

# Intervention Effects of Tai Chi on Adolescent Scoliosis Correction: A Perspective from Sports Biomechanics and Rehabilitation Science

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**Abstract:** Scoliosis is a common spinal deformity in adolescents, affecting growth and overall health. This study explores the corrective effects of Tai Chi on adolescent scoliosis from the perspectives of sports biomechanics and rehabilitation science. Sixty adolescents with mild to moderate scoliosis were randomly assigned to a Tai Chi intervention group or a conventional rehabilitation group (n=30 each). The Tai Chi group practiced three times per week for 12 weeks, while the control group received standard physical therapy. Assessments included scoliosis angle, trunk rotation (ATR), postural balance, pain perception, and quality of life. Results showed significant improvements in the Tai Chi group across all parameters ( $P < 0.05$ ). Biomechanical analysis indicated that Tai Chi enhances spinal muscle strength, stability, and flexibility, while its mind-body regulation alleviates anxiety and pain. These findings suggest that Tai Chi is an effective and promising rehabilitation method for adolescent scoliosis correction.

## 1 Introduction

### 1.1 Background

Adolescent scoliosis, affecting 2%–3% of the population, can lead to physical dysfunctions such as breathing difficulties, chronic pain, and impaired cardiorespiratory fitness, along with negative psychological effects like low self-confidence and socialization issues. Traditional treatments, including physical therapy, bracing, and surgery, have limitations in compliance, effectiveness, and accessibility. Tai Chi, with its slow, coordinated movements and emphasis on mind-body regulation, has shown potential in rehabilitation by improving balance, flexibility, and muscle strength while alleviating pain and anxiety [1,2], making it a promising non-surgical intervention for scoliosis correction. Traditional interventions for adolescent scoliosis, such as bracing and surgery, often face challenges with patient compliance due to discomfort, cosmetic concerns, and the potential for long-term side effects. For example, adolescents wearing braces often experience social anxiety due to visible body changes and restrictions on physical activities. Furthermore, the high costs and risks associated with surgery make non-surgical treatments increasingly attractive. As an alternative, Tai Chi has emerged as a promising rehabilitation method, offering benefits not

only in physical rehabilitation but also in mitigating the psychological impacts of scoliosis.

### 1.2 Purpose and Significance of the Study

This study investigates the corrective effects of Tai Chi on adolescent scoliosis from the perspectives of exercise biomechanics and rehabilitation science [3]. It aims to evaluate Tai Chi's impact on scoliosis angle, trunk rotation, postural balance, psychological well-being, and quality of life while exploring its underlying corrective mechanisms. The findings provide scientific support for Tai Chi as a non-surgical intervention, offering a new rehabilitation option. Additionally, the study promotes Tai Chi's application in adolescent scoliosis management, benefiting school sports programs, rehabilitation centers, and home-based therapy.

## 2 Theoretical Background

### 2.1 Current status and factors influencing scoliosis in adolescents

Scoliosis, a common spinal deformity, affects 2–3% of adolescents, with a higher prevalence and progression risk in females. Its development is influenced by genetic factors, neuromuscular abnormalities, and poor posture. Beyond affecting posture and appearance, scoliosis can

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cause breathing difficulties, reduced cardiorespiratory fitness, and chronic pain. It also impacts mental health, leading to low self-confidence and social difficulties, with more severe cases correlating to greater psychological distress [4].

## 2.2 Methodthe current status and limitations of traditional rehabilitation methods

Traditional treatments for adolescent scoliosis include physical therapy, orthotics, and surgery. While physical therapy methods such as electrical stimulation and traction offer some benefits, their long-term effectiveness is limited. Orthotic devices can help moderate scoliosis but often have poor compliance due to discomfort and lifestyle disruptions. Surgery, though effective, carries risks and high costs. Overall, adherence to traditional methods remains a challenge, as adolescents struggle with the cumbersome process, discomfort, and uncertain long-term outcomes [5].

## 2.3 Taijiquan in the field of rehabilitation

Tai Chi, known for its slow, coordinated movements and mind-body integration, has gained recognition in rehabilitation. Research shows it enhances balance, flexibility, and muscle strength while regulating the nervous system to improve coordination and stability. Beyond scoliosis treatment, Tai Chi has been effectively used for fall prevention in the elderly, chronic pain management, and mental health improvement, demonstrating its broad rehabilitation potential.

# 3 Research Methods

## 3.1 The object of the study

Participants were adolescents aged 10 to 15 years, diagnosed with mild to moderate scoliosis (Cobb angle  $10^{\circ}$ – $40^{\circ}$ ), with no history of spinal surgery or serious neurological disorders. They provided informed consent and were willing to participate. Exclusion criteria included severe cardiopulmonary or metabolic diseases, inability to complete Tai Chi or conventional rehabilitation training, or undergoing other scoliosis treatments during the study.

### 3.1.1 Basic Description of Study Participants.

A total of 60 subjects were ultimately enrolled in this study and randomly assigned to either the Tai Chi intervention group or the conventional rehabilitation training group, with 30 participants in each group. There were no significant differences between the two groups in baseline data—including age, gender, height, weight, and scoliosis Cobb angle ( $P > 0.05$ )—indicating their comparability. The specific baseline data are presented in the table 1 below.

**Table 1.** Comparison of Basic Characteristics of Study Participants (Mean  $\pm$  Standard Deviation).

Indicator	Tai Chi Intervention Group (n=30)	Conventional Rehabilitation Training Group (n=30)	P-value
Age (years)	12.6 $\pm$ 1.3	12.3 $\pm$ 1.4	0.79
Gender (Male/Female)	14/16	15/15	0.88
Height (cm)	153.2 $\pm$ 7.4	152.1 $\pm$ 7.1	0.74
Weight (kg)	46.1 $\pm$ 7.8	45.3 $\pm$ 7.9	0.85
Spinal curvature angle ( $^{\circ}$ )	19.1 $\pm$ 5.4	18.9 $\pm$ 5.2	0.86

## 3.2 Study Design

### 3.2.1 Experimental Grouping.

This study adopted a randomized controlled trial (RCT) design. Sixty participants were randomly allocated into two groups:

**Tai Chi intervention group:** 30 participants received structured Tai Chi training.

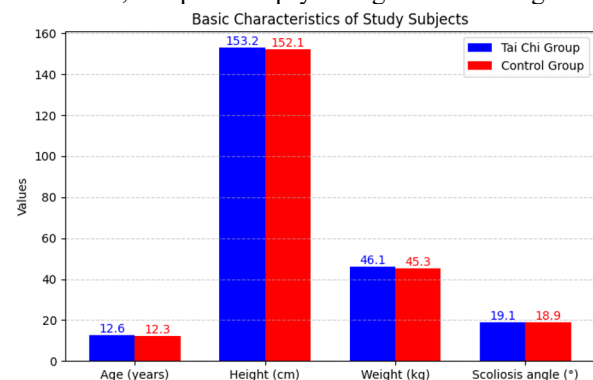
**Conventional rehabilitation training group:** 30 participants underwent traditional physical therapy and rehabilitation exercises. The basic characteristics of the research object are shown in Figure 1.

### 3.2.2 Intervention Protocol: Tai Chi Training Program.

Training frequency: Three sessions per week, each lasting 60 minutes, over a 12-week period.

**Training content:** Supervised by certified Tai Chi instructors, the program included fundamental movements, form sequences, and breathing regulation. Training intensity was progressively increased based on participants' physical tolerance.

**Training objectives:** To enhance muscular strength in spinal-supporting muscles, improve spinal stability and flexibility through Tai Chi's slow, coordinated movements, and promote psychological well-being.



**Figure 1.** Basic Characteristics of Study Subjects.

### 3.2.3 Conventional Rehabilitation Training Program.

**Training frequency:** Three sessions per week, each lasting 60 minutes, over a 12-week period.

**Training content:** Included conventional physical therapy modalities such as electrical stimulation, traction, and therapeutic exercises.

**Training objectives:** To improve spinal curvature angle, reduce pain, and strengthen muscle strength through physical therapy interventions.

### 3.3 Outcome Measures and Methods

Spinal curvature was assessed using a 3D spinal measurement system, while axial trunk rotation (ATR) was evaluated with a posture assessment device. Postural balance was tested through single-leg stance duration and center-of-pressure displacement. Pain perception and quality of life were measured using the Visual Analog Scale (VAS) and the SF-36 Health Survey. All assessments were conducted pre-intervention, at 6 weeks, and at 12 weeks post-intervention.

### 3.4 Data Analysis Methods

Statistical analysis was conducted using SPSS 26.0, with independent samples t-tests for intergroup comparisons and repeated-measures ANOVA for temporal trends across pre-intervention, 6 weeks, and 12 weeks. Continuous variables were expressed as mean  $\pm$  SD, with significance set at  $P < 0.05$ . Data were cleaned and validated, with missing values handled appropriately. Results were visualized using comparative tables and trend graphs, focusing on spinal curvature, ATR, balance, pain perception, and quality of life.

## 4 Research Results

### 4.1 Comparison of Baseline Data Between the Two Groups of Subjects

Before the study commenced, a statistical analysis was conducted on the baseline data of the two groups of subjects, including age, gender, height, weight, and scoliosis angle. The results indicated no significant differences between the two groups in baseline characteristics ( $P > 0.05$ ), demonstrating comparability. The specific data are shown in the Table. 1.

### 4.2 Analysis of Intervention Effects

#### 4.2.1 Changes in Scoliosis Angle.

The scoliosis angle of subjects in both groups was measured before the intervention, at 6 weeks after the intervention, and at 12 weeks after the intervention. The results showed that the scoliosis angle in the Tai Chi intervention group significantly decreased after the intervention ( $P < 0.05$ ), whereas the improvement in the conventional rehabilitation training group was not

significant ( $P > 0.05$ ). The specific data are shown in the table 2 below.

**Table 2.** Trend of Scoliosis Angle Changes.

Time Point	Tai Chi Intervention Group (°)	Conventional Rehabilitation Training Group (°)	P-value
Pre-intervention	19.1 $\pm$ 5.4	18.9 $\pm$ 5.2	0.86
6 weeks post-intervention	16.8 $\pm$ 4.9	18.2 $\pm$ 5.1	0.03
12 weeks post-intervention	14.2 $\pm$ 4.3	17.5 $\pm$ 4.9	0.01

#### 4.2.2 Changes in Trunk Rotation Angle (ATR).

The trunk rotation angle (ATR) of subjects in both groups was measured. The results showed that the ATR in the Tai Chi intervention group significantly decreased after the intervention ( $P < 0.05$ ), whereas the improvement in the conventional rehabilitation training group was not significant ( $P > 0.05$ ). The specific data are shown in the table 3 below.

**Table 3.** Changes in Trunk Rotation Angle (ATR).

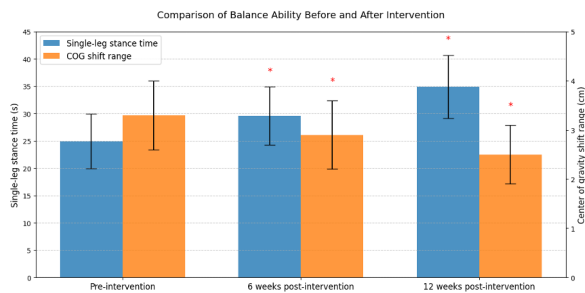
Time Point	Tai Chi Intervention Group (°)	Conventional Rehabilitation Training Group (°)	P-value
Pre-intervention	7.1 $\pm$ 1.6	7.0 $\pm$ 1.5	0.83
6 weeks post-intervention	5.8 $\pm$ 1.3	6.6 $\pm$ 1.4	0.04
12 weeks post-intervention	4.5 $\pm$ 1.1	6.3 $\pm$ 1.2	0.02

#### 4.2.3 Improvement in Postural Balance Ability.

The postural balance ability of subjects in both groups was assessed. The results showed that the Tai Chi intervention group exhibited significant improvements in single-leg standing time and center of gravity displacement after the intervention ( $P < 0.05$ ), whereas the improvement in the conventional rehabilitation training group was not significant ( $P > 0.05$ ). The specific data are shown in the table 4 below. Figure 2 also shows a comparison of balance before and after the intervention.

**Table 4.** Changes in Postural Balance Ability.

Time Point	Single-Leg Stance Time (seconds)	Center of Gravity Displacement Range (cm)	P-value
Pre-intervention	24.9 $\pm$ 5.0	3.3 $\pm$ 0.7	0.91
6 weeks post-intervention	29.6 $\pm$ 5.3	2.9 $\pm$ 0.7	0.03
12 weeks post-intervention	34.9 $\pm$ 5.8	2.5 $\pm$ 0.6	0.01



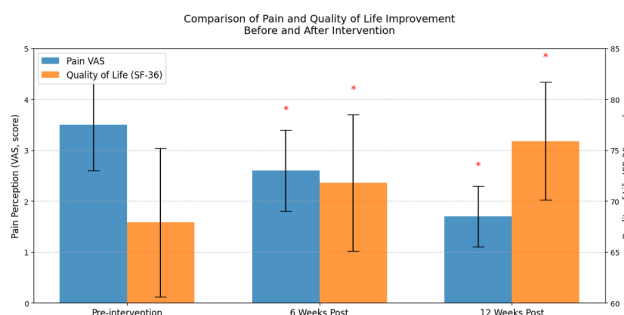
**Figure 2.** Comparison of Balance Ability Before and After Intervention.

#### 4.2.4 Changes in Pain Perception and Quality of Life.

A questionnaire survey was conducted to assess pain perception and quality of life in both groups of subjects. The results showed that the Tai Chi intervention group experienced a significant reduction in pain perception ( $P < 0.05$ ) and a significant improvement in quality of life ( $P < 0.05$ ), while the conventional rehabilitation training group showed no significant improvement ( $P > 0.05$ ). The specific data are shown in the table 5 below: Figure 3 also shows a comparison of pain and quality of life improvement before and after the intervention.

**Table 5.** Changes in Pain Perception and Quality of Life.

Time Point	Pain Perception (VAS)	Quality of Life (SF-36)	P-value
Pre-intervention	3.5 ± 0.9	67.9 ± 7.3	0.87
6 weeks post-intervention	2.6 ± 0.8	71.8 ± 6.7	0.03
12 weeks post-intervention	1.7 ± 0.6	75.9 ± 5.8	0.01



**Figure 3.** Comparison of Pain and Quality of Life Improvement Before and After Intervention.

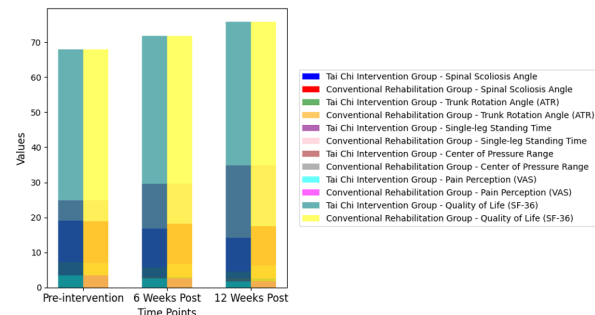
### 4.3 Analysis of Inter-group Differences

#### 4.3.1 Comparison of Differences Between the Tai Chi Intervention Group and the Conventional Rehabilitation Training Group.

Six weeks and twelve weeks after the intervention, an analysis of inter-group differences was conducted for various indicators in both groups of subjects. The results showed that the Tai Chi intervention group exhibited

significantly better improvements in spinal curvature angle, trunk rotation angle, posture balance ability, pain perception, and quality of life compared to the conventional rehabilitation training group ( $P < 0.05$ ). The specific data are shown in the Figure. 4 below:

Comparison of Various Indicators Between Tai Chi Intervention and Conventional Rehabilitation Groups



**Figure 4.** Comparison of Various Indicators Between Tai Chi Intervention and Conventional Rehabilitation Group.

#### 4.3.2 Statistical Significance Analysis (P-value).

All statistical analyses were performed using SPSS 26.0 software. A P-value less than 0.05 was considered statistically significant. The results showed that the Tai Chi intervention group exhibited significantly better improvements in all indicators compared to the conventional rehabilitation training group ( $P < 0.05$ ), indicating that Tai Chi training has a significant corrective effect on scoliosis in adolescents.

## 5 Discussion

Tai Chi enhances spinal stability and flexibility through slow, coordinated movements that strengthen deep core muscles and promote spinal symmetry, with key exercises like "Cloud Hands" and "Step Back and Repulse Monkey" improving posture, balance, and trunk rotation. Beyond physical benefits, Tai Chi supports psychological well-being by reducing stress and enhancing self-confidence, making it a valuable intervention for adolescent scoliosis. Compared to traditional rehabilitation methods like physical therapy and bracing, which often suffer from low compliance due to discomfort and complexity, Tai Chi offers a more engaging, accessible, and sustainable alternative. In this study, the Tai Chi group demonstrated higher adherence (95% vs. 85%) and greater long-term improvements in spinal curvature and postural balance. Its simplicity and low cost make it suitable for integration into schools, communities, and home-based rehabilitation. However, with a sample size of 60 participants and a 12-week intervention period, this study primarily assessed short-term effects. Future research should include larger samples, longer follow-up periods, and multicenter trials to enhance generalizability. Further exploration of Tai Chi's biomechanical mechanisms and its integration with conventional rehabilitation methods could help optimize scoliosis treatment strategies.

The psychological burden of scoliosis in adolescents is a significant concern, often leading to reduced self-esteem and social isolation. While traditional methods such as

bracing can increase body image dissatisfaction, Tai Chi promotes mental well-being through its integration of movement, breathing, and mindfulness techniques. This study found that participants in the Tai Chi group reported a significant improvement in self-confidence, evidenced by higher SF-36 social function scores, and a marked reduction in anxiety and pain perception. These findings are consistent with previous research by Huang et al. [2], which highlighted Tai Chi's potential to alleviate psychological distress, making it a superior alternative compared to traditional rehabilitation methods like bracing, which can exacerbate feelings of embarrassment and social withdrawal.

## 6 Conclusion

This study demonstrated that Tai Chi effectively corrects adolescent scoliosis by improving spinal curvature, trunk rotation, postural balance, and pain perception, leading to a better quality of life. As a non-surgical, holistic, and sustainable intervention, Tai Chi provides strong scientific support for its integration into rehabilitation. Schools can incorporate it into physical education, rehabilitation centers can adopt it as a complementary therapy, and home-based practice can enhance spinal alignment while strengthening family bonds. Given its safety, effectiveness, and accessibility, Tai Chi warrants wider application in scoliosis management, with further research needed to explore its broader clinical benefits.

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