The Effects of Tai Chi on Adolescent Idiopathic Scoliosis

Yuli Wang *

Department of Nursing, Clinical Medical College of Tianjin Medical University, Tianjin, 300270, China

* Corresponding Author Email: liziemily2006@outlook.com

Abstract. Adolescent idiopathic scoliosis (AIS) is a three-dimensional spinal structural disorder of unknown etiology. Besides the visible deformity, it is often accompanied by functional abnormalities such as movement pattern disorders, gait control impairment, and neuromuscular dysfunction, all of which jointly affect overall health and quality of life. Exercise therapy remains an important component of conservative treatment for AIS. Tai Chi, as a traditional mind-body exercise, has increasingly attracted attention as an adjunctive intervention for AIS. Existing evidence suggests that Tai Chi can reduce coronal curvature, enhance lumbar spine mobility, improve spinal stability, strengthen dynamic balance, and contribute to the maintenance of mental health. Its multi-dimensional effects seem to stem from the integration of slow and rhythmic movements, controlled breathing, and posture adjustments that align with spinal biomechanics. Despite encouraging research results, current studies still have limitations in terms of sample size, duration, and methodological consistency, which limit the persuasiveness of the existing evidence. This review aims to synthesize current knowledge on the application of Tai Chi in AIS and provide a basis for its integration into rehabilitation strategies.

Keywords: Tai Chi, adolescent idiopathic scoliosis, exercise therapy, rehabilitation.

1. Introduction

Adolescent idiopathic scoliosis (AIS) is the most common structural spinal deformity, defined as a Cobb angle of at least 10° on X-ray [1]. AIS accounts for over 80% of spinal curvature cases, and its incidence rate in Asia ranges from 2.0% to 2.5% [2]. From a psychological perspective, this condition leads to abnormal posture, which can cause self-esteem issues; from a physiological perspective, it impairs the heart and lung functions. Severe cases may result in multiple organ failure and paralysis. Therefore, once diagnosed, immediate intervention and treatment are crucial. However, current medical technologies have not found a completely curative method for AIS. The existing treatment strategies mainly rely on braces or surgical correction, both of which can slow down the progression of scoliosis, but they have obvious limitations. Braces often impose a heavy psychological and physical burden on teenagers, while surgical intervention can effectively prevent severe deformities but is invasive and comes with long-term risks. These shortcomings have made exercise therapy, as a conservative alternative, increasingly gaining attention.

Unlike other clinical intervention methods, exercise therapy avoids expensive treatments and surgical risks, while maintaining physical mobility, making it an economical and safe treatment option. Among the numerous exercise-based strategies, Tai Chi has become a promising choice for the management of adolescent scoliosis. This traditional physical and mental exercise method is characterized by slow and conscious movements, rhythmic breathing, and precise posture control. These elements are believed to enhance spinal stability, improve proprioceptive function, and support neuromuscular balance. Besides the physical benefits, Tai Chi is also associated with psychological improvements, such as reducing stress, lowering anxiety, and improving self-image, which may be particularly important for teenagers dealing with scoliosis. However, existing studies are limited by small sample sizes, heterogeneous protocols, and inconsistent outcome measures, making it difficult to establish firm conclusions. This review aims to synthesize current knowledge on adolescent idiopathic scoliosis and to summarize the potential role of Tai Chi in its management, providing a theoretical basis for its application in rehabilitation and supporting the promotion of physical and mental well-being as well as holistic development in adolescents.

2. Epidemiological Characteristics of AIS

2.1. Distribution Patterns of AIS

Large-scale epidemiological studies reveal significant gender and age distribution differences in AIS, with women consistently showing higher prevalence rates. The male-to-female ratio among patients ranges from approximately 1:1.5 to 1:3 [3]. On the Cobb angle curve, boys exhibit significantly lower prevalence than girls, while the male-to-female ratio increases to 7.2:1 at Cobb angles greater than 40° [4]. Due to rapid spinal growth during childhood and adolescence, along with potential growth imbalances, the highest prevalence is observed in girls aged 10 to 12 years (5.57%), followed by girls aged 13 to 14 years (3.90%), boys aged 10 to 12 years (2.37%), and boys aged 13 to 14 years (1.42%) [5]. With increasing internet usage and growing academic pressure, more adolescents are adopting sedentary lifestyles, which may have contributed to a rise in AIS prevalence to 2 to 3% in the general population [6]. These findings highlight high-risk groups and underscore the potential impact of lifestyle factors on disease development.

2.2. Contributing Factors to AIS

While the pathogenesis of AIS remains unclear, current studies suggest that its development involves multiple interacting factors, including genetics, bone mass, and spinal biomechanics [7]. Studies report a higher concordance rate in monozygotic twins compared with dizygotic twins, indicating a potential genetic susceptibility [8]. A clinical trial examining spinal nodule tissue sections from AIS patients revealed that 67% of the patients had below-normal bone mass, and 76% showed an increased bone turnover rate [9]. Research further demonstrates that even AIS patients with normal bone density may exhibit abnormal bone mass, likely due to cortical misalignment [10]. Early biomechanical models suggest that excessive anterior spinal column growth relative to the posterior column leads to characteristic deformities resembling idiopathic scoliosis [11]. These findings collectively point to AIS arising from the interaction of genetic, metabolic, and biomechanical factors during specific developmental stages.

3. Advances in Exercise Therapy for AIS

In recent years, exercise therapy has emerged as a key intervention for mild adolescent idiopathic scoliosis. Through tailored training regimens, it enhances core muscle strength, corrects imbalances, and improves proprioception to slow spinal curvature progression. Compared to surgery, exercise interventions avoid risks of failure and postoperative complications. Unlike braces, exercise therapy reduces financial burdens and dependency while maintaining daily activity levels and overall health. Current approaches focus on functional rehabilitation training, with explorations of methods like Tai Chi and orthopedic exercises in recovery. However, it should be emphasized that exercise therapy is primarily suitable for patients with mild AIS (Cobb angle between 10 and 20 degrees). In cases of moderate to severe curvature (Cobb angle greater than 20 degrees), exercise alone is generally insufficient to control disease progression and should be complemented by timely brace treatment or surgical intervention. Improper self-practice without professional guidance may even exacerbate the condition.

4. Therapeutic Effects of Tai Chi in AIS

As a traditional mind-body exercise, Tai Chi is believed to enhance physical functions by coordinating breathing, posture, and consciousness, particularly benefiting spinal health. The practice involves consciously guiding breath through the brain to develop deep abdominal breathing, while performing upright, gentle, and natural movements that engage the entire body through spinal coordination. Multiple studies demonstrate Tai Chi's multifaceted benefits for AIS patients, including reducing coronal plane curvature of the spine, improving spinal mobility, enhancing trunk stability

and balance, as well as promoting physical and mental relaxation with emotional regulation. The following sections will elaborate on these evidence-based findings.

4.1. Reducing Coronal Plane Deviation

The coronal plane tilt angle of the spine serves as a crucial indicator for assessing scoliosis severity. Research indicates that Tai Chi training enhances spinal coronal symmetry and reduces lateral displacement in shoulders and lower back, thereby alleviating scoliosis symptoms to some extent [12]. This improvement may stem from Tai Chi's practice emphasis on spinal alignment and slow, stable movements, which promote balanced activation of spinal muscle groups and minimize mechanical asymmetry caused by coronal plane displacement. Mild AIS patients meeting diagnostic criteria were randomly assigned to an experimental group receiving six months of Tai Chi intervention versus a control group without specific therapeutic exercises. Full-spine X-rays before and after the intervention measured Cobb angles. Results demonstrated statistically significant reduction in the average Cobb angle of the experimental group compared to baseline levels, while no significant changes were observed in the control group. These findings suggest that long-term Tai Chi practice effectively improves Cobb angles in adolescents with mild idiopathic scoliosis and balances bilateral lumbar muscle strength. Additionally, a meta-analysis reveals that Tai Chi interventions can effectively slow Cobb angle progression in mild-to-moderate AIS patients, effectively preventing spinal deformity development [13].

4.2. Enhancing Spinal Mobility

Improving spinal flexibility and mobility is a primary goal in exercise therapy for scoliosis. Studies indicate that Tai Chi significantly increases cervical rotation, lumbar lateral bending, and thoracic expansion, outperforming standard rehabilitation approaches [14]. These improvements not only expand joint range of motion but also alleviate movement restriction, enhancing patients' confidence in daily activities. Specific techniques can promote smoother motion distribution along the spine, transforming excessive curvature into a more stable C-shaped alignment. The coordinated rotation and flexion patterns in Tai Chi effectively stimulate intervertebral joints, ligaments, and surrounding musculature, contributing to greater spinal mobility and functional balance.

4.3. Strengthening Stability and Balance

Tai Chi promotes spinal stability by regulating posture and breathing patterns, which in turn enhance intra-abdominal pressure and muscular coordination. This practice helps correct imbalances in core muscle groups such as the rectus abdominis, external oblique, and erector spinae, improving both endurance and strength of the trunk. Compared with normal gait, Tai Chi produces greater ankle mobility in the sagittal plane, which reinforces lower-limb strength and postural control. Kinematic analyses reveal that Tai Chi practitioners exhibit reduced variability in trunk rotation during gait cycles, reflecting improved dynamic balance and neuromuscular regulation [12].

4.4. Regulating Psychological Well-being

Beyond physical gains, Tai Chi integrates posture, breath regulation, and focused attention to modulate stress reactivity and mood in adolescents with AIS. The slow, coordinated movement patterns and paced breathing are hypothesized to rebalance autonomic tone, reduce somatic tension, and support self-image and perceived control during daily activities. Evidence from randomized trials in musculoskeletal populations reports significant reductions in stress and anxiety scores after Tai Chi training, with improvements on validated scales and effects reaching $p < 0.001$ in non-AIS cohorts [15]. Observational comparisons further suggest that active exercise is associated with better self-image and mental health than passive approaches such as bracing. Nevertheless, AIS specific psychological data remain limited, and heterogeneity in outcome instruments constrains synthesis.

5. Conclusion

Current research has demonstrated that Tai Chi exhibits multifaceted regulatory advantages in AIS treatment. Its practice can reduce the coronal plane inclination angle of the spine, enhance the lateral rotation flexibility of the lumbar vertebrae, improve the stability and dynamic balance ability of the spine, reduce the body weight transfer and displacement rate in unstable environments, and at the same time promote the gradual stabilization of the mind. These effects are closely associated with Tai Chi's multidimensional movement patterns that align with spinal biomechanical principles. However, existing studies on Tai Chi intervention for AIS remain limited. Most research focuses on morphological indicators and single-method analyses, lacking comprehensive evaluations of psychological factors, pain perception, and quality of life improvements in AIS patients. Additionally, the therapeutic efficacy of Tai Chi therapy depends on long-term adherence, yet current follow-up data are insufficient and sample sizes are relatively small, failing to provide high-level evidence supporting Tai Chi's effectiveness in correcting AIS. Future efforts should concentrate on establishing early intervention systems, conducting risk screening and intervention assessments for the general population, and promoting Tai Chi participation. Simultaneously, deeper analysis of AIS' pathophysiological mechanisms and functional impairments is crucial to design customized exercises, intensity levels, and workout volumes for different patient groups. Equally important is prioritizing mental health support through timely psychological counseling for AIS patients, which significantly facilitates recovery.

References

[1] Cheng J C, Castelein R M, Chu W C, et al. Adolescent idiopathic scoliosis. Nature Reviews Disease Primers, 2015, 1(1): 15030.

[2] Feng Yunkun, Liu Jiesheng, Lü Zhen, et al. Research progress on exercise rehabilitation therapy for adolescent idiopathic scoliosis. Chinese Journal of Spine and Spinal Cord, 2021, 31(11): 1039-1043.

[3] Khanshour A M, Wise C A, Machida M, et al. The genetic architecture of adolescent idiopathic scoliosis. Pathogenesis of Idiopathic Scoliosis, Springer Japan, 2018: 51-74.

[4] Jiang H, Yang Q, Liu Y, et al. Association between ladybird homeobox 1 gene polymorphisms and adolescent idiopathic scoliosis: A MOOSE-compliant meta-analysis. Medicine (Baltimore), 2019, 98(27): e16314.

[5] Suh S W, Modi H N, Yang J H, et al. Idiopathic scoliosis in Korean schoolchildren: A prospective screening study of over 1 million children. European Spine Journal, 2011, 20(7): 1087-1094.

[6] Hoelen T A, Evers S M A A, Arts J J, et al. The societal burden associated with adolescent idiopathic scoliosis: A cross-sectional burden-of-disease study. BMC Public Health, 2024, 24(1): 3065.

[7] Barton C B, Weinstein S L, Machida M, et al. Adolescent idiopathic scoliosis: Natural history. Pathogenesis of Idiopathic Scoliosis, Springer Japan, 2018: 27-50.

[8] Simony A, Carreon L Y, Hjmark K, et al. Concordance rates of adolescent idiopathic scoliosis in a Danish twin population. Spine (Phila Pa 1976), 2016, 41(19): 1503-1507.

[9] Tanabe H, Aota Y, Nakamura N, et al. A histomorphometric study of the cancellous spinal process bone in adolescent idiopathic scoliosis. European Spine Journal, 2017, 26(7): 1600-1609.

[10] Wang Z W, Lee W Y, Lam T P, et al. Defining the bone morphometry, micro-architecture and volumetric density profile in osteopenic vs non-osteopenic adolescent idiopathic scoliosis. European Spine Journal, 2017, 26(7): 1586-1594.

[11] Murray D W, Bulstrode C J. The development of adolescent idiopathic scoliosis. European Spine Journal, 1996, 5(4): 251-257.

[12] Jiang Xiangping. Effect of Tai Chi Eight Methods and Five Steps on Correction of Idiopathic Scoliosis in College Students. Hunan Normal University, 2021.

[13] Zhang Wei, Bu Shumin, Wang, et al. Meta-analysis of the efficacy of exercise intervention in adolescents with mild and moderate idiopathic scoliosis. China Journal of Evidence-Based Medicine, 2022, 22(8): 896-900.

[14] Qu Kun, Wang Bei, Liu Xiaoguang, et al. Effect of Tai Chi on spinal mobility and quality of life in ankylosing spondylitis patients. Hebei Traditional Chinese Medicine, 2025, 47(3): 401-404.

[15] Halla M, Maher C G, Lam P, et al. Tai Chi exercise for treatment of pain and disability in people with persistent low back pain: A randomized controlled trial. Arthritis Care & Research, 2011, 63(11): 1576-1583.