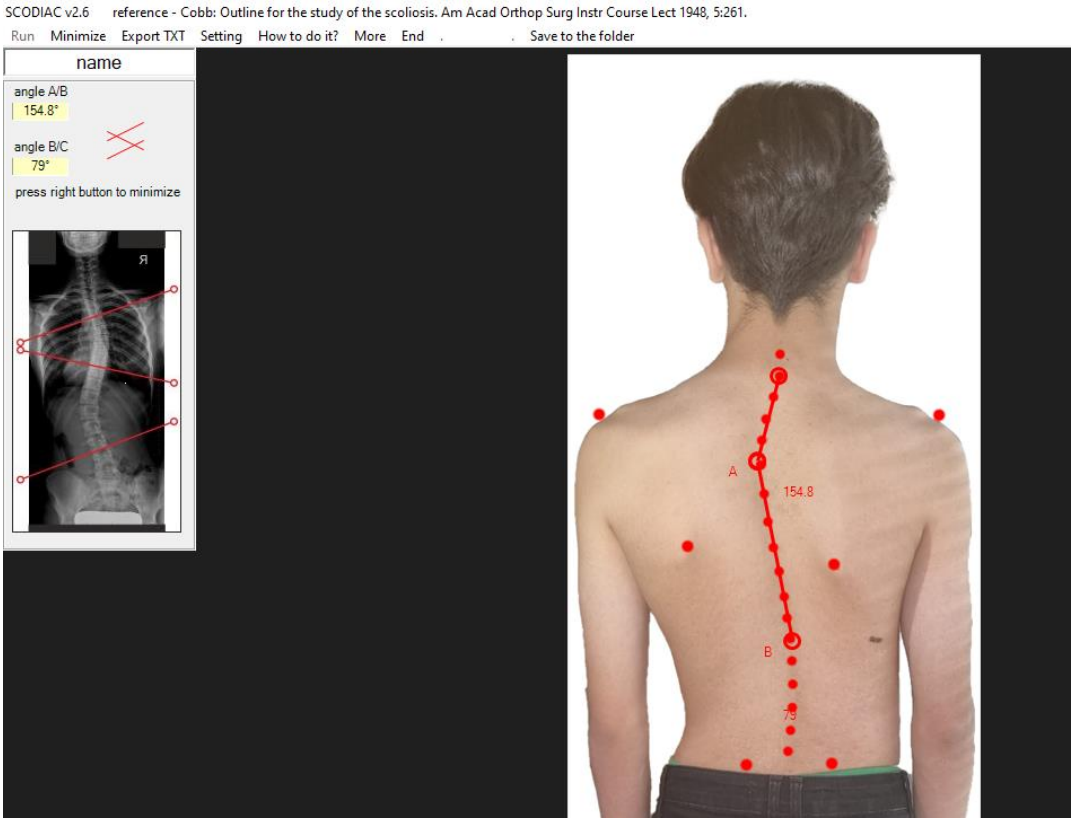

Figure 4. Cobb angle measurement using the photogrammetry method

Results

The results of the K-S test indicated that the research variables had normal distribution (P>0.05), and the parametric method was applied. The ANOCOVA underlying assumptions, including linearity of regression, homogeneity of error variances, independence of error, normality of error, and homogeneity of regression slopes were found to be valid. The characteristics of the participant demographic and the analyzed variables are presented in Tables [Tables 1 and 2, respectively]. In addition, tests of between-subjects effects using the covariance were reported in Table 3 [Table 3]. From the collected data, it can be understood that the Cobb angle, ATR, and QoL in the post-test in the two exercise groups improved after the intervention.

Table 1. Main characteristics of the demographic group

Groups	Frequency (n)	Age (years)	Height (cm)	Weight (kg)	BMI (kg/m2)
Control	10	15.4±1.51	163.6±12.76	50.01±16.97	20.77±5.25
Schroth	15	16.27±1.44	169.8±7.62	55.09±8.83	18.94±2.65
Schroth and ASSE	15	16.33±0.90	173.4±8.48	62.03±12.86	20.67±3.63
P-value	-	.17	.051	.060	.269

ASSE: asymmetric spinal stabilization exercises

Table 2. Main variables in pre- and post-tests, and the results of Bonferroni post-hoc test

Groups	Control		Schroth		Schroth and ASSE	
Variables /intervention time	pre-test	post-test	pre-test	post-test	pre-test	post-test
Cobb angle*	11.32±0.96	11.56±0.97	15.09±4.41	9.77±5.25[a]	16.45±5.25	9.01±2.78[ab]
ATR*	2.90±0.52	3.06±0.37	4.23±0.73	2.17±1.06[a]	4.93±1.41	1.33±0.59[ab]
QoL **	3.57±0.33	3.56±0.33	3.73±0.36	4.29±0.21[a]	3.57±0.31	4.40±0.21[ab]

* Degree, **Score. ASSE: asymmetric spinal stabilization exercises; ATR: angle of trunk rotation; QoL: quality of life
a P≤0.05, a significant difference with the Control group
b P≤0.05, a significant difference with the Schroth group

Table 3 presents the results of covariance analysis for each variable. The results showed a significant difference in the mean of Cobb angles ($F_{(2, 36)}$ =11.74, P<.001, η^2=.40), ATR ($F_{(2, 36)}$ =23.16, P<.001, η^2=.56), and QoL ($F_{(2, 36)}$ =72.26, P<.001, η^2=.80) in the three study groups [Table 3]. A significant difference was found between the Cobb angles in the SE and

the SE+ASSE groups with the control group (P<.001). The Cobb angles in the two experimental groups were found to be significantly less than in the control subjects (P<.001). Additionally, the Cobb angle in the SE+ASSE group was found to be significantly less than the SE group [P=.031; Table 2].

A significant difference (decrease) was found between the ATR in the SE and the SE+ASSE groups with the control group (P<.001). Additionally, a significant difference (decrease) was found between the ATR in the SE and SE+ASSE groups (P=.001). Therefore, the improvement was observed more in the SE+ASSE group [Table 2].

Finally, the QoL in the SE and SE+ASSE groups showed a significant difference from the control group (P<.001), and the SE group was significantly different from the SE+ASSE group (P=.019). As a result, the QoL of the patients increased after 12 weeks of the exercise program, and this increase was greater in the SE+ASSE group [Table 2].

Table 3. Tests of between-subjects effects using the covariance

	Source	SS	df	MS	F	Sig.
Cobb angle	Pre-test	132.87	1	132.87	19.30	< .001
	Groups	161.70	2	80.85	11.74	< .001
	Error	247.82	36	6.88	-	-
ATR	Pre test	.89	1	.89	1.87	.180
	Groups	21.99	2	10.99	23.16	< .001
	Error	17.09	36	.48	-	-
QoL	Pre-test	1.39	1	1.39	45.16	< .001
	Groups	4.44	2	2.22	72.26	< .001
	Error	1.11	36	.03	-	-

ATR: angle of trunk rotation; QoL: quality of life; SS: sum-of-squares; df: degrees of freedom; MS: mean squares; F: F ratio

Discussion

This RCT showed that, regarding mild AIS (Cobb angle 10˚-30˚), the combined exercises group (SE+ASSE) was superior in decreasing Cobb angle, ATR, and improving QoL compared to the SE group after 12 weeks of treatment under direct supervision. In addition, the amelioration of the mentioned issues was observed in the SE group compared to the group without receiving corrective exercises (control) on these patients. From the above findings, several novel scientific and practical aspects will be added to the literature and discussed.

Methods preventing the progression of the Cobb angle and ATR as major prognostic and clinical indications of the curve while also reducing the possibility of elective surgical treatment are important in the treatment of AIS.[11] The clinical standard for individual curve regression is a reduction of the Cobb angle > 5°. Therefore, any change less than this angle is not considered a real improvement.[36]

The findings of the current research indicate changes in Cobb angle of > 5° in both the combined SE+ASSE (16.45° to 9.01°) and SE (15.09° to 9.77°) groups. However, the positive changes were significantly better in the combined SE+ASSE group. While some previous studies reported the improvement of the Cobb angle and ATR, Cobb angle changes of < 5° have been reported, which is in conflict with the results of the present study.[18,19,24]

For example, Schreiber et al. found that after six months of SE added to standard care compared to the control group, only a 4° reduction in the sum of curves (root mean square value) occurred.[18] Similarly, Kuro et al. found that despite six months of Schroth therapeutic exercises, only a relative improvement in Cobb angles (-2.53°; P=0.003) and ATR (-4.23°; P=0.000) occurred.[24] Of course, the difference in the severity of the scoliosis curves (10°-60°) and the lack of gender segregation (boys/girls), as well as the major implementation of exercises at home (which increases the possibility of implementing incorrect movement techniques), can be the possible reasons for the difference in the findings obtained by the two mentioned studies and the present research. Nevertheless, the findings of the present study are in line with several previous studies in terms of Cobb angle and ATR.[30,31,37]

As stated, combined SE+ASSE resulted in more significant amelioration in patients, which is in line with the suggestion of a systematic review[13] and a meta-analysis[14], in which better efficacy of SE in combination with other general exercise methods (such as pilates, core stabilization, yoga, or tai chi) was indicated.[13,14] However, since the present study is the first to look at the combination of SE+ASSE, many gaps remain for future researchers to make a definitive decision, and many possible reasons can be attributed to this finding.

First, ASSE is part of core stabilization exercises involved in strengthening and correcting muscle imbalances in the extensor mechanisms of the hips and spine. Recently, three systematic reviews[12] and meta-analyses confirmed the hypothesis of the effectiveness of core-based exercise.[12,16,38] Second, ASSE improves postural instability and strengthens and activates concave side muscle weakness, especially unilateral side paraspinal, multifidus, and abdominal muscles in scoliotic people, and can cause reverse scoliotic curvature and ATR. The report of muscle weakness on the

concave side has been confirmed in several previous electromyography studies.[20-22] Third, performing ASSE requires less neuromuscular coordination than SE, and this makes it easier to perform, especially in the first weeks of treatment.[20]

Considering that poor QoL causes many problems, especially for the adolescent population, it is of great importance to find an exercise method that can have positive effects.[14] The general opinion is that to obtain a good posture, various aspects of the QoL (function, pain, mental health, self-image, and satisfaction) of a person should be improved. However, this is not always the case, and some studies have shown different results.[24,39,40]

For instance, in Gao et al., SE was used, and an improvement in the QoL and reduction of pain in AIS patients was found. However, significant results regarding reducing Cobb angles were not found.[40] In another study conducted by Vasiliadis and Grivas, the negative effect of conservative treatment in improving the health-related QoL of patients with idiopathic scoliosis was reported.[39] Likewise, Kuru et al. could not report a significant difference in improving the QoL of AIS patients after treatment with the SE method.[24]

All the mentioned studies[24,39,40] are in conflict with the findings of the present study, since the QoL of the AIS patients significantly improved in both exercise groups in the current research (especially in the combined exercises group). The possible reasons for this conflict can be due to the difference in the severity of scoliosis (moderate to severe or Cobb angles= 30°-60°) and the patients' gender (only boys with mild scoliosis in the present study).[24,39,40] Nonetheless, the findings of the present study in terms of QoL, whether in the application of the SE method alone or its combination with other exercise methods, are consistent with and conform to the findings of two original studies[17,23] and three recent systematic reviews and meta-analyses.[13-15]

It should be noted that the patients of the present study had mild scoliosis with a 12-week therapeutic exercise period. Therefore, the results of the combined exercises on Cobb angle, ATR, and QoL may change with changes such as the severity of scoliosis (moderate to severe), the length of the treatment period (more than 12 weeks), and its implementation at home. Future researchers can take these points into account and conduct further detailed investigations to account for these gaps. Although according to the obtained results, it seems that the combined SE and ASSE can be used as an effective method in correcting mild scoliosis in adolescents, therapists and specialists should be careful to use this method in treating more severe scoliosis cases (greater than 30°).

The present study had the following limitations. First, no inclusion of girls, who have higher prevalence of AIS compared to boys. Second, although the treatment of scoliosis requires a long period of follow-ups, the results of the present study were obtained from only 12 weeks of therapeutic exercise. Third, only the AIS patients with Lenke curve type 1 and 5 were recruited in this study. Finally, the Risser scale was not used to determine skeletal maturity.

The present study had several strengths. First, this study had an RCT design, which is considered the standard for clinical trials; therefore, a control group and a follow-up period were incorporated into the study. Second, as braces were not used, the effects of the therapeutic exercises in the intervention groups were accurately diagnosed. Lastly, the selection of patients with mild scoliosis to more accurately determine the effects of each exercise method in these patients.

Conclusion

The findings of the present study indicated positive effects of both exercise groups (SE+ASSE and SE) on the Cobb angle, ATR (main curve), and QoL in mild AIS (10°-30°), while the severity of the deformity in the control group remained almost unchanged. Additionally, these changes in SE+ASSE were superior to SE alone. However, to reach solid results regarding the effectiveness of combined SE+ASSE, future studies should be conducted in which moderate and severe scoliosis, longer treatment periods (more than 12 weeks), and other patient populations (e.g., early-onset, girls, adult, neuromuscular) are considered.

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