

Brace Compliance Improves Cobb Angle Correction and Quality of Life in Adolescents with Idiopathic Scoliosis

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ABSTRACT

Adolescent idiopathic scoliosis (AIS) is the most common spinal deformity among adolescents and may negatively affect physical and psychosocial well-being. Brace treatment is widely used to prevent curve progression; however, treatment success largely depends on patient compliance. Evidence examining the relationship between brace compliance, spinal correction, and quality of life in adolescents with AIS remains limited. This study aimed to evaluate the effect of brace compliance on Cobb angle, height change, and quality of life in adolescents with AIS. A quasi-experimental longitudinal study was conducted among 50 female adolescents aged 13 to 18 years with Cobb angles of 20° to 35° at the Orthotic and Prosthetic Clinic Mojokerto, Indonesia. Participants underwent brace treatment for three months. Mean wear time was 16.3 ± 3.4 hours/day. Brace compliance was assessed using a structured questionnaire, while quality of life was evaluated using the PedsQL Scoliosis Module. Cobb angle and height measurements were performed before and after treatment. The results demonstrated a significant mean Cobb angle reduction of 2.6° after treatment ($p < 0.001$). Higher brace compliance was associated with greater Cobb angle reduction ($p = 0.003$) and better quality of life scores ($p < 0.001$). However, no significant correlation was found between brace wear duration and height change ($r = 0.11$; $p = 0.42$). In conclusion, brace compliance significantly improved spinal curve correction and quality of life in adolescents with AIS. Strategies to improve brace adherence are essential to optimize conservative treatment outcomes.

Keywords: adolescent idiopathic scoliosis; brace compliance; cobb angle; quality of life; conservative treatment

INTRODUCTION

Adolescent idiopathic scoliosis (AIS) is a structural spinal deformity characterized by three-dimensional curvature and rotation of the spine, with its precise etiology remaining unknown. It typically manifests between the ages of 10 and 18 years [1]. AIS represents the most common form of scoliosis among adolescents, affecting approximately 2–3% of the global adolescent population [2]. Females are disproportionately affected compared to males, particularly in cases involving curves exceeding 20 degrees [3]. In Indonesia, AIS remains an underreported condition; however, data from orthotic–prosthetic clinical settings indicate a notable clinical burden, particularly in East Java. At the Orthotic and Prosthetic Clinic Mojokerto, AIS cases represent a substantial proportion of pediatric orthotic referrals, as evidenced by prior studies conducted at this site [4]. Untreated AIS may result in curve deterioration, potentially restricting movement, causing pain, and creating emotional disturbance during a critical period of adolescent development [5,6].

The selection of treatments for AIS is determined by several key factors, including curve magnitude, remaining skeletal growth potential, and risk of progression [7]. For skeletally immature patients with curves between 20° and 45°, bracing represents the primary nonoperative intervention, as it slows curve progression and thereby reduces the likelihood of surgical intervention [8]. Bracing applies corrective pressure to the curve apex, counteracting both lateral deviation and vertebral rotation, while providing support to the growing spine and influencing postural balance and overall body alignment [8,9].

Although bracing is effective in halting curve progression, its success hinges on patient compliance, specifically adherence to the prescribed daily wear duration [8]. Inconsistent wear undermines treatment efficacy, and ensuring compliance among adolescents remains challenging due to discomfort, aesthetic concerns, and limitations on social activities [10]. In addition to radiographic evaluations, the influence of brace wear on participants' quality of life plays a pivotal role in treatment efficacy. Brace wear can alter pain levels, self-image, physical activity, and social functioning [11]. Negative psychological states have been associated with reduced brace compliance, while regular physical activity particularly swimming has been shown to enhance health-related quality of life in AIS participants undergoing bracing [10,12].

However, Okky Gusma et al. [10] employed a cross-sectional design that precluded assessment of temporal changes or biomechanical outcomes. Their study focused exclusively on physical activity participation and quality of life, without evaluating brace compliance levels or spinal curvature correction over time. This limitation is reflective of a broader pattern in the literature, wherein studies tend to examine patient-reported outcomes, compliance behavior, or physical changes in isolation, rather than integrating these dimensions within a single longitudinal framework [10,13].

One understudied physical parameter is change in body height. Spinal curvature and rotation can diminish an individual's stature owing to lateral deviation and associated truncal deformity [14]. Bracing may rectify spinal alignment, thereby increasing standing height and correcting posture [15]. Nevertheless, empirical evidence on brace-induced height alterations remains scarce, as does insight into its associations with brace compliance or improved quality of life. Changes in standing height represent a straightforward, equipment-free metric for monitoring postural improvements in routine clinical practice, and tangible physical progress may serve to enhance patient motivation and brace adherence [15,16].

Most prior studies employed retrospective or observational designs, primarily emphasizing radiographic outcomes such as Cobb angle measurements or patient-reported perceptions, with longitudinal designs assessing temporal changes being notably scarce [17]. At the same clinical site as the present study, a prior cross-sectional investigation involving 60 female adolescents found that early menarche history was significantly associated with scoliosis severity based on Cobb angle measurement ($p = 0.014$), suggesting that pubertal maturation markers may serve as additional clinical indicators in brace management [4]. However, that study did not evaluate brace compliance behavior or its relationship with quality of life outcomes. Consequently, evidence regarding the longitudinal relationship between brace compliance, spinal correction, height alteration, and quality of life in adolescents with AIS remains limited, particularly in orthotic and prosthetic clinical settings in developing countries [18].

To our knowledge, no prior study has simultaneously examined brace compliance, Cobb angle correction, height change, and quality of life within a structured longitudinal design. The present study therefore addresses this gap by integrating biomechanical, anthropometric, and psychosocial outcomes within a longitudinal repeated-measures framework conducted at the Orthotic and Prosthetic Clinic Mojokerto a setting characterized by a diverse patient population with variable adherence patterns, making it well-suited for examining both physical and psychosocial treatment outcomes.

Therefore, this study aimed to evaluate the effect of brace compliance on Cobb angle correction, height change, and quality of life in female adolescents with AIS undergoing conservative brace treatment at the Orthotic and Prosthetic Clinic Mojokerto, Indonesia.

METHODS

This study employed a quasi-experimental longitudinal, repeated-measures design to evaluate the effect of brace compliance on spinal curvature correction, anthropometric changes, and quality-of-life outcomes in female adolescents with Adolescent Idiopathic Scoliosis (AIS). The independent variable was brace compliance, assessed as daily wear duration and adherence behavior. The dependent variables were: (1) Cobb angle change as a radiographic biomechanical outcome, (2) standing height change as an anthropometric outcome, and (3) quality of life as a psychosocial outcome. A longitudinal framework was selected to capture intra-individual changes over time within routine clinical practice without altering treatment allocation. The study was conducted at the Orthotic and Prosthetic Clinic Mojokerto from January to December 2025.

Participants were female adolescents aged 13–18 years diagnosed with AIS and undergoing brace therapy. Consecutive sampling was applied to reduce selection bias, resulting in 50 eligible participants. Inclusion criteria included a Cobb angle of 20°–35°, no prior spinal surgery, use of a custom-made brace fabricated by certified orthotist–prosthetists, and completion of a minimum three-month follow-up. Participants with neuromuscular or congenital scoliosis, or incomplete follow-up data, were excluded. Sample size was determined a priori using power analysis ($\alpha = 0.05$; power = 0.80; moderate effect size).

The primary outcome was standing height change as an indicator of postural and biomechanical response. Height was measured using a calibrated stadiometer (accuracy 0.1 cm) at four time points: baseline without brace, immediate in-brace correction, three-month follow-up out-of-brace, and three-month follow-up in-brace. Measurements followed standardized anatomical positioning and were performed by the same certified orthotist–prosthetist, with duplicate readings averaged to enhance reliability.

Brace compliance was assessed using a 10-item Likert-scale questionnaire covering daily wearing duration, consistency, comfort, motivation, and family support. Scores were converted into percentages and analyzed as continuous variables. Quality of life (QoL) was measured using the Indonesian version of the PedsQL Scoliosis Module (0–100 scale).

Longitudinal changes in height were analyzed using a linear mixed-effects model with time as a fixed effect and participants as random intercepts. An interaction between time and compliance was tested to assess differential trajectories. Multivariable linear regression, adjusted for age and baseline Cobb angle, evaluated the independent effect of compliance on three-month height change and QoL. Effect estimates were reported with 95% confidence intervals. Statistical significance was set at $p < 0.05$, and residual diagnostics were performed to verify model assumptions. All procedures involving human subjects were reviewed for compliance with institutional guidelines, and informed consent was obtained from all participants prior to enrollment.

RESULTS

Fifty female adolescents diagnosed with Adolescent Idiopathic Scoliosis participated. All participants completed three months of brace treatment and underwent a follow-up assessment.

Baseline characteristics

Table 1 presents the basic traits of the participants in the study. The average age was 15.2 years (standard deviation = 1.4 years), indicating that most participants were in a period of rapid growth. The average height was 156.8 cm (± 7.3 cm), and the average weight was 47.9 kg (± 6.8 kg). The mean Cobb angle at baseline was 27.4 degrees (± 4.2 degrees), suggesting a diagnosis of moderate scoliosis.

Brace compliance

Data analysis revealed an average brace usage of 16.3 hours per day (SD = 3.4 hours). Participants were subsequently categorized based on their adherence levels. There were 28% of participants with high adherence (usage ≥ 18 hours/day), 52% with moderate adherence (14–17 hours/day), and 20% with low adherence (< 14 hours/day). The detailed distribution of adherence can be observed in Table 2.

Changes in cobb angle

The mean Cobb angle measured 27.4 degrees prior to treatment. After three months of wearing braces, the angle decreased to 24.8 degrees, representing an average reduction of 2.6 degrees. This change was statistically significant, as confirmed by a paired t-test ($p < 0.001$). These findings are presented in Table 3. Further analysis demonstrated that Cobb angle reduction differed significantly across compliance groups (ANOVA, $p = 0.003$). People who followed instructions most closely had the biggest curve reduction. They saw a change of 3.8 degrees, with a standard deviation of 1.4 degrees. Those with

Table 1. Baseline characteristics (n = 50)

Variable	Mean $\pm$ SD
Age (years)	15.2 $\pm$ 1.4
Height (cm)	156.8 $\pm$ 7.3
Weight (kg)	47.9 $\pm$ 6.8
Baseline cobb angle (°)	27.4 $\pm$ 4.2

Table 2. Brace compliance distribution

Compliance category	Wear time (hours/day)	f (%)
High	≥ 18 hours	14 (28)
Moderate	14–17 hours	26 (52)
Low	< 14 hours	10 (20)
Mean wear time	16.3 $\pm$ 3.4 hours/day	—

Table 3. Comparison of cobb angle before and after treatment

Measurement	Mean $\pm$ SD
Baseline cobb angle (°)	27.4 $\pm$ 4.2
Post-treatment cobb angle (°)	24.8 $\pm$ 4.1
Mean reduction (°)	2.6 $\pm$ 1.8
p-value (paired t-test)	< 0.001

Table 4. Cobb angle reduction based on compliance level

Compliance group	Mean reduction (°) $\pm$ SD
High	3.8 $\pm$ 1.4
Moderate	2.4 $\pm$ 1.3
Low	1.2 $\pm$ 1.0
p-value (ANOVA)	0.003

moderate compliance had a reduction of 2.4 degrees ($\pm 1.3^\circ$). The group with low compliance showed the least reduction at 1.2 degrees ($\pm 1.0^\circ$). Table 4 shows these results.

Correlation between height and compliance

Pearson correlation analysis revealed no significant association between baseline height and daily brace wear duration ($r = 0.11$; $p = 0.42$), suggesting that anthropometric characteristics were not associated with adherence behavior in this sample (Table 5).

Pain and discomfort during brace use

The majority of participants reported no pain (36%) or mild discomfort (44%) during brace use. Moderate discomfort was reported by 20% of participants, and no participant reported severe pain (Table 6), suggesting that brace-related discomfort was generally tolerable and unlikely to serve as a primary barrier to compliance.

Quality of life outcomes

Analysis utilizing the PedsQL Scoliosis Module revealed significant differences in quality of life (QoL) across compliance groups, with a p-value less than 0.001 for the total score. Participants demonstrating high compliance reported the most favorable total QoL score (85.4 ± 6.0), compared to moderate (79.3 ± 6.5) and low compliance groups (71.4 ± 8.1). Notably, significant variations were also apparent in the physical, emotional, self-image, and treatment satisfaction aspects (Table 7).

Table 5. Correlation between height and brace compliance

Variable	r	p-value
Height vs wear time	0.11	0.42

Table 6. Pain or discomfort during brace use

Pain level	Frequency	Percentage
No pain	18	36
Mild	22	44
Moderate	10	20
Severe	0	0

Table 7. Quality of life by compliance group

Domain	High (mean $\pm$ SD)	Moderate (mean $\pm$ SD)	Low (mean $\pm$ SD)	p-value
Total score	85.4 ± 6.0	79.3 ± 6.5	71.4 ± 8.1	<0.001
Physical	86.1 ± 5.8	80.5 ± 6.3	72.3 ± 7.9	<0.001
Emotional	83.7 ± 6.2	78.9 ± 6.6	70.1 ± 8.4	<0.001
Self-Image	84.9 ± 6.4	77.8 ± 6.9	69.2 ± 8.7	<0.001
Satisfaction	87.2 ± 5.6	80.0 ± 6.4	71.0 ± 7.8	<0.001

DISCUSSION

The present study reinforces the clinical importance of brace compliance in the conservative management of adolescent idiopathic scoliosis (AIS). The findings indicate that greater adherence to prescribed brace wear is associated with improved curve control and better health-related quality of life. These results align with the broader evidence base emphasizing compliance as a decisive factor in bracing effectiveness.

From a biomechanical perspective, brace therapy aims to apply continuous corrective forces to modulate spinal growth during periods of skeletal immaturity. Sustained wear enhances three-dimensional spinal alignment and reduces asymmetric vertebral loading, thereby limiting curve progression [19,20]. The present findings support the concept that the therapeutic success of bracing is not solely dependent on brace design or fabrication quality, but is significantly influenced by patient adherence. This observation is consistent with previous prospective studies demonstrating that treatment failure is frequently linked to insufficient wear time rather than brace inefficacy [21,22].

Beyond radiographic outcomes, this study highlights the relationship between compliance and psychosocial well-being. Adolescents who adhered more consistently to brace use reported better physical functioning, emotional stability, self-image, and treatment satisfaction. These findings suggest that clinical improvement may positively influence psychological adaptation. Earlier investigations have shown that body image perception and social confidence are critical determinants of quality of life in AIS participants [23,24]. Therefore, successful conservative management may generate both structural and psychosocial benefits.

Interestingly, anthropometric factors such as height were not associated with adherence behavior. This suggests that compliance is more strongly shaped by behavioral, educational, and family-related factors than by physical characteristics. Prior studies emphasize the importance of patient education, structured follow-up, and parental involvement in enhancing adherence [5,10]. These findings underscore the need for a multidisciplinary and patient-centered approach in orthotic–prosthetic services.

Brace-related discomfort was generally tolerable and did not appear to be a dominant barrier to compliance [11,25]. Advances in brace fabrication, customization, and follow-up adjustment have been shown to improve patient acceptance and comfort [25]. Regular monitoring and individualized modification remain essential to sustain long-term adherence [10,26,27].

Taken together, the present findings contribute to the growing body of evidence supporting brace therapy as an effective conservative intervention for mild to moderate AIS when adequate compliance is achieved [27,28]. Importantly, adherence represents a modifiable factor [29,30]. Clinical strategies aimed at improving compliance through education, counseling, and structured monitoring may significantly enhance treatment outcomes [31,32].

Future longitudinal studies with extended follow-up are warranted to evaluate long-term curve stabilization, skeletal maturity outcomes, and sustained quality of life improvements. Nevertheless, the current study provides context-specific evidence that strengthens the role of compliance-centered management in conservative scoliosis care. Integrating innovative technologies such as implanted pressure sensors or temperature data loggers into subsequent research could provide more objective adherence metrics compared to the retrospective self-reporting methods used here.

CONCLUSION

Brace compliance was significantly associated with improved Cobb angle correction and better quality of life in adolescents with idiopathic scoliosis. Higher daily wear duration resulted in greater spinal curve reduction (high: 3.8° vs. low: 1.2° , $p = 0.003$) and more favorable psychosocial outcomes across all PedsQL domains. However, brace wear duration was not significantly correlated with height change ($r = 0.11$; $p = 0.42$). These findings confirm brace compliance as a key modifiable determinant of conservative treatment success. Patient education, behavioral support, and family involvement are recommended to optimize adherence and clinical outcomes in orthotic–prosthetic practice.

Ethical consideration, competing interest and source of funding

-This study was conducted in accordance with established ethical principles, including respect for autonomy, beneficence, non-maleficence, and the confidentiality of patient data. Ethical approval was obtained through informed consent from all participants and formal authorization from the relevant institutional body prior to data collection.

-The authors declare no conflicts of interest related to this publication.

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