

Research Progress on Early Screening and Rehabilitation Intervention for Adolescent Idiopathic Scoliosis in Secondary Vocational Schools

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Abstract: Adolescent idiopathic scoliosis (AIS) is a three-dimensional spinal deformity that develops during the growth and development period. In addition to lateral curvature of the spine, patients may also present with vertebral rotation and altered sagittal alignment. Because early signs are inconspicuous, some students are not identified until accelerated growth and curve progression occur in adolescence; therefore, school screening and timely intervention are necessary. At present, school-based initial screening predominantly relies on postural observation, the Adams forward bend test, and measurement of the angle of trunk rotation (ATR); after abnormalities are detected, students are referred for professional assessment and, when necessary, imaging examination. Radiation-free techniques such as three-dimensional ultrasound and digital photogrammetry have also begun to be applied to screening and follow-up. Bracing and physiotherapeutic scoliosis-specific exercises (PSSE) are important means of conservative treatment. Secondary vocational school students are predominantly in late adolescence, and classroom learning and professional practical training involve distinctive postural and activity exposures. This article reviews research on AIS screening, related factors, and rehabilitation treatment and discusses the “screening-assessment-intervention-follow-up” management pathway in the context of secondary vocational schools, with the aim of providing a reference for school-based spinal health work.

Keywords: Adolescent idiopathic scoliosis; School screening; Angle of trunk rotation; Rehabilitation treatment; Secondary vocational school students

Online publication: October 23, 2026

1. Introduction

Adolescent idiopathic scoliosis (AIS) is a common structural spinal deformity in children and adolescents aged 10–18 years. Clinical diagnosis usually requires exclusion of scoliosis caused by congenital,

neuromuscular, and other definite etiologies, followed by standing full-spine X-ray examination, with a Cobb angle of $\geq 10^\circ$ typically used as the diagnostic criterion^[1,2]. AIS is a three-dimensional spinal deformity, including coronal plane curvature, vertebral rotation, and abnormal sagittal alignment^[3].

AIS has an insidious onset, and early stages are often accompanied by no obvious discomfort; in some patients, the curve progresses rapidly and worsens during the accelerated growth phase of adolescence. Prevalence rates reported by existing studies vary because of differences in region, age composition, and survey methods, with an overall prevalence of approximately 0.5–5%; as the severity of scoliosis increases, the proportion of female patients and the risk of further curve progression generally increase^[1,4]. The value of active screening during adolescence lies not only in detecting abnormalities, but also in enabling timely stratified management of curve magnitude, growth potential, and risk of progression.

Existing school screening data come mainly from general primary and secondary schools, and secondary vocational school students have received relatively limited attention. This group is predominantly aged 15–18 years, and both curriculum formats and practical training content vary by specialty, resulting in different exposures such as prolonged sitting, fixed postures, or repetitive operations. Designing screening, related-factor surveys, and follow-up management according to these characteristics is more consistent with the actual circumstances of secondary vocational schools than directly applying the protocols of general secondary schools.

2. Advances in school-based AIS screening

2.1. School-based AIS screening methods

School screening is an important approach for the early detection of AIS and is often conducted using postural observation, the Adams forward bend test, and ATR measurement. Postural observation principally evaluates surface features such as shoulder height, scapular position, waistline, and pelvic level; it is simple to perform and suitable for large-scale screening, but the results are readily influenced by examiner experience.

During the Adams forward bend test, the examiner observes the individual from behind while the trunk is flexed forward to identify asymmetric rib or lumbar prominence associated with axial trunk rotation. In clinical and school screening settings, a scoliometer may be used to quantify the angle of trunk rotation (ATR) and improve the objectivity of assessment^[5]. An ATR of approximately 5° is commonly used as a threshold for further evaluation or referral; however, the decision to obtain radiographs should be based on the screening protocol and subsequent clinical assessment^[5].

School screening identifies students with suspected abnormalities but does not establish a diagnosis of AIS. Students with abnormal screening findings should undergo further clinical assessment and, when indicated, standing whole-spine radiography^[1–2].

2.2. Advances in AIS screening technologies

Traditional X-ray examination is an important method for evaluating spinal structure and measuring the Cobb angle; however, because repeated examinations raise concerns regarding cumulative radiation exposure, radiation-free or low-radiation evaluation techniques are receiving increasing attention.

Three-dimensional ultrasound can evaluate spinal morphology without ionizing radiation. Studies have shown that its angle measurements have good reliability and good consistency with X-ray Cobb angles, indicating potential for application in AIS assessment and follow-up^[6,7]. Digital photogrammetry and posture analysis can obtain postural parameters of the shoulders, trunk, and pelvis from images of the body surface,

providing new technical means for radiation-free AIS screening and monitoring ^[8]. However, the screening accuracy, degree of standardization, equipment costs, and value for school-based application of these techniques have not yet been extensively validated, and further research is still needed.

2.3. Factors associated with AIS

The etiology of AIS has not been fully clarified; current research suggests that it is related to multiple factors including genetics, growth and development, spinal biomechanics, and neuromuscular regulation ^[1,4]. The rapid growth phase of adolescence is an important stage for curve progression, and familial clustering suggests that genetic factors may be involved in susceptibility to AIS ^[1].

For lifestyle factors such as physical activity, sedentary behavior, study posture, and electronic device use, there is currently insufficient evidence to demonstrate a clear causal relationship with the occurrence of AIS. Therefore, prolonged looking down, sedentary behavior, or insufficient exercise should not simply be defined as direct causes of AIS. In surveys of secondary vocational school students, physical activity level, sedentary time, study and practical training postures, electronic device use, and spinal health awareness can be analyzed as exploratory related factors, and attention should be paid to distinguishing statistical correlation from causal relationships when interpreting the results.

2.4. Current status of AIS screening research in secondary vocational schools

Epidemiological and intervention studies of AIS in secondary vocational school students remain relatively limited. Learning and practical training patterns in different specialties may have different postural exposure characteristics; for example, computer-related specialties may involve prolonged seated learning, while some operation-oriented specialties may require maintaining fixed or repetitive working postures. Although the above factors cannot directly explain the occurrence of AIS, they can constitute important subjects for research on school-based postural health management and rehabilitation adherence.

Current research on AIS in secondary vocational schools primarily has the following shortcomings: first, there is a lack of epidemiological data from large samples; second, surveys of related factors are not yet systematic, with insufficient attention to specialty-specific learning characteristics, physical activity, and spinal health awareness; third, the system for re-screening, referral, rehabilitation, and long-term follow-up after abnormal screening results is not yet well established. Therefore, continuous spinal health management research tailored to the characteristics of secondary vocational students is needed.

3. Advances in the rehabilitation management of AIS

3.1. Bracing

Bracing is an important component of conservative management for AIS. Its primary objective is to prevent or limit curve progression and reduce the likelihood of progression to a surgical threshold. Some patients with mild-to-moderate curves and remaining growth potential may achieve a degree of deformity correction during appropriately prescribed treatment; however, bracing should not be interpreted as completely eliminating an established structural spinal deformity ^[2,9].

A randomized controlled study by Weinstein et al. demonstrated that, among patients with AIS at risk of progression, bracing significantly reduced the likelihood of progression to the surgical threshold. A dose-response relationship was also observed between brace-wear duration and treatment success, providing important evidence for bracing ^[10].

Bracing protocols should be individualized according to the Cobb angle, age, remaining growth potential, skeletal maturity, risk of curve progression, and patient adherence. Because indications vary to some extent across guidelines and expert consensus statements, treatment decisions require specialist assessment of the individual patient ^[2,9]. Bracing must not be prescribed solely on the basis of screening measures such as ATR.

3.2. Physiotherapeutic scoliosis-specific exercises

Physiotherapeutic scoliosis-specific exercises (PSSE) differ from ordinary physical fitness training in that they emphasize individualized training protocols formulated according to curve type and three-dimensional deformity characteristics, principally including three-dimensional self-correction, breathing training, postural control, and postural adjustments in daily activities. The International Society on Scoliosis Orthopedic and Rehabilitation Treatment (SOSORT) regards PSSE as an important component of conservative treatment for AIS ^[9].

Common PSSE systems include Schroth, the Scientific Exercise Approach to Scoliosis (SEAS), and Lyon, among which the Schroth method emphasizes three-dimensional self-correction, postural control, and specific breathing training. A randomized controlled study by Schreiber et al. showed that adding 6 months of Schroth training to standard care led to better Cobb angle outcomes than standard care alone ^[11]. Studies by Kuru et al. also showed that supervised three-dimensional Schroth training can improve clinical indicators such as the Cobb angle and trunk rotation in AIS patients ^[12].

An overview of systematic reviews and meta-analyses suggests that PSSE or exercise therapy may improve selected outcomes in patients with AIS, including the Cobb angle, ATR, and quality of life. However, substantial heterogeneity and limitations in the quality of evidence remain, and the long-term effects on curve correction require confirmation in further high-quality studies ^[13,14].

3.3. Adjunctive rehabilitation and outcome assessment

In addition to PSSE, core stabilization, balance, flexibility, and general conditioning exercises may be incorporated as adjuncts to AIS rehabilitation. However, nonspecific exercise should not be equated with PSSE tailored to three-dimensional curve patterns. Existing evidence provides some support for PSSE in improving selected clinical outcomes, whereas evidence that nonspecific exercise alone can control or reverse structural curve progression remains limited ^[9,14,15].

Evaluation of AIS rehabilitation should encompass radiographic, postural, functional, and quality-of-life outcomes. Radiographic outcomes primarily include the Cobb angle and changes in spinal morphology; school-based follow-up may prioritize ATR, trunk symmetry, postural control, physical function, and exercise adherence. Quality of life may be assessed using instruments such as the Scoliosis Research Society-22 (SRS-22) questionnaire. For students with mild AIS, school follow-up should emphasize noninvasive, repeatable postural and functional measures, whereas repeat radiography should be determined by healthcare professionals according to clinical need to avoid unnecessary radiation exposure.

4. A Screening–assessment–intervention–follow-up model for AIS management in secondary vocational schools

Given the characteristics of secondary vocational students, a continuous management model of “screening-

assessment-intervention-follow-up” can be established.

In the screening stage, uniformly trained personnel collect basic information, conduct postural observation, the Adams forward bend test, and ATR measurement, and use questionnaires to obtain information on physical activity, sedentary time, study and practical training postures, electronic device use, and spinal health awareness.

In the assessment stage, students with abnormal screening results undergo professional re-screening and, when necessary, are referred to medical institutions for imaging examination; stratified assessment is then conducted based on the Cobb angle, growth potential, skeletal maturity, and risk of progression ^[2,9].

In the intervention stage, individualized management should be implemented according to the results of professional assessment. For students with mild AIS suitable for conservative rehabilitation, training centered on PSSE can be carried out under the guidance of professionals, combined with core stability, breathing training, and postural education. Campus implementation can be made more targeted according to specialty characteristics: for specialties involving prolonged seated learning, emphasis should be placed on seat posture adjustment, active position changes, and guidance for break-time activities; for practical training specialties requiring fixed postures or repetitive operations for long periods, emphasis should be placed on work posture adjustment, trunk control, and regular activity guidance. The above measures are primarily intended to improve postural health management and rehabilitation adherence and should not be described as treatment targeting the etiology of AIS.

In the follow-up stage, spinal health records are established for students to dynamically document ATR, postural and functional changes, training adherence, and quality of life. Students with marked changes in screening indicators or those meeting the indications for further medical evaluation should be referred in a timely manner; through coordination among schools, families, and medical institutions, the efficiency of continuous AIS management can be improved.

5. Conclusions and future directions

School screening facilitates the early detection and risk-stratified management of AIS. Postural observation, the Adams forward bend test, and ATR measurement remain important school-based screening methods. Non-radiographic assessment modalities, including three-dimensional ultrasound and digital photogrammetry, may reduce radiation exposure and facilitate follow-up; however, their large-scale application requires further validation. Bracing and PSSE are important components of conservative AIS management, but intervention protocols should be individualized according to curve magnitude, remaining growth potential, and risk of progression. An ATR of approximately 5° indicates the need for further evaluation rather than confirming AIS or determining treatment; diagnosis requires appropriate clinical assessment and, when indicated, standing whole-spine radiography.

Specialized research on secondary vocational students is still relatively scarce. In the future, large-sample epidemiological surveys of AIS in secondary vocational schools should be conducted. While avoiding the simplistic interpretation of lifestyle factors as direct causes, further analysis should be made of postural exposure, physical activity, and rehabilitation adherence under different specialty learning and practical training environments. At the same time, the feasibility of technologies such as digital postural analysis and three-dimensional ultrasound in campus screening and follow-up can be explored, digital spinal health records can be established, and the mechanism of re-screening, referral, rehabilitation, and follow-up coordinated among schools, families, and medical institutions can be improved, so as to establish a spinal health management pathway tailored to the characteristics of secondary vocational students.

Disclosure statement

The authors declare no conflict of interest.

References

- [1] Cheng J, Castelein R, Chu W, et al., 2015, Adolescent Idiopathic Scoliosis. *Nature Reviews Disease Primers*, 1: 15030.
- [2] Bai Y, Chen K, Shao J, et al., 2025, Consensus on Diagnosis and Treatment of Adolescent Idiopathic Scoliosis. *Academic Journal of Naval Medical University*, 46(3): 291–300.
- [3] Labrom F, Izatt M, Claus A, et al., 2021, Adolescent Idiopathic Scoliosis 3D Vertebral Morphology, Progression and Nomenclature: A Current Concepts Review. *European Spine Journal*, 30(7): 1823–1834.
- [4] Konieczny M, Senyurt H, Krauspe R, 2013, Epidemiology of Adolescent Idiopathic Scoliosis. *Journal of Children's Orthopaedics*, 7(1): 3–9.
- [5] Bunnell W, 1984, An Objective Criterion for Scoliosis Screening. *Journal of Bone and Joint Surgery American Volume*, 66(9): 1381–1387.
- [6] de Reuver S, Brink R, Lee T, et al., 2021, Cross-Validation of Ultrasound Imaging in Adolescent Idiopathic Scoliosis. *European Spine Journal*, 30(3): 628–633.
- [7] Lee T, Lai K, Cheng J, et al., 2021, 3D Ultrasound Imaging Provides Reliable Angle Measurement with Validity Comparable to X-Ray in Patients with Adolescent Idiopathic Scoliosis. *Journal of Orthopaedic Translation*, 29: 51–59.
- [8] Zheng Q, Xie L, Xu J, et al., 2023, A Feasibility Study of Applying Two-Dimensional Photogrammetry for Screening and Monitoring of Patients with Adolescent Idiopathic Scoliosis in Clinical Practice. *Scientific Reports*, 13(1): 14273.
- [9] Fan Y, Ren Q, To M, et al., 2020, Effectiveness of Scoliosis-Specific Exercises for Alleviating Adolescent Idiopathic Scoliosis: A Systematic Review. *BMC Musculoskeletal Disorders*, 21: 495.
- [10] Negrini S, Donzelli S, Aulisa A, et al., 2018, 2016 SOSORT Guidelines: Orthopaedic and Rehabilitation Treatment of Idiopathic Scoliosis During Growth. *Scoliosis and Spinal Disorders*, 13: 3.
- [11] Weinstein S, Dolan L, Wright J, et al., 2013, Effects of Bracing in Adolescents with Idiopathic Scoliosis. *New England Journal of Medicine*, 369(16): 1512–1521.
- [12] Schreiber S, Parent E, Khodayari Moez E, et al., 2016, Schroth Physiotherapeutic Scoliosis-Specific Exercises Added to the Standard of Care Lead to Better Cobb Angle Outcomes in Adolescents with Idiopathic Scoliosis: An Assessor- and Statistician-Blinded Randomized Controlled Trial. *PLoS One*, 11(12): e0168746.
- [13] Kuru T, Yeldan I, Dereli E, et al., 2016, The Efficacy of Three-Dimensional Schroth Exercises in Adolescent Idiopathic Scoliosis: A Randomized Controlled Clinical Trial. *Clinical Rehabilitation*, 30(2): 181–190.
- [14] Zhou Z, Liu F, Li R, et al., 2021, The Effects of Exercise Therapy on Adolescent Idiopathic Scoliosis: An Overview of Systematic Reviews and Meta-Analyses. *Complementary Therapies in Medicine*, 58: 102697.
- [15] Romano M, Minozzi S, Bettany-Saltikov J, et al., 2012, Exercises for Adolescent Idiopathic Scoliosis. *Cochrane Database of Systematic Reviews*, (8): CD007837.

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