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Conservative treatment of adolescent idiopathic scoliosis (AIS): A narrative review of current evidence and implications for clinical practice

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ABSTRACT:

Introduction and purpose: Adolescent idiopathic scoliosis (AIS) is characterized by lateral curvature, vertebral rotation, and disruption of physiological curvature of the spine with the Cobb angle ≥10°. AIS affects 1-3% of children aged 10-16 years, representing the most common form of idiopathic scoliosis. Diagnosis of AIS is by exclusion and can be suspected based on Adams forward bend test and scoliometer. Untreated AIS can lead to serious consequences, such as progression of the deformity, back pain, reduced respiratory and cardiovascular function. The aim of this review is to update overview of conservative treatment options.

Description of the state of knowledge: AIS treatment guidelines from the Scoliosis Research Society (SRS) and the Scientific Society on Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT) advocate for observation, bracing, or surgery depending on curve severity, with a focus on avoiding spinal fusion when possible. Additionally, SOSORT recommends scoliosis-specific physiotherapy exercises for smaller curves or as an adjunct to bracing. Conservative treatment aims to prevent curve progression, manage respiratory and spinal complications, and improve quality of life.

Conclusions: AIS can significantly impair the physical and psychosocial well-being of young patients, with potential long-term consequences extending into adulthood Individualized treatment plans and patient/parent education are crucial for optimal outcomes. Schroth exercises are superior to Core Stabilization (CS) exercises in reducing Cobb angle, trunk rotation and improving spinal mobility, cosmetic trunk deformities and quality of life. CS exercises are more effective in increasing peripheral muscle strength, reducing pain and correcting vertebral rotation.

INTRODUCTION

Adolescent idiopathic scoliosis (AIS) is defined as a three-dimensional structural spinal deformity, characterized by lateral curvature, vertebral rotation, and disruption of physiological curvature of the spine[1–3].

Diagnosis of AIS is by exclusion and can be suspected based on a clinical examination using the Adams forward bend test[2]. Upon assuming a forward-bent position resembling a dive, a patient with scoliosis exhibits a prominent spinal midline deviation, with one side of the back noticeably elevated compared to the other. Conversely, a patient without scoliosis maintains a straight back alignment in this posture[4]. A positive test result is indicative of scoliosis, but objective measurements using a scoliometer are essential[1,2]. Cut-off points of 5 degrees (sensitivity approximately 100%, specificity 47%) and 7 degrees (sensitivity 83%, specificity 86%) help determine when imaging is warranted[5–7].

Definitive diagnosis requires spinal posteroanterior radiographs to assess the Cobb angle (≥10°) and associated vertebral rotation[1,2].

AIS, classified under M41.1 in the International Classification of Diseases Revision 10 (ICD-10)[8], affects 1-3% of seemingly healthy children aged 10-16 years, representing the most common form of idiopathic scoliosis[1]. Of those diagnosed, approximately 10% require conservative management to control progression and prevent complications, while 0.1-0.3% necessitate surgical correction[2,9]. The two adjectives added to the word *scoliosis* indicate the separation of this disease entity from a larger group of diagnoses[2]. *Idiopathic*, because the cause of the disorder could not be determined, although AIS has a familial occurrence in approximately 30% of patients[10]. *Adolescent* refers to the late onset during the intense peri-pubertal growth phase (S2 and P2 in girls, T2 and P2 in boys on the Tanner scale)[2,11]. Menarche marks the passing of peak growth, gradually reducing the risk of progression. However, in adulthood, AIS can worsen due to progressive bony deformity and spinal collapse, especially when the Cobb angle exceeds 30°. Experts agree that a Cobb angle exceeding 50° will lead to significant health issues and reduced quality of life[2].

In most cases, idiopathic scoliosis manifests as a single spinal deformity, but further investigation may reveal other significant subclinical manifestations[2]. Untreated AIS can lead to serious consequences, such as progression of the deformity, back pain, reduced respiratory and cardiovascular function and, ultimately, reduced quality of life[12–14]. Long-term sequelae include postural defects, thoracic and shoulder girdle deformities, balance and gait disturbances, foot overload and neuromuscular dysfunction[15–17]. AIS also correlates with lower body mass index (BMI) and delayed onset of menarche[18,19]. A significant proportion of adolescent girls with AIS also have lower bone mineral density (BMD), with more than 30% having a Z-score of less than -1, suggesting an increased risk of osteoporosis[19–21].

AIM

The primary aim of this review is to provide clinicians with an updated overview of conservative treatment options for adolescent idiopathic scoliosis. By summarizing current evidence and identifying gaps in knowledge, this review aims to inform clinical decision-making and guide the development of effective, patient-centered treatment plans for AIS.

MATERIAL AND METHODS

Database such as Pubmed was used for the literature review with the keywords: scoliosis; OR postural defects AND exercise OR physical therapy. Twenty-five were considered for inclusion, with publication dates between 2016 and 2024 to ensure relevance to contemporary understanding and practice.

DESCRIPTION OF THE STATE OF KNOWLEDGE:

Early detection of adolescent idiopathic scoliosis is crucial, particularly in asymptomatic children and adolescents. During medical examinations, a comprehensive assessment of the patient's posture, including alignment of the head, neck, and pelvis, and symmetry of the shoulders, shoulder blades, legs, arms, hips, and other body parts, should be conducted[10].

Several clinical signs are associated with AIS. The most prominent is a rib hump, a posterior protrusion caused by spinal rotation.

Other signs include shoulder asymmetry, torso lean (lateral shift of the body, often observed in single-curve scoliosis), and hip asymmetry (apparent leg length discrepancy)[10].

The Society on Scoliosis Orthopedic and Rehabilitation Treatment (SOSORT) guidelines recommend screening for AIS in children aged 8-15 years by pediatricians and general practitioners using the Adams forward bend test and scoliometer. School-based screening programs are also recommended[2]. To reduce referrals for clinically insignificant curvatures and minimize radiation exposure, Leone et al. proposed to use a two-step procedure involving initial screening by a physician at school, followed by orthopedic evaluation in uncertain cases, is suggested[2,22].

The Scoliosis Research Society (SRS) recommends the following treatment options for idiopathic scoliosis: observation with x-rays for patients with a Cobb angle <25°, use of an bracing for curvatures of 25°-45° and planned surgery for angles >45°[23]. Surgical anastomosis that causes spinal stiffness should be avoided if possible[24,25]. In addition, the SOSORT guidelines recommend scoliosis-specific physiotherapeutic exercises (PSSE) for smaller curvatures and as an adjunct to orthoses[2]. The main goals of comprehensive conservative treatment of idiopathic scoliosis are:

- Stopping the progression of curvature during adolescence
- Prevention or treatment of respiratory dysfunction
- Prevention or treatment of spinal pain syndromes
- Improving aesthetics through postural correction[2,26]

DESCRIPTION OF PHYSIOTHERAPEUTIC METHODS:

- **Schroth method:**

Schroth therapy is a specific exercise program for scoliosis. It uses a combination of individually tailored postural, sensorimotor, and breathing exercises to comprehensively correct the three-dimensional spinal deformity[13,27,28]. The detailed therapeutic plan includes correction of abnormal posture using methods such as external sensory and deep sensory stimulation, mirror exercises, isometric exercises, and special rotational angular breathing (RAB) techniques[13,27–29]. The goal of these activities is to lengthen and strengthen asymmetrically developed muscles. A key component of the method is learning to self-correct posture. This involves actively straightening the spine in three dimensions, resulting in the reduction of deformities[13,27,28]. Through repetitive exercises, in which the physiotherapist's involvement gradually decreases, the patient gradually takes control of his own posture, which contributes to the long-term effects of the therapy[13,27,30].

According to Wang et al., Schroth therapy is often combined with techniques such as the use of a back brace to increase the effectiveness of the treatment[31]. As highlighted by Fan, active patient participation is critical to achieving results[25].

The main goals of Schroth therapy are to improve the quality of life of patients with AIS by correcting three-dimensional spinal deformity, reducing curvature, improving trunk symmetry, and restoring spinal and pelvic alignment [13,29], as well as improving respiratory function and reducing pain [14,15,29].

- **Core stabilization (CS) exercises:**

Core stabilisation (CS) exercises are designed to strengthen the deep trunk muscles that stabilise the spine and pelvis[13,32]. These include deep abdominal muscle activation[13,32], plank, side plank, and exercises with a gym ball/unstable ground. planks, side planks and gym ball/unstable floor exercises. They consist of three phases, the first of which involves training local muscle stability in static postures before increasing exercise intensity[13].

The primary goals of core stability (CS) exercises in AIS management are to improve spinal stability[13,33], improve muscle function, and increase muscle strength and endurance [13,32]. This is important in scoliosis, which refers to lateral curvature of the spine, where strong deep trunk muscles provide a firm support for the spine. As pointed out by Gür et al., strengthening the core muscles reduces the axial load on the spine, which also leads to pain relief. [33]. Ultimately, core stabilisation exercises aim to improve neuromuscular control, strength and endurance of the muscles around the spine, thereby affecting the patient's overall functionality [13].

Research provides evidence for the efficacy of CS in the treatment of AIS, primarily in improving respiratory muscle strength and appearance perception as measured by the Walter Reed Visual Assessment Scale (WRVAS), which is important for patient well-being and quality of life [32].

- **Other physiotherapeutic methods:**
  - Combined aerobic and resistance training: Improves respiratory function more than aerobic training alone [14].
  - Hippotherapy with Schroth exercises: Improves lung function and aerobic capacity[34].
  - Balance training with Schroth therapy: Significantly improves overall balance function in mild cases of AIS [35].
  - Pilates with hybrid telerehabilitation: Improves Cobb angle and respiratory muscle strength. Can potentially increase spinal flexibility and range of motion [36].
  - Manual therapy and kinesiotaping: Suggested as effective conservative treatments but need further research [15].
  - XTS (Xinmiao treatment system), a scoliosis treatment system consisting of two parts: daily corrective positions and intensive corrective exercises[37].

EFFECTIVENESS OF PHYSIOTHERAPY METHODS:

- **Effectiveness comparison:**

Schroth exercises are superior to Core Stabilization (CS) exercises in reducing Cobb angle, trunk rotation and improving spinal mobility, cosmetic trunk deformities and quality of life. However, CS exercises have been shown to be more effective in increasing peripheral muscle strength [13].

In moderate cases of AIS, CS exercises were superior to traditional exercises in reducing pain and correcting vertebral rotation [33]. For young patients, the XTS exercise protocol has proven to be very effective in preventing curvature progression [38]

- **Factors affecting effectiveness:**
    - Patient age (younger patients have better results in improving and stabilizing spinal curvature) [38]
    - Degree of curvature (Schroth exercises are more effective in correcting curvatures of mild degree)[13]
    - Type of curvature (lumbar curvatures may respond better to PSSE) [25]
    - Duration of therapy (longer duration may be more effective) [25]
    - Patient engagement (higher compliance with exercise in the major lumbar curvature group contributed to greater reduction in Cobb angle) [25.]

- **Effectiveness of conservative treatment (bracing + exercise):**

Conservative treatment of AIS, which combines the use of an orthosis with specialized exercises such as Schroth therapy, leads to better correction of the Cobb angle than the use of a bracing alone [15,39] .

Moreover, a significant improvement in balance in the anteroposterior and medial-lateral planes, as well as a reduction in soleus overload during gait, was observed in both short- and long-term use of the orthosis along with an exercise program [15].

- **Effects of exercise on biomechanical parameters:**

Exercise, especially central stabilization, can improve lower limb muscle strength, which can affect gait parameters [13]. Combining exercise with an orthopedic corset reduces foot loading and improves balance during gait [15]. In addition, it has been suggested that improved respiratory capacity through inspiratory muscle training can translate into better functional capacity during gait [40] (Table1).

Table 1. Comparison of the effects of conservative treatment methods for adolescent idiopathic scoliosis.

Reference	Treatment method	Effects
Kocaman H et al.[13]	Schroth exercises	Reduce Cobb angle, reduce trunk rotation, improve spinal mobility, improve cosmetic trunk deformities, improve quality of life
Yildirim S et al.[32]; Gür G, et al. [33]	Central stabilization exercises (CS)	Increase peripheral muscle strength, reduce pain, correct vertebral rotation, improve respiratory muscle strength, improve appearance perception
da Silveira GE et al.[15] ; Gao C et al.[39]	Orthopedic corset + exercises	Better correction of Cobb's angle than the corset alone, improvement of balance in the anteroposterior and medial-lateral planes, reduction of overloading of the hamstring muscle during gait

Xavier VB et al.[14]	Aerobic training + resistance training	Greater improvement in respiratory function and exercise capacity than aerobic training alone
Abdel Ghafar MA et al.[34]	Hippotherapy + Schroth exercises	Improve lung function and aerobic capacity
Shen X et al.[35]	Balance training + Schroth therapy	Improve overall balance function
Manzak Dursun AS et al. [36]	Pilates + hybrid telerehabilitation	Improve Cobb angle, respiratory muscle strength, spinal flexibility and range of motion

EVALUATING THE EFFECTIVENESS OF PHYSIOTHERAPY

- Monitoring the Cobb angle: The doctor should monitor the Cobb angle by ordering regular X-rays of the spine. By comparing Cobb angles from different time periods, it is possible to assess whether the spinal curvature is progressing, stabilizing or regressing. This is a key parameter in assessing the effectiveness of treatment[13,15]
- Postural assessment: The doctor can assess the patient's posture by observing the patient's posture, shoulder, shoulder blade and pelvic alignment. He or she may also note any asymmetries in the trunk. Postural assessment is an important part of monitoring the effects of physiotherapy, since improving posture is one of the goals of treatment [13,15]
- Patient interview: A regular interview with the patient, allows for an assessment of the patient's well-being, pain level, quality of life and any difficulties in performing daily activities. This provides information on the effectiveness of physiotherapy and its impact on the patient's functioning[13]. During the interview, the doctor may also ask about adherence to exercise recommendations and wearing an bracing, which can affect the effectiveness of treatment[31]
- Additional assessment methods (if available):
    - Measurement of trunk rotation using a scoliometer [13,41]
    - Examination of health-related quality of life using the SRS-22 questionnaire[13,31,41]
    - Assessment of respiratory muscle strength and endurance and functional capacity, such as with the 6-minute walk test[14,32,40]
    - Assessing the deep sensation of the spinal joints[41]

CONCLUSION:

Adolescent idiopathic scoliosis can significantly impair the physical and psychosocial well-being of young patients, with potential long-term consequences extending into adulthood. Early intervention is therefore crucial.

General practitioners play a pivotal role in identifying suspected AIS, referring patients to specialists (orthopedic surgeons, physiotherapists), and monitoring treatment progress, which forms the basis of appropriate therapeutic management. Understanding the timing of structural changes and the periods of greatest risk for progression is essential.

Equally important is recognizing the impact of medical interventions and conservative treatment on halting curve progression, with the goal of avoiding surgical intervention. Individualized treatment plans and patient/parent education are paramount. The effectiveness of AIS treatment hinges on active parental involvement, adherence to exercise recommendations, and compliance with bracing protocols.

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