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EFFECT OF STANDING AND SITTING POSTURES ON THE ANGLE OF TRUNK ROTATION IN PATIENTS WITH ADOLESCENT IDIOPATHIC SCOLIOSIS

Burçin Akçay[1], Tuğba Kuru Çolak[2], Adnan Apti[3]

[1]Bandırma Onyedi Eylül University Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Balıkesir, Turkey
[2]Marmara University Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, İstanbul, Turkey
[3]İstanbul Kültür University Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, İstanbul, Turkey

ABSTRACT

Objective: The objective of this study was to evaluate the immediate effect of relaxed and corrected posture applied while sitting and standing on the angle of trunk rotation (ATR) in adolescent idiopathic scoliosis (AIS) patients.

Materials and Methods: The study included 38 patients with AIS. Corrected sitting and standing postures were taught according to the Schroth Best Practice® method, and patients were asked to sit/stand for 5 min. ATR was measured using a scoliometer before and after four postural positions: relaxed sitting and standingand corrected sitting and standing.

Results: The mean age of the participants was 14 years, the Cobb angle was 28.63°, and the ATR was 8.14°. Baseline ATR values increased after relaxed sitting and standing postures and decreased after corrected sitting and standing ($p<0.001$). Improvements in corrected sitting were superior to corrected standing ($p<0.001$). ATR values increased more in relaxed sitting than in relaxed standing ($p=0.008$).

Conclusion: The results showed that corrected posture might have a corrective effect on scoliosis curvature during activities of daily living (ADL). Integrating ADL adaptations into a rehabilitation program may help decrease asymmetric loading on the spine in growing adolescents with AIS.

Keywords: Adolescent idiopathic scoliosis, angle of trunk rotation, posture, activities of daily living

INTRODUCTION

Scoliosis, a three-dimensional deformity of the spine, can be differentiated from different etiologies, but the adolescent idiopathic form is the most frequently seen[1]. Adolescent idiopathic scoliosis (AIS) is a deformity of the trunk in otherwise healthy adolescents[2].

Conservative scoliosis treatment approaches mainly focus on stopping the progression of the curvature and improving the deformity by reversing the biomechanical factors, which are assumed to be the etiopathogenetic factors of scoliosis[3,4]. Although biomechanical theories vary, they address the ongoing effects of gravitational forces on the spine[5]. Gravitational forces act on the spine all day long, so conservative management of scoliosis should include correction techniques during the activities of daily living (ADL)[6-8]. The Schroth Best Practice® (SBP) program, one of the scoliosis-specific conservative methods, includes load modification protocols that allow patients to influence postural control through self-correction during various daily activities[6,9]. Self-correction is the transformation of the new/corrected posture into a natural one. This approach helps prevent the progression of scoliosis by not allowing increases in curvature or asymmetric loading during daily activities[3,4,7].

Studies investigating the effect of daily living activities in treating patients with AIS are limited. In a study by Weiss et al.[10], comparisons were made of the results of a 2-week activity of daily living (ADL)-based rehabilitation program and a 4-week exercise-based rehabilitation program in the treatment of patients with AIS. Similar results were reported to be obtained in both programs, but the ADL-based rehabilitation seemed to provide better time efficiency[10].

Relaxed postural habits in ADL in patients with AIS have been discussed in literature generally in terms of sitting and standing postures. In patients with AIS, hyperextension of the upper thoracic region due to standing in a relaxed posture may increase, and the degree of curvature may increase accordingly[11]. It has been stated that the relaxed sitting

Address for Correspondence: Burçin Akçay, Bandırma Onyedi Eylül University Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Balıkesir, Turkey
Phone: +90 505 653 32 73 **E-mail:** bakcay@bandirma.edu.tr **Received:** 20.07.2023 **Accepted:** 17.09.2023
ORCID ID: orcid.org/0000-0002-0883-0311

posture increases the curvature similar to that of the standing posture[11,12].

There are no studies examining the changes in the spine during standing and sitting in the corrected posture in patients with AIS. With the current increased use of technology, increased sedentary behaviors and sitting times, especially in children, have also become a problem[13]. Therefore, this study aims to assess the immediate effect of the relaxed and corrected posture applied in sitting and standing daily living activities to prevent the progression of scoliosis.

MATERIALS AND METHODS

Study Design

This cross-sectional study included individuals with AIS who presented at the Physiotherapy and Rehabilitation Department of Bandırma Onyedi Eylül University between December 2021 and March 2022.

This study was approved by the Bandırma Onyedi Eylül University Ethics Committee (study number: 2021-61, date: 12.11.2021, no: 2021-29).

Participants

The study inclusion criteria were defined as age >10 years and a diagnosis of AIS with a Cobb angle of >10°. Patients were excluded from the study if they had non-idiopathic scoliosis, any contraindications for exercise, a history of spinal surgery, apex ≥T6, any chronic disease that required neurological or psychiatric medication, or any mental problems.

Variables

The demographic characteristics of the participants were recorded, including age, gender, weight, height, age at first diagnosis, exercise habits, current treatments, and brace use.

The degree of curvature in the coronal plane was assessed radiographically using the Cobb method[14]. The Risser sign was used to determine the age of bone development[15]. The Cobb angle and Risser sign were obtained from X-ray measurements, routinely required for the diagnosis of AIS, so no new X-rays were requested. The Cobb method is the gold standard for measuring curvature[16]. However, the angle of trunk rotation (ATR) measurement can be used in clinical devices as a safe and reliable alternative to serial radiographs[17]. The degree of trunk rotation correlates with the Cobb angle[18,19]. Therefore curvature status can be assessed by Scoliometer measurements of the trunk rotation angle, which are reliable and repeatable up to 3°[17]. In this study, the ATR measurement was made with a Scoliometer®[20]. Each patient was evaluated by the same experienced therapist. The therapist stood behind the patient for the standardization of the measurements. He/she was asked to bend forward until the scapulae aligned with the pelvis. Care was taken not to flexion the knee. The children's feet were open until the therapist's feet intervened and parallelled each other. The maximum value was recorded as the definition of the ATR measurement, and no marking was defined for it. Therefore, the maximum value was taken before and after each posture on the same day following the same procedure[21]. The ATR measurement was performed on the same day, before and after each intervention by the same researcher. The value measured before relaxed and corrected postures was recorded as baseline ATR.

Augmented Lehnert-Schroth (ALS) classification was used to describe the curve type. According to the ALS classification, the 3CH (functional three curves, hip protrusion), 3CTL (functional three curves, thoracolumbar with hip protrusion), 3CN (functional three curves, neutral with the balanced pelvis), 3CL (functional three curves with the long lumbar counter curve), 4C (functional four curves, double major), 4CL (functional four curves with single lumbar) and 4CTL (functional four curves with single thoracolumbar)[4,22]. Functional 3-curve patterns primarily define thoracic curves, and functional 4-curves represent double major or single lumbar and thoracolumbar curves and additional lumbosacral curves[4,22,23].

Intervention/Experimental Design

After the demographic and clinical evaluation, adolescents were requested to sit in a chair in a relaxed and comfortable position that they would normally adopt during the day and to hold this position for 5 minutes (Figure 1a). To evaluate standing, the adolescent was asked to stand in the position that she/he was used to during the day and to hold that position for 5 minutes (Figure 2a).

Then, the participants were asked to sit for 5 minutes in the corrected posture, which had been taught specifically for their curve pattern. The patients were requested to stand in a corrected posture for 5 minutes for the standing task. The corrected sitting and standing postures were applied according to the curve patterns defined in the daily living activities education, which is one of the components of the SBP program. The Schroth-based SBP program has been under development since 2004[4]. For all 3-curve patterns, the corrected movement for sitting and standing postures is described as "lowering the shifted pelvis (thoracic concave side) and translating the thoracic spine to the side of concavity" (Figures 1b, 2b)[6]. In addition to the 3-curve pattern, in the 3CH pattern, the convex side leg crosses the concave leg to strengthen the pelvic tilt in a corrected sitting position and the convex side knee semi-flexion in a corrected standing position. In the 3CN pattern, the concave leg crosses the convex leg, or both feet rest on the floor to strengthen pelvic glide and prevent pelvic tilt in a corrected sitting position[4]. For 4-curve patterns, the corrected movement for sitting and standing posture is described as lowering the shifted pelvis (thoracic convex side) and translating the thoracic spine to the side of concavity[6]. In addition to the 4-curve pattern, in the 4CL pattern, the concave-side pelvis is shifted by the ipsilateral knee semi-flexion during corrected standing, while the lumbar concave side is shifted by the concave-side pelvis tilt while in a corrected sitting position. Since the curvature

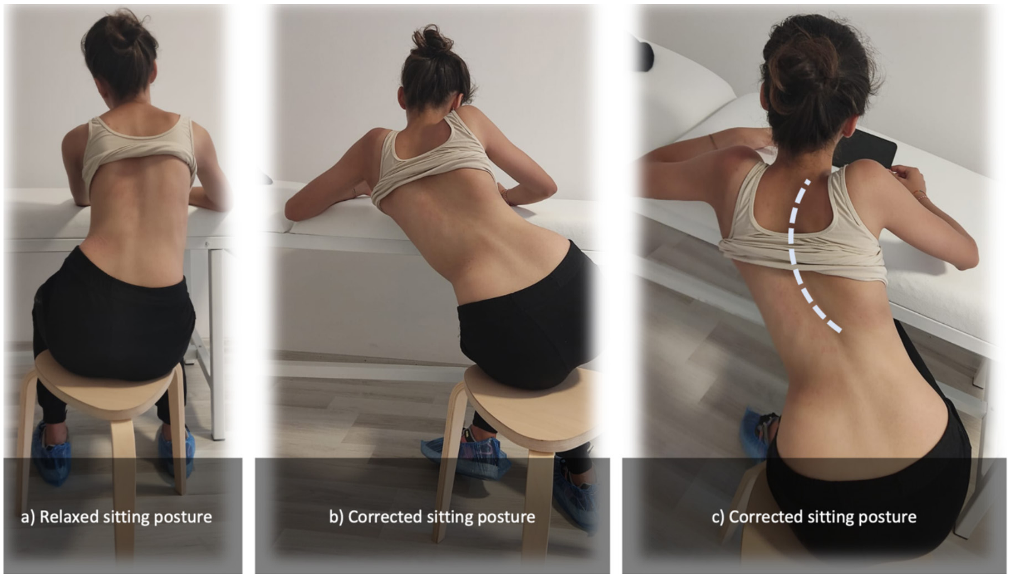

Figure 1. Sitting posture **a)** relaxed sitting posture, **b, c)** corrected sitting posture

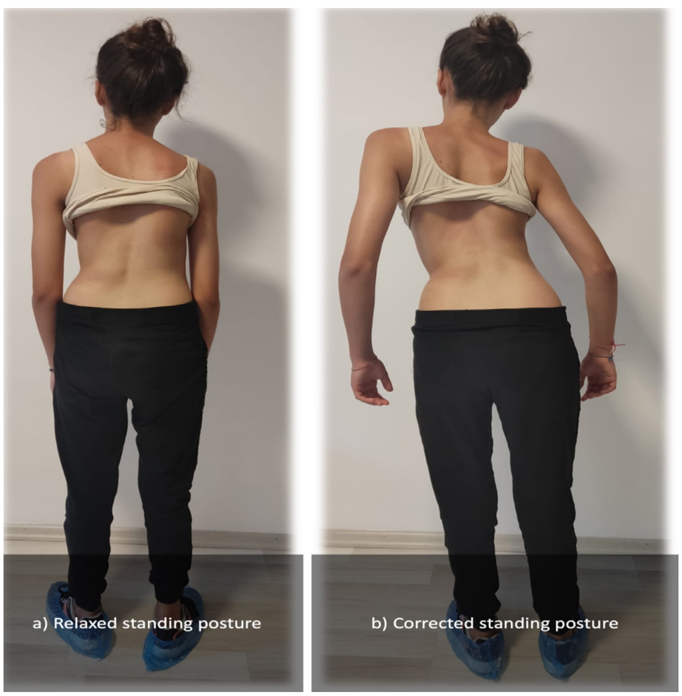

Figure 2. Standing posture **a)** relaxed standing posture, **b)** corrected standing posture

pattern is the only major curvature pattern in the 3CTL and 4CTL patterns, the same corrections in the 3C pattern were applied[4].

Between all conditions, a rest period of 10-15 minutes was given. In all postural conditions, the patients were asked to watch a video on a mobile phone or read a book to simulate an environment close to daily habits. After 5 minutes of sitting or standing respectively, trunk rotation was measured three times, and the average value was re-recorded.

Statistical Analysis

IBM SPSS Statistics version 23 software was used to analyze the data obtained in the study statistically (IBM Corp., Armonk, NY, USA). The normality of the data was checked with the Shapiro-Wilks test; the data was found to show heterogeneous distribution. Descriptive statistics were reported as mean, standard deviation, range, minimum, and maximum values. The Wilcoxon signed-rank test was used to evaluate the changes from baseline in each postural condition, and the Mann-Whitney U test was applied in the comparisons of the differences between the different postural conditions. The relationships between Cobb angle, ATR, and age were evaluated with the Spearman correlation test. A value of $p<0.05$ was deemed statistically significant for all tests.

RESULTS

Participants and Sample Characteristics

From a total of 41 patients evaluated, 38 patients with a mean age of 14 years were included in this study. The mean Cobb angle was 28.63°, the mean ATR was 8.14°, and the mean Risser grade was 2.80 (Table 1). The curvature pattern in 16 subjects (57.9%) was functional 3-curve (major thoracic), and in 12 (42.1%) was functional 4-curve (major lumbar/double major).

Comparison of Baseline and After the Postural Conditions

A significant increase was determined from the baseline ATR values after relaxed habitual sitting and habitual standing postures ($p<0.001$). There was a statistically significant decrease in ATR values after corrected sitting and standing postures ($p<0.001$), which indicated improvement in the deformity (Table 2).

Table 1. Demographic characteristics of the participants

Variables	Frequency n (%)
Gender	Female - 26 (68.4%) Male - 12 (31.6%)
Risser grade	Risser 0- 5 (13.20%) Risser 1- 4 (10.50%) Risser 2- 6 (15.80%) Risser 3- 8 (21.10%) Risser 4- 7 (18.40%) Risser 5- 8 (21.10%)
	Mean ± SD (min-max)
Age (years)	14.07±2.57 (10-20)
Heigh (cm)	164.10±9.04 (146-184)
Weight (kg)	51.05±14.63 (31-104)
Cobb angle (°)	28.63±9.69 (12-60)
ATR (°)	8.14±4.20 (2-23)

SD: Standard deviation, Min: Minimum, Max: Maximum °: Degree, cm: Centimeter, kg: Kilogram, %: Percentage

Table 2. Changes in ATR values in sitting and standing postures

ATR values	Sitting position Mean ± SD Min-max	Standing position Mean ± SD Min-max
After relaxed posture	9.86±4.38 3.50-25.00	9.30±4.32 3.50-25.00
After corrected posture	5.25±3.95 1.00-20.00	6.28±4.22 1.00-23.00
Mean difference Relaxed-corrected posture	-4.61±1.73 (-2 - -10.00)	-3.01±0.94 (-4.50 - -1.00)
P value Relaxed-corrected posture	**<0.001**[b]**	**<0.001**[b]**
Mean difference Baseline-relaxed posture	1.70±1.05 1.50 (0 - 5.00)	1.15±0.98 1.00 (0-3.50)
P value Baseline-relaxed posture	**<0.001**[a]**	**<0.001**[a]**
Mean difference Baseline-corrected posture	-2.89±1.55 -3.00 (-7.00 - 0)	-1.85±1.08 -2.00 (-4.50 - 0)
P value Baseline-corrected posture	**<0.001**[a]**	**<0.001**[a]**

[a]Wilcoxon signed-rank test,[b]Mann-Whitney U test, **p<0.001
SD: Standard deviation, Min: Minimum, Max: Maximum, ATR: Angle of trunk rotation

Comparison of Relaxed and Corrected Postural Conditions

There was a statistically significant difference in ATR values obtained in relaxed and corrected sitting and standing postures (p<0.001) (Table 2).

Comparison of Sitting and Standing Postural Conditions

Significantly greater improvements were determined in the corrected sitting postures compared to the corrected standing postures (p<0.001). The ATR values increased more in relaxed sitting posture than in relaxed standing (p=0.008).

Comparison of ATR Values According to Gender and Age Groups

When the participants were separated into two groups according to the curve patterns (functional three and functional four curve patterns) and compared, the differences obtained in ATR values after corrected sitting and standing postures were similar (p>0.05). The ATR values were similar when the subjects were compared according to gender and age groups of younger and older than 14 years (p>0.05).

DISCUSSION

The aim of this study was to evaluate the acute effect of corrected ADL on the ATR in patients with scoliosis. The results showed that sitting and standing in the habitual relaxed posture in the short-term negatively affected ATR. Short-term sitting and standing in the corrected posture significantly improved the ATR, indicating an immediate improvement of the deformity.

In individuals with scoliosis, postural changes are seen in the head, shoulder, scapula, waist, and pelvis according to the curvature pattern[23]. When scoliosis patients are standing, the pelvis shifts to the thoracic concave side in a 3-curve curvature pattern, while in a 4-curve, the pelvis shifts to the thoracic convex side[6]. Patients with AIS also tend to carry more weight on one leg than the other[23]. These postural changes continue during ADL, leading to asymmetrical loading on the growing spine.

In general, conservative scoliosis treatment approaches are supposed to reduce or eliminate the asymmetrical loading on the spine[4,23]. Asymmetrical loading is based on the Hueter-Volkmann Law and the "vicious cycle" concept. The Hueter-Volkmann Law states that increased mechanical compression acting on growth plates impairs skeletal growth, and reduced loading increases skeletal growth[3].

Asymmetric loading increases asymmetric development/growth, which increases spinal curvature by increasing asymmetric bone and disc development. This cycle continues naturally or until it is stopped externally[3,24]. Therefore, the asymmetrical load that occurs during ADL (sitting/standing) can increase the curvature according to this principle, and regulating daily activities in a corrected posture can reduce the curvature.

There is a current increase in sedentary lifestyles, including screen time, leisure time, and school and homework, in children and adolescents[13]. Sitting and standing are important because asymmetric sitting postures may foster the progression of spinal curvatures[25]. Previous studies have reported increased curvature in relaxed sitting and standing postures[11,12]. This study observed an increase in trunk rotation angle after short-term relaxed sitting and standing postures, similar to the literature[11,12].

In this study, the degree of trunk rotation was investigated with Scoliometer. Smidt et al.[12] compared the sitting position of individuals with scoliosis and healthy individuals with a non-invasive computer model. They reported that while sagittal plane changes were similar, lateral curvature increased while sitting in individuals with scoliosis[12]. Gram and Hasan[11] evaluated the apex angle in sitting comfortably and standing upright and placed markers at the upper end, apex, and lower end of the curve, as well as on the vertebrae at C7 and S1. With this method, the front plane apex angle and lateral slope were measured. However, the current study did not measure the change in frontal correction. Since lateral flexion and rotation occur together due to the double movement of the spine[26], only the amount of trunk rotation was measured in this study. The Cobb method is the gold standard for measuring lateral spinal curvature magnitude[16], and the degree of trunk rotation correlates with the Cobb angle[18,19]. Therefore measurement of the ATR can be used in clinical devices as an alternative to serial radiographs[17]. Although there are differences in the evaluation parameters used in previous studies, the application times of relaxed sitting and standing postures were similar[11,12].

In the current study, it was determined that the maximum ATR value measured after sitting in the relaxed posture was higher than in the relaxed standing posture. The ATR value measured at the baseline decreased more with the corrected sitting than with the standing posture. This result may be due to the activation of different muscles in sitting and standing[27,28] and changes in the pelvis and sagittal plane of the spine. This issue can be addressed in future studies.

Gram and Hasan[11] stated that patients with single, either thoracic or lumbar curvature tend to move laterally to the convex side. Subjects with double curvature tend to move to the convexity of the lumbar curvature in all postures except relaxed sitting, thus reducing the angle of the lumbar apex and exacerbating the thoracic angle. The improvements obtained in the corrected sitting and standing postures in the current study were similar for both the three and four-functional curve patterns. Since the number of cases with different curvature patterns according to the ALS classification was small, no further analysis was performed according to the curve patterns.

According to the SBP® method, corrected ADLs are applied according to the individual's curve pattern. Hence, patients learn to oto-correct and decrease asymmetric loading on the spine, particularly in the frontal plane in both static and dynamic postures[4]. In the current study, there was observed to be a significant decrease in ATR values after sitting and standing in corrected postures, which were taught as described in the SBP approach. To the best of our knowledge, no study in the literature has investigated the immediate or long-term effects of sitting and standing in the corrected posture according to the curve pattern. Weiss et al.[10] compared the results of a 2-week ADL-based rehabilitation program and a 4-week exercise-based SBP rehabilitation program. It was reported that the improvements were similar in the two groups, but ADL-based rehabilitation seemed to provide better time efficiency[10].

Study Limitations

The measurement of changes in the spine only with the degree of rotation can be considered a limitation of this study. Another limitation is that only a short-term improvement of the ATR is demonstrated with ADL postures. There is a need for further studies to evaluate the effect of prolonged corrected ADL postural rehabilitation to reach a well-balanced stance with different objective outcome measures. The clinical implication might be that sitting and standing postures during ADL affect the curvature in patients with AIS. This finding might have important clinical implications for more emphasis on ADL education in rehabilitation programs and regular follow-up of ADL habits in patients with AIS. However, corrected ADL exercises need to be integrated into 3-dimensional with a well-balanced corrected posture. Postural compensations that may occur during ADL, can be corrected by therapists more frequently checking how individuals with scoliosis perform their ADL activities during each therapy session. Also, it can be recommended that the different behavior of curvature patterns is examined in daily living activities in future studies with larger sample sizes.

CONCLUSION

The results of currents study showed that short-term sitting and standing in the corrected posture significantly improved the trunk rotation in patients with AIS, indicating an immediate improvement. Integrating ADL adaptations in a rehabilitation program may help decrease asymmetric loading on the spine in growing adolescents with scoliosis. Future studies are still needed to evaluate the long-term effects of these corrected exercises on posture and scoliotic curves.

Ethics

Ethics Committee Approval: This study was approved by the Bandırma Onyedi Eylül University Ethics Committee (study number: 2021-61, date: 12.11.2021, no: 2021-29).

Informed Consent: Informed consent was obtained from all parents and patients.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: B.A., T.K.Ç., Concept: B.A., T.K.Ç., Design: B.A., T.K.Ç., A.A., Data Collection or Processing: B.A., Analysis or Interpretation: B.A., T.K.Ç., A.A., Literature Search: B.A., T.K.Ç., A.A., Writing: B.A., T.K.Ç., A.A.

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