Comparison of the Effectiveness of Schroth Exercise Method and Combined (Manual Therapy + Schroth Exercise Method) Method in Idiopathic Adolescent Scoliosis

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Abstract

Aim: This study aimed to assess the impact of the Schroth exercise method alone versus a combination of the Schroth exercise method and manual therapy on adolescent idiopathic scoliosis patients.

Method: Participants aged 11-18 were divided into two groups: one practicing Schroth exercises and the other combining these exercises with manual therapy. Gibbosity, static and dynamic balance, visual perception, and quality of life were measured at baseline and after 3-month intervention period.

Results: Results indicated no significant differences between the groups in gender distribution, age, height, weight, body mass index, static and dynamic balance, gibbosity, and quality of life ($p>0.05$), except for visual perception, where the combined therapy group showed better results ($p<0.05$). Despite some observed benefits in gibbosity, quality of life, and static balance in the combined therapy group, these differences were not statistically significant ($p>0.05$).

Conclusion: The study concludes that, except for improved visual perception in the combined therapy group, there were no significant advantages over the Schroth exercise method alone in treating adolescent idiopathic scoliosis.

Keywords: Scoliosis, schroth, manual therapy.

İdiyopatik Adölesan Skolyozda Schroth Egzersiz Yöntemi ile Kombine (Manuel Terapi+ Schroth Egzersiz Yöntemi) Yöntemin Etkinliğinin Karşılaştırılması

Öz

Amaç: Bu çalışmada tek başına Schroth egzersiz yöntemine karşı Schroth egzersiz yöntemi ve manuel terapi kombinasyonunun adölesan idiyopatik skolyoz hastaları üzerindeki etkisinin değerlendirilmesi amaçlanmıştır.

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ETHICAL STATEMENT: This research study was undertaken between January 2021 and July 2021. Non-Interventional Clinical Research Ethics Committee approval of the Gazi University was obtained before starting the study on 21.01.2021 (approval no:2020/21-876).

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Yöntem: 11-18 yaş arası katılımcılar iki gruba ayrılmıştır: bir grup Schroth egzersizlerini uygularken diğeri bu egzersizleri manuel terapi ile birleştirmiştir. Başlangıçta ve 3 aylık tedavi periyodunun ardından gibozite, statik ve dinamik denge, görsel algı ve yaşam kalitesi ölçüldü.

Bulgular: Sonuçlar cinsiyet dağılımı, yaş, boy, kilo, vücut kitle indeksi, statik ve dinamik denge, gibozite ve yaşam kalitesi açısından gruplar arasında anlamlı bir fark olmadığını ($p>0,05$) ancak görsel algı açısından kombine terapi grubunun daha iyi sonuçlar gösterdiğini ortaya koydu ($p<0,05$). Kombine terapi grubunda gibozite, yaşam kalitesi ve statik dengede iyileşme gözlenmesine rağmen, bu farklılıklar istatistiksel olarak anlamlı değildi ($p>0.05$).

Sonuç: Bu çalışma kombine tedavi grubunun, görsel algıda iyileşme dışında adölesan idiyopatik skolyoz tedavisinde tek başına Schroth egzersiz yöntemine göre anlamlı bir avantaj sağlamadığı sonucuna varmıştır.

Anahtar Sözcükler: Skolyoz, schroth, manuel terapi.

Introduction

Adolescent idiopathic scoliosis (AIS) is a three-dimensional spinal deformity characterized by lateral curvature, vertebral rotation, and alterations in sagittal alignment. When a spinal curvature of 10° or more is measured on standing radiographs using the Cobb method, the condition is defined as scoliosis[1]. AIS accounts for approximately 80% of all scoliosis cases and commonly develops during the adolescent growth period. The reported prevalence ranges between 0.47% and 5.2%, with a significantly higher prevalence and progression risk in females compared to males[2].

Although the exact etiology of AIS remains unclear, several mechanisms, including genetic predisposition, neuromuscular factors, connective tissue abnormalities, melatonin dysfunction, and biomechanical influences, have been proposed[3,4]. The structural spinal deformity observed in AIS may lead to postural asymmetry, trunk rotation, rib prominence, and alterations in spinal alignment. Therefore, evaluating curve magnitude and trunk deformity using parameters such as Cobb angle and gibbosity is essential for clinical decision-making and treatment planning[5].

Beyond structural changes, AIS may also affect postural control and balance mechanisms. The maintenance of upright posture depends on the integration of sensory inputs from the somatosensory, vestibular, and visual systems, which together provide spatial orientation and stability[6-8]. Previous studies have reported that individuals with scoliosis may demonstrate altered postural control and may rely on inaccurate spatial references when maintaining balance[6,9,10]. Correct perception of the vertical axis is therefore an important component of postural regulation, and rehabilitation strategies aiming to improve neuromuscular control and postural awareness may contribute to improved functional outcomes[6,11].

In addition to biomechanical impairments, trunk deformity in AIS may influence body image and visual perception of posture. Visible asymmetries such as rib hump, shoulder imbalance, trunk rotation, and lumbar asymmetry may negatively affect adolescents' perception of their physical appearance[6,12]. Since adolescence is a critical developmental period during which body image plays an important role in psychosocial well-being, these deformities may lead to emotional distress and decreased self-esteem[6,13]. For this reason, evaluating the visual perception of trunk deformity has become an important outcome measure in scoliosis rehabilitation. The Walter Reed Visual Assessment Scale (WRVAS) is frequently used to assess how individuals perceive their trunk deformity and body appearance[5,14,15].

Conservative treatment plays a crucial role in the management of mild to moderate AIS. The primary goals of conservative interventions include preventing curve progression, improving postural alignment, enhancing trunk stability, and improving cosmetic appearance and quality of life[5,16]. Physiotherapeutic scoliosis-specific exercises (PSSE) represent one of the most commonly used conservative treatment approaches. These methods include several exercise-based protocols such as the Schroth Method, Barcelona Scoliosis Physical Therapy School, Side Shift, Lyon Approach, Dobomed, and Functional Individualized Therapy for Scoliosis[17].

Among these approaches, the Schroth Method is one of the most widely studied PSSE techniques. It focuses on three-dimensional correction of spinal deformities through principles such as auto-elongation, deflection, derotation, rotational breathing, and postural stabilization[18]. Schroth exercises aim to restore muscular symmetry, improve postural awareness, and facilitate active spinal correction through neuromuscular re-education[19].

In addition to exercise-based approaches, manual therapy techniques are sometimes incorporated into scoliosis rehabilitation programs to address mobility restrictions and improve neuromuscular function. Manual therapy may include joint mobilization and soft tissue techniques aimed at increasing spinal and thoracic mobility, improving rib cage flexibility, and enhancing proprioceptive input. These interventions may theoretically support corrective exercise programs by facilitating optimal movement patterns and improving trunk control. However, despite these potential benefits, the additional value of combining manual therapy with scoliosis-specific exercise programs remains insufficiently investigated in the current literature.

Therefore, a clear research gap exists regarding whether the integration of manual therapy with Schroth-based exercise programs provides additional benefits beyond exercise therapy alone in adolescents with idiopathic scoliosis.

The aim of this study was to compare the effectiveness of the Schroth exercise method and a combined intervention consisting of manual therapy and Schroth exercises in adolescents with idiopathic scoliosis. The study evaluated outcomes including balance, trunk rotation (gibbosity), quality of life, and visual perception of trunk deformity.

Material and Methods

This study was conducted to compare the effectiveness of the Schroth exercise method with a combined intervention consisting of manual therapy and the Schroth exercise method in individuals with adolescent idiopathic scoliosis. A total of 23 individuals diagnosed with adolescent idiopathic scoliosis (mean age: 13.74±1.86 years) who were followed by their physicians between January 1, 2021, and July 1, 2021 were included in the study.

A priori power analysis was conducted using G*Power software to estimate the required sample size based on previously reported effects of Schroth-based interventions in adolescents with scoliosis. The analysis indicated that a minimum sample size of 20 participants would be required to detect a moderate effect size with a statistical power of 80% at a significance level of $p < 0.05$. The final sample size of 23 participants therefore met the minimum requirement for statistical analysis.

The data for this study were collected in 2021. The delay between data collection and manuscript submission was primarily due to the time required for detailed data verification, statistical analyses, and preparation of the manuscript for publication. In addition, interruptions in clinical research activities and administrative processes during the COVID-19 period contributed to delays in the completion of the study report.

Participants

Initially, 33 male and female participants aged between 11 and 18 years (mean age 13.74 ± 1.86 years) with a diagnosis of adolescent idiopathic scoliosis voluntarily agreed to participate in the study. However, 10 participants withdrew from the study because they were unable to maintain regular participation in the home exercise program and clinical sessions. Participants who failed to attend two or more home or clinical exercise sessions during the intervention period were excluded from the final analysis due to non-compliance with the intervention protocol. Consequently, the study was completed with 23 participants.

Participants were allocated to two groups: the Schroth Exercise Group (n=12; 8 females, 4 males) and the Schroth + Manual Therapy Group (n=11; 7 females, 4 males). A simple random sampling method was used to assign participants to the exercise and combined groups. The randomization process was performed using numerical sequences generated by computer-assisted software. Before the measurements and tests were performed, demographic characteristics, including age (years), height (cm), and body weight (kg), were recorded. In addition, scoliosis-related characteristics such as the spinal region involved (thoracic, lumbar, or thoracolumbar), curve apex, Cobb angle, and bone maturation according to the Risser sign were determined from standing anterior–posterior full-spine radiographs.

Participants were eligible for inclusion if they were between 11 and 18 years of age, had a radiographically confirmed diagnosis of adolescent idiopathic scoliosis, and presented with mild to moderate scoliosis based on clinical and radiological parameters (Cobb angle between 10° and 40°). In addition, participants were required to be medically stable and able to understand and participate in exercise-based rehabilitation procedures.

Participants were excluded if they had previously undergone spinal surgery, had any diagnosed neurological disorder affecting motor control, had musculoskeletal pain that could interfere with exercise participation, or had cognitive or psychological conditions that could limit their ability to follow exercise instructions and participate in the intervention protocol.

Due to the nature of the exercise-based intervention, blinding of participants and treating physiotherapists was not feasible. However, all outcome measurements were performed by the same physiotherapist using standardized assessment procedures in order to minimize measurement variability.

Participants were followed for a total intervention period of three months.

Intervention Protocol

Schroth Exercise Program

In both groups, the Schroth exercise program consisted of exercises selected according to each participant's scoliosis curve type and affected spinal region. Although the exercise program was individualized, several core components of the Schroth method were consistently applied across all participants in order to standardize the intervention. These core components included auto-elongation, rotational angular breathing, trunk derotation exercises, and postural stabilization exercises aimed at improving spinal alignment and neuromuscular control.

Participants in the Schroth exercise group performed the exercise program five days per week at home and two days per week under the supervision of a specialized physiotherapist in the clinic for 12 weeks. Each supervised session lasted approximately 60 minutes and included postural correction training, breathing control techniques, and neuromuscular stabilization exercises. The number of repetitions, sets, and rest intervals were standardized across participants to maintain consistency of the exercise dosage.

To monitor adherence to the home exercise program, participants were asked to record their exercise sessions in a home exercise diary and submit weekly exercise videos. In addition, parents provided written confirmation regarding adherence to the home exercise protocol during each clinical visit.

Representative photographs demonstrating selected Schroth exercises used in the intervention program have been added as figures to illustrate the exercise positions and corrective principles applied during the treatment.

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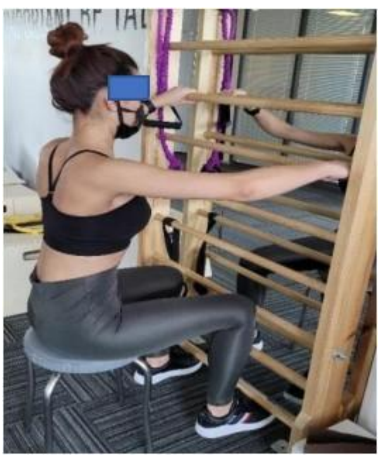
Figure 1. Schroth auto-elongation exercise.

Figure 2. Schroth side-lying correction exercise.

Figure 3. Schroth sitting Psoas synergy exercise.



Manual Therapy Intervention

Participants in the Schroth + Manual Therapy group received manual therapy in addition to the Schroth exercise program. Manual therapy was applied by an experienced physiotherapist once per week for six consecutive weeks during the three-month intervention period, resulting in a total of six sessions. Each manual therapy session lasted approximately 20–25 minutes.

The manual therapy protocol consisted of thoracic and lumbar joint mobilization techniques, soft tissue mobilization of paraspinal and intercostal muscles, and myofascial release techniques targeting areas with increased muscle tension or restricted mobility. Joint mobilizations were primarily applied to the apical vertebral segments associated with the scoliotic curvature to improve segmental spinal mobility and reduce asymmetrical movement restrictions.

The clinical rationale for the application of manual therapy was to improve spinal segmental mobility, reduce soft tissue restrictions, and enhance proprioceptive input. These effects were expected to facilitate improved neuromuscular control of the trunk and support the corrective mechanisms of the Schroth exercise program.

Data Collection Tools

To evaluate body image perception, deformity perception, and quality of life in individuals with adolescent idiopathic scoliosis, the Walter Reed Visual Assessment Scale (WRVAS) and the SRS-22 Scoliosis Patient Questionnaire were used. Static and dynamic balance were assessed using the Standing Stork Balance Test and the Y-Balance Test, respectively. The degree of trunk rotation (gibbosity) was evaluated using the Adams Forward Bend Test.

All assessments were performed twice: once before the intervention and once after the three-month treatment period.

Adams Forward Bend Test: The Adams forward bend test, conducted with a scoliometer, was applied to measure the rotation angle of the apex vertebra in degrees, and vertebral torsion was evaluated in the horizontal plane. During the test, participants bent forward while the examiner measured the angle of trunk rotation at the level of the apex vertebra. The scoliometer smartphone application was used in this study[20]. Previous studies have demonstrated that smartphone-based scoliometer applications show high validity and reliability in measuring trunk rotation in individuals with scoliosis, with good agreement compared with traditional scoliometer measurements[20] (Figure 4).

Figure 4. Assessment of gibbosity using the Adams forward test[5].

Standing Stork Balance Test: The Standing Stork Balance Test was used to evaluate static balance capacity. Prior to testing, the procedure was demonstrated to each participant, and three practice trials were allowed to ensure correct performance.

The test was performed barefoot with eyes open on both the right and left legs. Participants stood comfortably with their hands on their hips and placed the toes of one foot against the knee of the supporting leg. Upon the examiner's command, the participant raised the heel of the supporting foot and attempted to maintain balance on the toes. Timing began when the heel was lifted from the ground.

The test was terminated if the participant removed their hands from their hips, rotated or moved the supporting foot, lost contact between the unsupported foot and the knee, or if the heel of the supporting foot touched the floor. Three trials were performed for each leg and the mean value was recorded for analysis[21]. The Standing Stork Balance Test has been reported to demonstrate acceptable reliability for assessing static balance performance in adolescents and young adults[21] (Figure 6).

Figure 6. Standing stroke balance test starting position [21].

Y-Balance Test: Dynamic balance was assessed using the Y-Balance Test, which measures reach distance in three directions: anterior (ANT), posteromedial (PM), and posterolateral (PL). Prior to testing, the participant's lower limb length was measured in the supine position as the distance between the anterior superior iliac spine and the medial malleolus.

Participants were asked to reach in each direction while maintaining the heel of the stance foot on the floor and keeping their hands on the iliac crest. Lifting the heel of the stance foot or removing the hands from the hips was considered an invalid trial.

Participants performed six trials in each direction with two minutes of rest between trials[22,23]. Reach distances were normalized to leg length using the following formula:

Normalized Score = Reach Distance / Leg Length

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A composite score was calculated using the following formula:

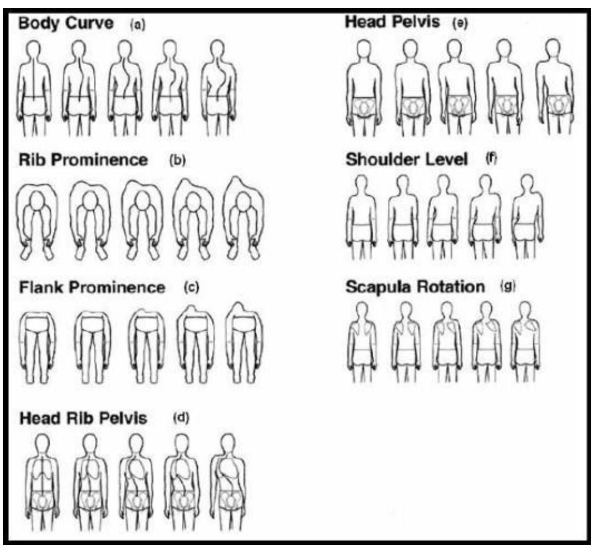
(Anterior + Posteromedial + Posterolateral) / (3 × Lower Extremity Length) × 100 = Composite Score

The Y-Balance Test has been shown to have high intra-rater and inter-rater reliability for assessing dynamic balance in both adolescent and adult populations[22,23].

Walter Reed Visual Assessment Scale (WRVAS): The Walter Reed Visual Assessment Scale (WRVAS) includes illustrations evaluating rib prominence, lumbar prominence, spinal deformity, thoracic deformity, trunk imbalance, shoulder asymmetry, and scapular asymmetry[5,14]. Each deformity category consists of five images representing increasing severity of the deformity. Participants are asked to select the image that best represents their perceived trunk appearance.

Each item is scored between 1 and 5, with higher scores indicating greater perceived deformity[5,14]. WRVAS evaluates subjective perception of deformity rather than the actual radiological severity of scoliosis[5,15]. The scale has demonstrated acceptable validity and reliability for assessing body image perception in individuals with scoliosis[14,15]. In this study, the Turkish version of the scale[19] was used (Figure 7).

Figure 7. WRVAS [2].



SRS-22 Scoliosis Patient Questionnaire: Quality of life was assessed using the SRS-22 Scoliosis Patient Questionnaire, which consists of 22 questions divided into five domains: pain (questions 1,2,8,11,17), self-image (questions 4,6,10,14,19), function/activity (questions 5,9,12,15,18), mental health (questions 3,7,13,16,20), and satisfaction with treatment (questions 21,22).

Each item is scored from 1 (worst) to 5 (best). The satisfaction with the treatment domain ranges from 2–10 points, while the other domains range from 5–25 points. Domain

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scores are calculated by dividing the total score of each domain by the number of items in that domain. Higher scores indicate better quality of life[5,24]. The SRS-22 questionnaire has been widely used in scoliosis research and has demonstrated strong validity and reliability for assessing health-related quality of life in individuals with scoliosis[24].

Ethical Statement

Ethical approval for the study was obtained from the Gazi University Non-Interventional Clinical Research Ethics Committee (Decision date: December 21, 2020; Approval number: 2020/21-876). Written informed consent was obtained from the parents of all participants prior to participation in the study.

Statistical Analysis

Nominal and ordinal data were summarized using frequencies, while continuous variables were expressed as mean values and standard deviations. Fisher's Exact test was used to analyze differences in nominal and ordinal variables. Since the measurement data were not normally distributed, non-parametric statistical tests were applied. The Mann–Whitney U test was used to compare differences between the two groups. Spearman's rho correlation analysis was performed to evaluate correlations between variables. The Wilcoxon signed-rank test was used to analyze within-group differences between pre- and post-intervention measurements. All statistical analyses were performed using SPSS software (version 17.0; SPSS Inc., Chicago, IL, USA), and a 95% confidence interval was accepted as statistically significant.

Results

In this study, 23 (13.74±1.86 years) adolescents with Idiopathic Scoliosis were homogeneously divided into two groups as Schroth exercise group (EG, n=12) and the combined group (CG, n=11) based on the pretest values. Demographic characteristics of the individuals are listed in Table 1. There were no statistically significant differences between groups ($p>0.05$). Baseline values of quality of life, visual perception, gibbosity, static and dynamic balance in both groups were also similar ($p>0.05$) except for WRVAS scores, in which the combined group was significantly higher than the exercise group ($p<0.05$).

Table 1. Physical properties of the study groups.

Characteristics	Exercise Group (n=12)	Combined Group (n=11)	P-value
Age (years), mean (SD)	13.17±1.90	14.36±1.69	0.069
Height (cm), mean (SD)	159.83±10.09	162.73±8.05	0.347
Weight (kg), mean (SD)	46.67±12.74	49.55±10.35	0.413
BMI (kg/m²), mean (SD)	18.09±3.64	18.64±3.18	0.740
Female / male, n (%)	8 (66.7) / 4 (33.3)	7 (63.6) / 4 (36.4)	0.611

BMI: Body mass index; SD: Standard deviation.

Table 2 demonstrates pre-treatment and post-treatment values, within-group and between- group comparison of SRS-22, WRVAS, gibbosity, Stork and Y-balance test scores. Quality of life, except SRS-22 function value for the combined group, showed a nonsignificant change in both groups (p>0.05). Visual perception and gibbosity scores improved significantly in both groups at 12 weeks (p<0.05). Both Stork scores in the exercise group and the left lower limb Stork score were similar at 12 weeks of intervention (p>0.05). In the combined group, Stork measurement taken from the right lower limb revealed statistically significant improvement (p=0.041). Combined group showed a nonsignificant increase in all of the Y-Balance test measurements 12 weeks post-treatment (p>0.05). In the exercise group, Y-Balance test measurements of right anterior, right posteromedial, left posterolateral, left posteromedial, composite right, and composite left showed statistically significant improvement in dynamic balance compared with pre-treatment values (p<0.05). No statistically significant differences between groups were detected for all the outcomes (p>0.05) (Table 2).

Table 2. Pre-treatment and post-treatment values (mean (SD)), within-group and between-group comparison of quality of life, visual perception, gibbosity, static and dynamic balance.

Outcome variable	**Exercise Group (n=12)**			**Combined Group (n=11)**			
	Pre-treatment mean (SD)	**Post-treatment mean (SD)**	**Within-group P-value**	**Pre-treatment mean (SD)**	**Post-treatment mean (SD)**	**Within-group P-value**	**Between group P-value**
SRS-22							
Pain	22.33±2.61	23.25±1.91	0.180	22.55±2.81	23.18±1.99	0.221	0.342
Image	17.58±3.18	18.50±3.73	0.194	17.36±3.32	17.73±2.24	0.670	0.312
Function	23.67±1.15	24.00±0.95	0.157	23.09±1.70	24.36±0.67	**0.048**	0.247
Mental Health	19.08±3.53	19.17±4.67	0.833	18.36±4.86	20.18±3.74	0.190	0.417
Treatment Satisfaction	8.83±1.27	9.08±0.67	0.582	9.55±0.69	9.27±1.01	0.257	0.543
SRS-22 Total	91.50±7.14	94.00±8.09	0.222	90.91±11.40	94.73±6.74	0.266	0.614
WRVAS							
Own	12.42±1.56	9.92±1.68	**0.007**	15.91±3.42	13.82±4.09	**0.028**	0.321
Family	11.92±3.18	9.58±2.54	**0.011**	16.45±4.89	13.36±4.32	**0.035**	0.457
Gibbosity	4.00±3.36	2.75±2.73	**0.007**	6.64±2.66	4.73±3.00	**0.016**	0.211
Stork							
Right	4.21±2.60	5.24±4.15	0.388	3.08±1.22	4.63±2.52	**0.041**	0.242
Left	4.51±3.11	5.19±3.38	0.530	3.16±1.19	3.61±2.14	0.722	0.351
Y-Balance (Reach Distance / Leg Length)							
Anterior (R)	0.67±0.07	0.69±0.07	**0.002**	0.68±0.07	0.70±0.07	0.074	0.082
Posterolateral (R)	0.77±0.11	0.85±0.11	0.071	0.82±0.13	0.84±0.13	0.859	0.267
Posteromedial (R)	0.83±0.27	0.96±0.09	**0.015**	0.95±0.07	0.97±0.07	0.155	0.074
Anterior (L)	0.66±0.08	0.67±0.07	0.638	0.62±0.13	0.69±0.06	0.059	0.202

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Posterolateral (L)	0.74±0.15	0.82±0.17	**0.010**	0.77±0.14	0.83±0.11	0.075	0.060
Posteromedial (L)	0.93±0.11	0.95±0.12	**0.041**	0.84±0.29	0.97±0.07	0.050	0.064
Composite (R)	78.83±7.33	83.39±8.95	**0.023**	81.71±7.07	83.67±6.50	0.155	0.081
Composite (L)	77.68±10.53	81.26±11.7	**0.012**	78.68±7.41	83.23±6.01	0.050	0.094

L: Left; R: Right; SD: Standard deviation; SRS-22: Scoliosis Research Society-22; WRVAS: Walter Reed Visual Rating Scale

Discussion

The present study aimed to compare the effects of the Schroth exercise method alone and the Schroth exercise method combined with manual therapy on gibbosity angle, visual perception of trunk deformity by the participant and family, static balance, dynamic balance, and quality of life in adolescents with idiopathic scoliosis.

Although numerous studies have investigated different treatment approaches for scoliosis, relatively few studies have examined the specific effects of manual therapy on parameters such as gibbosity angle, trunk deformity perception, and balance performance. Therefore, the current study aimed to contribute to the literature by investigating whether the addition of manual therapy to a Schroth-based exercise program provides additional benefits in adolescents with idiopathic scoliosis.

Baseline demographic characteristics such as gender distribution, age, height, and body mass index were comparable between the two groups, suggesting that the groups were similar prior to the intervention. Previous studies have reported that the progression of scoliosis during adolescence is closely associated with skeletal maturation, and commonly used indicators include chronological age, Risser sign, and age at menarche[2]. In addition, the incidence and risk of progression of scoliosis have been reported to be approximately three to five times higher in females than in males[2]. The similar demographic distribution between the groups in the present study supports the comparability of the study population.

Quality of life outcomes assessed using the SRS-22 questionnaire were slightly higher in the combined intervention group compared with the exercise-only group, although these differences were not statistically significant. Reichel and Schanz[25] reported that the negative perception of body image associated with scoliosis can significantly influence quality of life and that improvements in spinal curvature may lead to improvements in patient perception and quality of life. In the present study, although visual perception scores appeared to be higher in the combined intervention group, the absence of statistically significant differences between the groups suggests that these findings should be interpreted cautiously.

Similarly, visual perception of trunk deformity assessed using the WRVAS scale was higher in the combined intervention group. Manual therapy techniques such as mobilization and manual corrective pressures may theoretically influence proprioceptive

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feedback and postural awareness. However, the results of the present study do not provide strong evidence confirming a direct causal relationship between manual therapy and improvements in visual perception. Therefore, further controlled studies are required to clarify the potential role of manual therapy in influencing cosmetic perception in adolescents with scoliosis.

Regarding balance performance, no statistically significant differences were observed between the groups in either static or dynamic balance parameters following the intervention. Nevertheless, improvements were observed in several balance measures in both groups. Previous studies have reported that postural control and proprioceptive mechanisms may be affected in individuals with idiopathic scoliosis[6,26]. The Schroth method is one of the most widely studied physiotherapeutic scoliosis-specific exercise (PSSE) approaches and includes fundamental principles such as postural stabilization, trunk alignment, and proprioceptive training[18]. Therefore, improvements observed in balance performance in both groups may be related to the neuromuscular training components of the Schroth exercise program.

Although greater reductions in gibbosity values were observed in the combined intervention group compared with the exercise group, the differences between the groups were not statistically significant. While manual corrective pressures applied during manual therapy may theoretically contribute to improved spinal mobility and trunk symmetry, the findings of the present study do not provide clear evidence supporting a superior effect of manual therapy. A case report describing a 15-year-old female with thoracic scoliosis reported a reduction in gibbosity angle following a three-month manual therapy intervention[27]. However, findings from individual case reports should be interpreted cautiously and cannot be generalized to larger clinical populations.

Another factor that may influence scoliosis progression is body composition. Previous studies have suggested that individuals with low leptin levels may have an increased risk of scoliosis[28]. In addition, Tekgül et al.[29] reported that BMI values between 20–25 kg/m^2 are considered normal for adolescents. The relatively low BMI values observed in the present study population are consistent with findings reported in previous studies.

Several limitations of the present study should be considered when interpreting the results. First, the relatively small sample size may have limited the statistical power to detect significant differences between the groups. Second, participants were allocated according to the order of admission rather than through randomization, which may introduce potential selection bias. Third, blinding of participants and therapists was not feasible due to the nature of the intervention, and outcome assessments were conducted by the same physiotherapist, which may increase the risk of measurement bias. Furthermore, although the intervention period lasted three months, longer follow-up periods may be necessary to evaluate structural changes in spinal deformity in adolescents with idiopathic scoliosis.

Future studies with larger sample sizes, randomized controlled designs, and longer follow-up periods are required to better understand the potential additive effects of manual therapy when combined with physiotherapeutic scoliosis-specific exercises. Despite these limitations, the findings of the present study suggest that Schroth-based exercise programs may contribute to improvements in trunk deformity perception, balance performance, and quality of life in adolescents with idiopathic scoliosis. However, further high-quality studies are required to determine whether the addition of manual therapy provides clinically meaningful additional benefits.

Conclusion

In this study, no difference was found between the exercise and combined groups in terms of static and dynamic balance, gibbosity and quality of life except for the visual perception evaluation parameter. Although gibbosity and quality of life values were higher in the combined group than in the exercise group and static balance was better in the exercise group, there was no statistically significant difference between the two groups.

In future studies, women and men can be evaluated in separate groups due to different physiological characteristics and different maturation processes, and individuals can be categorized according to their daily physical activity levels. With larger sample sizes and longer follow-up periods, more significant and reliable results may be obtained in the combined treatment group for degree of gibbosity, quality of life and static-dynamic balance. Further studies are required to explore the continuity of the positive results obtained with the two treatment methods in this study.

Ethical Approval: The protocol was approved by the Non-Interventional Clinical Research Ethics Committee of the Gazi University, Türkiye (Number: 2020/21-876, Date: 21.12.2020). Informed consent was obtained from all participants.

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