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Outcome of 24 Weeks of Combined Schroth and Pilates Exercises on Cobb Angle, Angle of Trunk Rotation, Chest Expansion, Flexibility and Quality of Life in Adolescents with Idiopathic Scoliosis

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Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
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Background: This study aimed to quantify the outcomes of combining Schroth and Pilates exercises on the Cobb angle, angle of trunk rotation (ATR), chest expansion, flexibility (trunk flexion), and quality of life (QoL) in adolescents with mild and moderate idiopathic scoliosis.

Material/Methods: Sixty-nine adolescents with idiopathic scoliosis aged 10–17 years, presenting with a Cobb angle of 10–45° were enrolled in this study. The treatment protocol, including selected exercises from Schroth and Pilates methods, was performed over 24 weeks and consisted of 2 periods of 2-week treatment regimens performed daily for 60 minutes. Each of treatment periods was then followed by the same home program treatment for 10 weeks. Cobb angle (x-rays), ATR (Scoliometer), chest expansion (cm), trunk flexion (cm, distance between C7 to S2 with measuring tape), and QoL (SRS-22r Scoliosis Research Society Questionnaire) were assessed pre-treatment, at 12 week, and at 24 weeks.

Results: Significant improvements ($P<0.05$) were found in both groups of patients wearing and not wearing a brace for Cobb angle (from 21.97±4.99° to 18.11±6.39°; from 14.19±3.11° to 11.66±2.73°), angle of trunk rotation (from 7.19±1.36° to 5.36±1.66°; from 4.72±1.04° to 3.58±0.94°), chest expansion (from 2.56±0.84 cm to 3.46±0.72 cm; from 2.57±0.87 cm to 3.52±0.72 cm), trunk flexion (from 9.55±1.95 cm to 14.33±2.40 cm; from 9.82±2.61 cm to 13.98±2.18 cm) and QoL (from 3.50±0.27 to 3.82±0.2; from 3.42±0.24 to 3.78±0.23) respectively.

Conclusions: This study showed that combined exercises provided benefit on the Cobb angle, ATR, chest expansion, trunk flexion and QoL in adolescents with mild and moderate idiopathic scoliosis.

MeSH Keywords: Angle of Rotation • Cobb Angle • Exercise • Quality of Life • Scoliosis

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Background

Scoliosis is a spine deformity, quite common worldwide and is frequently found in adolescents with a prevalence of 0.47–5.2% [1,2]. Scoliosis can cause several problems such as body asymmetry, muscle imbalance, loss of flexibility, back pain, and negative impacts on psychological aspects and quality of life [3]. Some researchers have reported that for many consecutive years there has been a paucity in research on methods of exercise regarding treatment of scoliosis [4–6]. In 2003, Hawes stated there exist some studies reporting that patients who had moderate scoliosis and who had undergone conservative treatment, more precisely exercise methods, which were classified as a group of patients who did not undergo therapy [6]. Additionally, in North America, exercises are usually not recommended to treat scoliosis [7,8]. In the last 2 centuries, physical therapy exercises have been applied in some parts of Europe [9]. By reviewing the literature, we found many studies that identified conservative treatments, more precisely application of physical therapy and various exercise methods (Scientific Approach to Scoliosis [SEAS], Schroth, Dobomed, Pilates, Side-shift, Lyon, etc.), as effective in altering scoliosis symptoms [10–18], are all methods supported by papers cited in our study.

According to Lenssinck et al. [8], the effect of exercises is promising in conservative treatment for scoliosis. Negrini et al. [19] reported that physical exercises should be considered as a specific program of exercises developed by physiotherapists; they also concluded that exercises in the context of scoliosis have an effect in preventing the progression of deformity. Furthermore, according to the Society on Scoliosis Orthopedic and Rehabilitation Treatment (SOSORT), physiotherapy is considered a therapeutic intervention which can be used solely or combined with other procedures such as orthopedic management and surgical correction [20]. The treatment depends on several factors including patient age, Cobb angle, Risser scale, and region of deviation [1]. The main aim of our study was the evaluation of the effect of selected combined Schroth and Pilates exercises in prevention of development of deformity, the decrease in the Cobb angle, the decrease in the angle of trunk rotation (ATR), improvement of flexibility (trunk flexion), and improvement of back posture and quality of life (QoL).

Material and Methods

Study design

This prospective research involved 69 consecutive adolescent patients with idiopathic scoliosis during their outpatient visit at the Physical Therapy and Rehabilitation Clinic, University Clinical Center of Kosovo (UCCK)-Pristine, from December 2016 to December 2017. Participants enrolled in this study included males and females aged 10 to 17 years old, with a Cobb angle between 10° and 45°. There were 18 participants who were using a brace and 51 participants who were not using a brace. Patients were excluded from this study if they had a Cobb angle over 45°, accompanying mental problems, neuromuscular or neurological problems, congenital malformation, trauma-related comorbidity, cervical scoliosis, non-idiopathic scoliosis or previous spinal surgery. The physiatrist (VK) determined the diagnoses and the Cobb angle, while the evaluation of other variables such as ATR, chest expansion (N1-in sub axillary, N2-nipple line, and N3-around the waist), flexibility (trunk flexion, distance between C7 to S2) and QoL were determined by an experienced physiotherapist (ShM) who also implemented the rehabilitation program. The Ethical Committee of UCCK issued a formal approval of this study (Protocol no. 368/17). Each participant (child) and parent were informed about the purpose and exercise methods used in the research. All parents were asked to sign the consent form agreeing to the participation of their child in the study.

Exercise program

The treatment program was performed over 24 weeks and included a combination of Schroth [21] and Pilates exercises [22] that were analyzed and selected based on the qualitative biomechanical analysis method using algorithm ALPROBI [23]. The algorithm analysis was performed separately for Schroth and Pilates exercises. For both exercise approaches, there were several exercises incorporating the same groups of muscles. Exercises that activated more groups of muscles responsible for maintenance of correct posture and correction of curvature were selected for application in this study.

The first stage lasted for 2 weeks, with a treatment regime consisting of 1-hour daily exercises (Figures 1, 2), followed by the same home program treatment for 10 weeks. After re-evaluation, patients continued with the second part of daily exercises for 2 weeks, followed by the same home program treatment for 10 weeks. The application of exercises was performed depending on the patient's diagnosis and examination results. The following exercises from the Schroth method were selected. The session for patients with thoracic scoliosis consisted of thoracic spine correction, hanging, stretching of the weak side (concave side of the scoliosis curve), sitting on the Swiss ball, strengthening the back muscles and side stretching (concave side) (Figure 1A, 1E, 1H, 1I, 1J). The exercises for the patients with lumbar scoliosis included lumbar spine correction, lifting the pelvis laterally, hanging, stretching the weak side (concave side of the scoliosis curve), strengthening the back muscles and side stretching (concave side) (Figure 1B, 1E, 1G, 1H, 1J). The session for the patients with thoracolumbar scoliosis or double scoliosis, including thoracic

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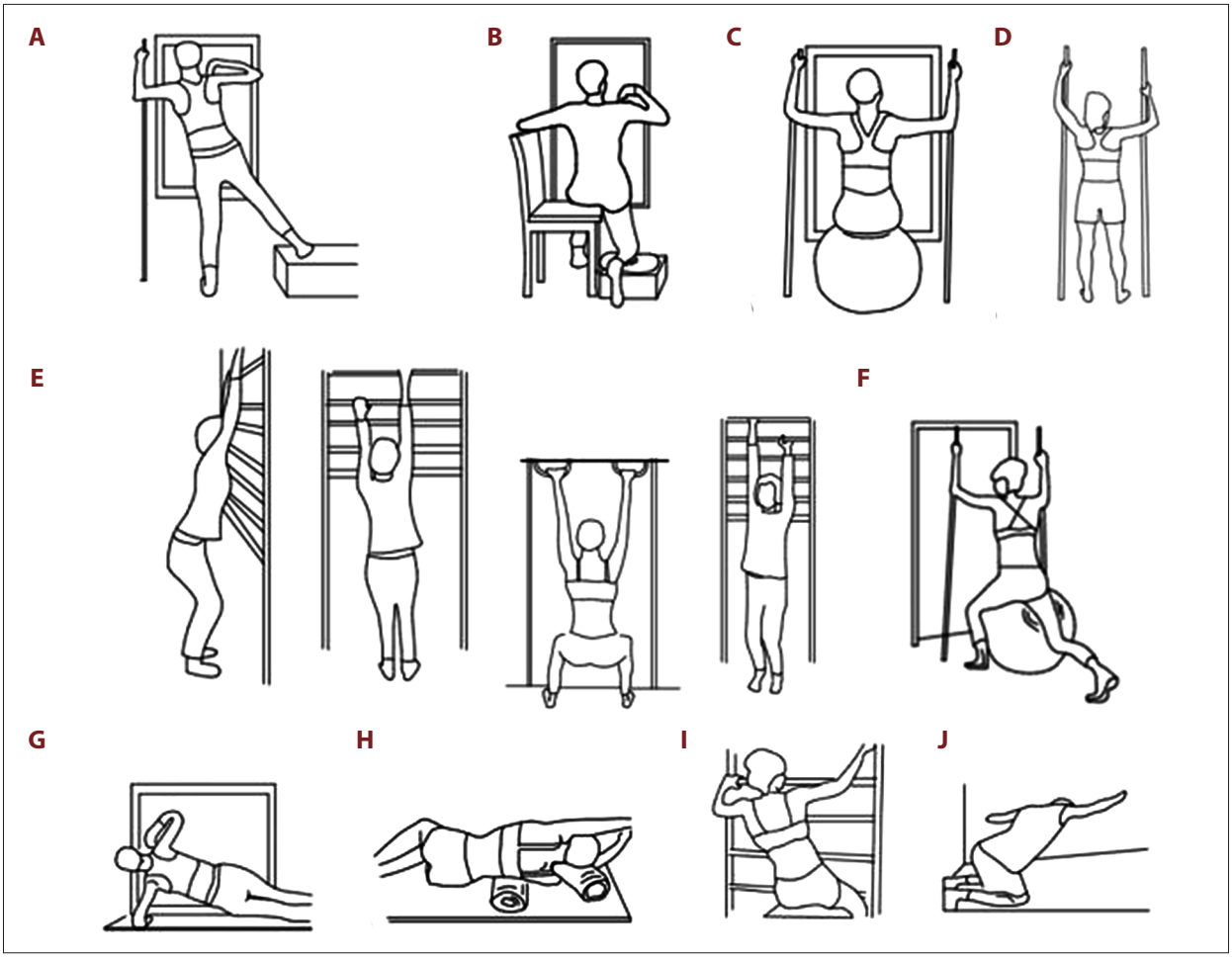

Figure 1. Schroth exercises examples: (**A**) thoracic spine correction, (**B**) lumbar spine correction, (**C**) basic correction sitting, (**D**) self-correction exercise in front of mirror, (**E**) hanging, (**F**) thoracolumbar spine correction, (**G**) lift the pelvis laterally, (**H**) stretch weak side, (**I**) thoracic spine correction sitting on the sews boll, (**J**) strength the muscle of the back and stretch side.

and lumbar scoliosis, consisted of the following exercises: basic correction sitting, self-correction exercise in front of the mirror, hanging, stretching the weak side (concave side of the scoliosis curve), strengthening the back muscles, and thoracolumbar spine correction (Figure 1C, 1D, 1E, 1H, 1I, 1J). The duration of the Schroth exercise session was 30 minutes, and the session continued with the Pilates exercises, which were also applied over a duration of 30 minutes. Pilates exercises were grouped as follows: spine and trunk strengthening exercises, spine and trunk stretching exercises, and limb strengthening and stretching exercises (Figure 2). After 24 weeks of completing the exercises, patients were evaluated and advised on how to continue with the same exercise program at home.

Measurements

General information including age and gender were obtained through subjective examination. X-ray was used to evaluate the Cobb angle [24] at pretreatment and 24 weeks after treatment (x-ray was done in posterior and lateral position, with the patient standing in an anatomical position). All patients wearing a brace had been wearing the brace before being included in the study and continued wearing it after the end of treatment. For patients wearing a brace, the time they stayed out-of-brace before x-ray was within the limits they were allowed to be out of brace. The same procedure was followed for both evaluations, at beginning and end of treatment. The ATR was measured by the bending forward test (Adam's test) using the Bunnell scoliometer (MIZUHO OSI, USA, Union City, CA, USA) [25] as follows: if scoliosis was in the thoracic, thoracolumbar, or lumbar regions, the most prominent part of the respective region was measured, while in double scoliosis, ATR was measured in the 2 most prominent regions, the thoracic and lumbar regions. Chest expansion was evaluated at the end of deep inspiration in 3 levels, the sub-axillary (N1), nipple line (N2), and around the waist (N3), using a measuring tape, and for the measurement of this variable, the patient was standing in an anatomical position [26]. Additionally,

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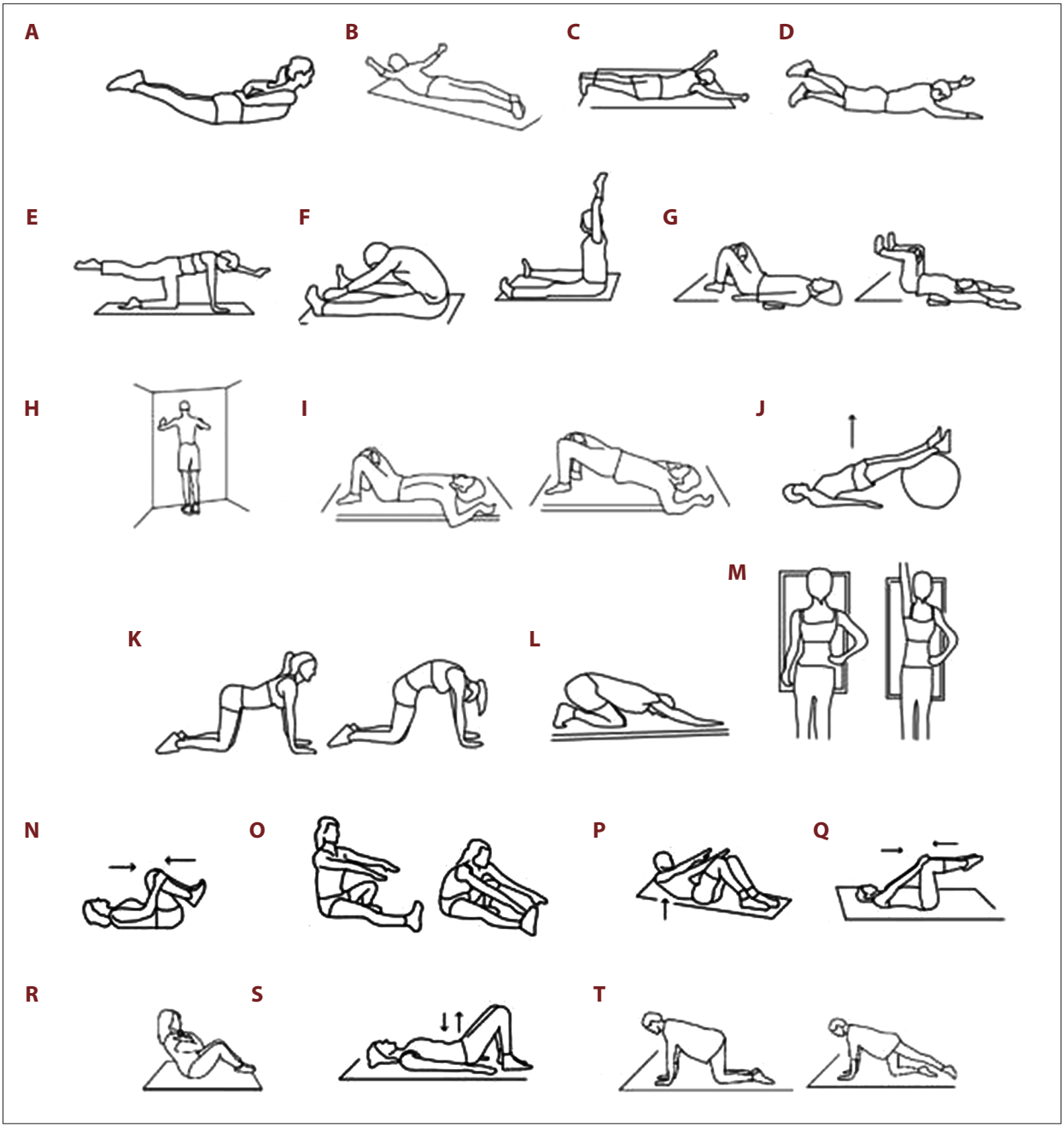

Figure 2. Pilates exercises examples: (**A**) back hyperextension, (**B**) back hyperextension from T prone position, (**C**) back hyperextension from Y prone position, (**D**) arm and leg rise in prone position, (**E**) quadruped arm/leg rise, (**F**) back hyperextension with hands forward, (**G**) flex the shoulder/raise the leg in supination, (**H**) scapula pushups in standing position, (**I**) body bridge, (**J**) body bridge with ball, (**K**) cat and camel exercise, (**L**) Mohammedan prayer, (**M**) Stretch side, (**N**) lower back muscle stretch, (**O**) runner's stretch, (**P**) Abdominal crunch, (**Q**) double-leg abdominal press, (**R**) cross arm/hip flex – abdominal strength, (**S**) finding your pelvic floor, (**T**) swimming level.

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Table 1. General characteristics of patients at the start of treatment.

Patients (n =69)	Frequency	%	Mean
Male	25	36.2	
Female	44	63.8	
Age (years)			13.40±1.93
Scoliosis region			
Thoracic	13	18.8	
Lumbar	5	7.2	
Thoracolumbar	51	73.9	
Scoliosis curve			
Left curve	29	42.1	
Right curve	19	27.5	
Double curve	21	30.4	
Cobb angle (°)			16.23±6.08 (min. 10; max. 36)
ATR (°)			5.49±2.06 (min. 3; max. 14)
Without brace	51	73.9	
With brace	18	26.1	

ATR – angle of trunk rotation.

flexibility was evaluated with a measuring tape (distance between C7 to S2) from vertical posture until a maximum forward bend was achieved, avoiding compensation with other parts of body, such as flexion of knees [27].

QoL was evaluated using the SRS-22r questionnaire which was utilized with the permission of the Scoliosis Research Society and translated into Albanian language by a certified translator.

The SRS-22r questionnaire is a QoL scoliosis questionnaire that assesses 5 domains: function, pain, self-image, mental health, and satisfaction (5 questions each, except satisfaction with treatment, which included 2 questions) [28,29]. The interviewer administered questionnaire was utilized. All of these variables were evaluated at pretreatment and at 12 weeks and at 24 weeks of treatment.

Statistical analysis

The statistical analysis was performed using SPSS22.0. Descriptive analyses were presented using means and standard deviations for normally distributed variables. The Shapiro-Wilk test was used for testing of sample normality with an alpha level of.05. After meeting the assumptions of normal distribution, the following analyses were carried out: the differences in the Cobb angle from the beginning and end of treatment were assessed with a paired-samples *t*-test, while the exercise impact on the Cobb angle was calculated using Cohen's d. To define differences in ATR, chest expansion, trunk flexion, and QoL, we used repeated measures ANOVA with post-hoc analysis using LSD (least significant difference) test. Statistical significance was set $P<0.05$.

Results

Characteristics of patients are presented in Table 1. Table 2 shows the significant difference in the mean value of the Cobb angle in patients wearing a brace and patients not wearing a brace. Improvement was seen in the thoracic region (t=7.96, P=0.00), and in the lumbar region (t=4.80, P=0.00) of patients wearing a brace. In the group of patients not wearing a brace, a significant positive difference was found in thoracolumbar (t=5.46, P=0.00) and thoracic region (t=5.85, P=0.00). Also, the total average of the Cobb angle in both groups had significantly improved after 24 weeks of treatment (t=5.80, P=0.00; t=7.07, P=0.00). The exercise impact on the Cobb angle outcomes using Cohen's d was medium-large after 24 weeks of treatment (Table 2).

Table 3 shows the statistical differences in the mean value of the ATR, chest expansion, trunk flexion, and QoL from before the treatment, after 12 weeks and after 24 weeks of treatment separately for the groups of patients with and without a brace.

In patients wearing a brace, improvement was seen in the thoracic (F=46.44, P=0.00), lumbar (F=9.73, P=0.01), and the average of the ATR total (F = 22.10, P = 0.00). Improvement was

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Table 2. Mean change in Cobb angle, pre-treatment and after 24 weeks of treatment presented separately for patients with and without a brace.

Cobb angle (°)	S curve (%)	C curve (%)	Patients (n=69)					
			Pre-treatment Mean±SD	After 24 weeks Mean±SD	T	Df	Sig	Cohen's d
With brace								
Thoracolumbar			22.71±3.49	18.57±6.29	2.53	6	0.45	0.81
Thoracic			20.54±8.78	17.09±8.96	7.96	10	0.00	0.39
Lumbar			22.44±6.44	18.44±6.73	4.80	8	0.00	0.61
Total	50	50	21.97±4.99	18.11±6.39	5.80	17	0.00	0.67
Without brace								
Thoracolumbar			15.00±3.33	12.54±2.65	5.46	21	0.00	0.82
Thoracic			13.80±2.50	10.80±2.61	5.85	19	0.00	1.17
Lumbar			12.71±4.29	11.36±3.91	1.54	13	0.15	0.33
Total	28	72	14.19±3.11	11.66±2.73	7.07	48	0.00	0.86

Mean±SD, Significant difference from before intervention, and after 24 weeks, $P<0.05$. SD – standard deviation.

Table 3. Mean change of angle of trunk rotation, chest expansion, flexibility and quality of life (SRS-22r measurements data) Presented separately for patients with and without a brace.

	Patients (n=69)							
	Pre-treatment Mean±SD	At 12 weeks Mean±SD	At 24 weeks Mean±SD	F	Sig	Post hoc pairwise comparisons		
						1–2	1–3	2–3
With brace								
ATR (°)								
Thoracic	7.82±3.49	7.09±3.83	5.73±3.72	46.44	0.00	0.26	0.00	0.00
Lumbar	6.33±1.94	5.17±1.46	4.55±1.01	9.73	0.01	0.01	0.01	0.14
Thoracolumbar	7.28±0.95	5.86±0.69	5.57±1.27	9.74	0.19	0.01	0.05	1.00
Total	7.19±1.36	6.12±1.58	5.36±1.66	22.10	0.00	0.00	0.00	0.00
Chest exp. (cm)								
N1	2.67±0.77	3.28±0.55	3.75±0.75	30.93	0.00	0.00	0.00	0.00
N2	2.69±1.06	3.41±0.99	3.86±1.04	43.65	0.00	0.00	0.00	0.01
N3	2.33±1.16	2.67±0.87	2.78±0.88	3.59	0.05	0.07	0.04	0.49
Total	2.56±0.84	3.12±0.61	3.46±0.72	37.75	0.00	0.00	0.00	0.00
Trunk flex. (cm)	9.55±1.95	12.39±2.25	14.33±2.40	40.92	0.00	0.00	0.00	0.00
QoL (SRS-22r total)								
Function	3.32±0.53	3.48±0.49	3.61±0.47	2.66	0.10	0.22	0.09	0.47
Pain	3.82±0.43	3.82±0.42	4.03±0.39	4.96	0.02	0.54	0.02	0.57
Self-image	3.60±0.42	3.65±0.33	3.88±0.34	6.17	0.01	0.93	0.01	0.02

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Table 3 continued. Mean change of angle of trunk rotation, chest expansion, flexibility and quality of life (SRS-22r measurements data) Presented separately for patients with and without a brace.

	Patients (n=69)							
	Pre-treatment Mean±SD	At 12 weeks Mean±SD	At 24 weeks Mean±SD	F	Sig	Post hoc pairwise comparisons		
						1–2	1–3	2–3
Mental health	2.95±0.31	3.11±0.34	3.35±0.42	7.9	0.00	0.38	0.01	0.01
QoL-subtotal	3.36±0.25	3.53±0.21	3.72±0.21	21.45	0.00	0.01	0.00	0.00
Satisfaction	4.58±0.57	4.80±0.35	4.92±0.19	3.23	0.07	0.36	0.69	0.31
QoL-total	3.50±0.27	3.63±0.19	3.82±0.2	18.68	0.00	0.02	0.00	0.00
Without brace								
ATR (°)								
Thoracic	4.62±0.86	3.81±0.87	3.38±0.92	21.67	0.00	0.00	0.00	0.17
Lumbar	4.07±1.14	3.57±1.16	3.71±1.32	6.15	0.01	0.01	0.72	1.00
Thoracolumbar	5.09±1.15	4.27±1.03	3.72±0.93	24.08	0.00	0.00	0.00	0.07
Total	4.72±1.04	3.94±1.01	3.58±0.94	42.33	0.00	0.00	0.00	0.42
Chest exp. (cm)								
N1	2.92±0.91	3.54±0.92	3.97±0.81	44.90	0.00	0.00	0.00	0.00
N2	2.84±0.95	3.60±0.98	3.95±0.83	64.41	0.00	0.00	0.00	0.00
N3	1.94±1.13	2.48±0.97	2.63±0.81	19.96	0.00	0.00	0.00	0.17
Total	2.57±0.87	3.20±0.83	3.52±0.72	73.91	0.00	0.00	0.00	0.17
Trunk flex. (cm)	9.82±2.61	12.26±2.52	13.98±2.18	78.23	0.00	0.00	0.00	0.00
QoL (SRS-22r total)								
Function	3.19±0.41	3.38±0.31	3.49±0.41	11.63	0.00	0.00	0.00	0.11
Pain	3.47±0.58	3.78±0.43	3.89±0.48	13.81	0.00	0.00	0.00	0.03
Self-image	3.48±0.50	3.60±0.49	3.85±0.40	20.43	0.00	0.18	0.00	0.00
Mental health	3.09±0.41	3.18±0.39	3.32±0.39	9.03	0.00	0.36	0.00	0.00
QoL-subtotal	3.31±0.27	3.47±0.26	3.74±0.56	17.85	0.00	0.00	0.00	0.00
Satisfaction	4.59±0.61	4.80±0.42	4.94±0.19	10.85	0.00	0.01	0.00	0.03
QoL-total	3.42±0.24	3.59±0.24	3.78±0.23	74.37	0.00	0.00	0.00	0.00

Mean±SD, ATR – angel of trunk rotation; N1 – chest expansion in subaxilary; N2 – chest expansion in nipple line; N3 – chest expansion around the waist; SRS-22r – Scoliosis Research Society 22r; Questionnaire, satisfaction – satisfaction with management; QoL – quality of life.

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also seen in chest expansion at the level of N1-in sub axillary (F=30.93, *P*=0.00), N2-nipple line (F=43.65, *P*=0.00), and N3-around the waist (F=3.59, *P*=0.05). The total average of chest expansion had significantly improved after 24 weeks of treatment (F=37.75, *P*=0.00). Regarding the trunk flexion, significant statistical improvement was observed (F=40.92, *P*=0.00), compared pre-treatment, 12 weeks and after 24 weeks of treatment. Also we found significant improvement in most of components of QoL: pain (F=6.17, *P*=0.01), self-image (F=6.17, *P*=0.01), mental health (F=7.9, *P*<0.00), QoL subtotal (F=21.45, *P*=0.00), and the QoL total (F=18.68, *P*=0.00). Post hoc analysis with the LSD test showed improvement in ATR total, chest expansion total, flexibility, and QoL total when comparing data from pretreatment with 12 weeks of treatment and 12 weeks of treatment with 24 weeks of treatment (Table 3).

In patients not wearing a brace, significant positive changes were found in ATR values, thoracic (F=21.67, *P*=0.00, lumbar (F=6.15, *P*=0.01), thoracolumbar (F=24.08, *P*=0.00), and ATR total (F=42.33, *P*=0.00). Chest expansion improvement is also seen on all 3 levels N1 (F=44.90, *P*=0.00), N2 (64.41, *P*=0.00), N3 (N=19.96, *P*=0.00), and N total (N=7 3.91, *P*=0.00). Similarly, trunk flexion underwent statistically significant change across the treatments (F=78.23, *P*=0.00). To our positive surprise, all QoL components including QoL total showed significant improvement in patients not wearing a brace (*P*=0.00).

Discussion

The success of different methods of exercise in decreasing or stopping the increase in the Cobb angle, improving the ATR, QoL and other outcomes has been documented in numerous studies performed all over the world.

The Schroth 3-dimensional exercise approach was shown to have significant effects on decreasing the Cobb angle and pain in patients with scoliosis, improving the cosmetic appearance in children, improving waist asymmetry, and decreasing the height of the hump. Additionally, Pilates exercises have been reported to change the trunk flexibility through the backbone segmentation movement, decrease non-structural scoliosis patients' Cobb angle, improve their flexibility and pain, positively affect posture, and improve quality of life [5,15,30–34].

Since our sample consisted of patients with various degrees of Cobb angle, different regions and orientations of the curve, and some of the patients also showed movement limitation, we decided to combine Schroth and Pilates methods for which we expected to find positive effects based on the existing literature. Hence, the aim of this study was to verify the effectiveness of a combination of exercises from the Schroth and Pilates methods on the Cobb angle, ATR, flexibility, chest expansion, and QoL in adolescent idiopathic scoliosis.

Otman et al. [35] applied the Schroth method in patients with adolescent idiopathic scoliosis and reported a reduction in the Cobb angle. Kuru et al. [5] showed that patients who participated in Schroth exercises in the clinic showed improvement in reducing the Cobb angle compared with a group of patients following a home Schroth program or the control group that did not participate in exercises. Schreiber et al. [11,36] also reported that the Schroth PSSE methods combined with standard care is more effective in the treatment of scoliosis compared with standard care alone. Another study that compared the effects of Schroth exercises and back braces in adolescent idiopathic scoliosis patients reported that the group of patients who participated in Schroth exercises showed better results in improving the Cobb angle [14]. Kim and Hwangbo [17] showed that Schroth exercises also have good results in patients who had Cobb angles of 40° or higher. However, Kim and Hwangbo [17] in another study reported that both methods, Schroth and Pilates, were effective in changing the Cobb angle, but Schroth exercises were significantly more effective than Pilates exercises. As we mentioned, our study showed a decrease in the Cobb angle in patients with adolescent idiopathic scoliosis who were treated with a combination of Schroth and Pilates exercises. These results were similar to those of the aforementioned studies and other studies that also reported a decrease in the Cobb angle after application of the Schroth method [12,24,37,38]. It should be emphasized that most of the studies complying with our study results involved participants with moderate scoliosis curves, while the majority of our patients had mild scoliosis curves. Being aware of the fact that Schroth exercises were initially developed for patients with large Cobb angle, we wanted to evaluate the effect of combined Schroth and Pilates exercises in patients with mild and moderate curves, which as a result caused a positive effect. Similar findings were also reported by the study of Park et al. who found that Schroth exercises could be beneficial for patients with a Cobb angle from 10° to 30° rather than for patients with a Cobb angle larger than 30° [39].

In our research, improvement in the Cobb angle of the thoracolumbar curve in patients with a brace was not statistically significant. It is important to note that the group of patients with a brace was comprised of 50% of patients with double scoliosis, whereas in the group without a brace the rate was 28% (Table 2). Double scoliosis is known to present with a greater risk of progression in comparison to single scoliosis, and in addition, thoracolumbar and lumbar scoliosis are at greater risk of progression compared to thoracic scoliosis [40]. In relation to the latter, we also found significant improvement in the Cobb angle in thoracic scoliosis compared to non-significant result in lumbar scoliosis in patients without a brace. It is

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unknown whether worse prognosis in lumbar scoliosis might be responsible for this finding or if perhaps the exercises were not sufficiently effective. To address this uncertainty, more research is needed.

Besides the Cobb angle, another very important variable in determining scoliosis severity is the ATR. In our study, we observed significant improvement in the total ATR when comparing pretreatment measurements to those obtained after 24 weeks of treatment. Many studies have obtained similar results in the improvement of ATR after the application of different treatment exercise methods, especially Schroth exercises [5,17,18,41–43].

In this study we reported that these exercises also have positive effects on other variables, such as chest expansion, vital capacity, flexibility and QoL. There is insufficient evidence that chest expansion and flexibility are reliable and valid examination tools in patients with scoliosis. However, our results were in line with other studies [5,17,26,32,42,44] that reported improvements in chest expansion and other variables, such as trunk deviation, vital capacity and waist asymmetry, after the application of conservative treatment, especially after Schroth and Pilates exercises [5,35]. It should be noted that besides treatment, improvement in chest expansion could have been affected by patients' growth over the treatment period. In relation to flexibility, our study results were similar to the results of the study by Alves de Araujo et al. [15] that reported a significant increase in flexibility after the application of Pilates exercises.

Real idiopathic scoliosis causes deformity of the spinal column, and as a consequence of this deformity, physical and psychological problems can arise in patients; these problems can have a negative impact on QoL [45]. Some studies have reported that different protocols of exercises have no impact on the improvement of QoL, while some studies have reported positive effects in the improvement of QoL for patients with idiopathic scoliosis. Vasiliadis and Grivas [46] reported that health related QoL (HRQoL) was negatively affected after conservative treatment of patients with idiopathic scoliosis. Kuru et al. [5] reported that there were no significant differences in QoL from before to after treatment of patients with scoliosis. Atanasio et al. [47] showed that the application of exercises in patients with idiopathic scoliosis did not have an effect on overall QoL but had a positive effect on the cosmetic appearance score. The results of our study were similar to the results of other studies that have reported the positive impact of the application of different methods of conservative treatment, especially the influence of the application of the Schroth method on the QoL of scoliosis patients. Some of those studies have concluded that the application of the Schroth method alone or in combination with other methods of exercise improves self-image as well as function and QoL in general [14,48,49].

This study had a few limitations. We are aware that having a control group is desirable. Knowing that scoliosis requires long-term treatment, a longer follow-up is needed. The comprehensive literature also uses the Risser scale to determine skeletal maturation, which we did not use in this study and consider it as another limitation.

Conclusions

Although Schroth exercises were initially developed for patients with severe scoliosis curve, our study demonstrated that the treatment of adolescent idiopathic scoliosis patients with mild and moderate curve with a combination of Schroth and Pilates exercises was proven to be statistically significant in decreasing the Cobb angle and ATR, improving chest expansion and trunk flexion, and increasing QoL. However controlled studies with longer follow-up periods, taking into consideration skeletal maturity using the Risser scale, are needed to provide more solid conclusions about the efficacy of this approach and about its potential to improve scoliosis over time.

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