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Analysis of Causes and Summary of Treatment Methods for Adolescent Scoliosis in China

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Abstract. Adolescent scoliosis is a common three-dimensional spinal deformity in children and adolescents. Its onset and progression may be influenced by genetics, age, gender, growth and development, and lifestyle. Early detection and standardized treatment are therefore important. The article is targeted at adolescent scoliosis in China and analyzes the major influencing factors with current treatment methods. Genetic factors, pubertal growth and development, and gender differences are strongly related to the onset and progression of scoliosis, and lifestyle factors may play a role, but evidence of such association is scarce. At the present time, mild to moderate scoliosis is treated with scoliosis-specific exercises and bracing, and surgical treatment is considered for severe cases or those at high risk to progress. Robot-assisted surgery and minimally invasive techniques are technological advancements over traditional surgical methods, making surgical treatment more efficient. By using this article as a reference for early screening, risk assessment, and standardized treatment for scoliosis in Chinese adolescents, future research should be focused on large-scale prospective studies and long-term follow-up to investigate lifestyle factors and also to incorporate artificial intelligence technologies into treatment and to develop technology-driven treatment.

Keywords: Adolescent Scoliosis, Surgery Treatment, Bone development

1. Introduction

Scoliosis is a three-dimensional spinal deformity characterized by lateral curvature and vertebral rotation (e.g. 10° or more). A Cobb angle of 10° is commonly used as a radiographic threshold for diagnosis. Scoliosis is generally classified as idiopathic or non-idiopathic by etiology. In the world, idiopathic scoliosis occurs in about 75% to 85% of cases and is most commonly seen in children and adolescents from 10 to 18 years of age [1]. In China, scoliosis is reported as a common disease in adolescents [1]. Because adolescence is a fast period of development, spinal curvature may develop during these years. Scoliosis can impact spine function and physical activities and daily life in many young adults, as well as the psychological state (e.g., anxiety or depression). Finding the causes and mechanisms of scoliosis and offering effective, standardized treatments are thus crucial to manage the progression of scoliosis and to manage spinal alignment and health of adolescents. Age, sex, genetic factors, lifestyle, exercise, and growth and development are among the factors most commonly considered. Treatment is generally based on conservative management and surgery.

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Conservative management is commonly assumed for mild to moderate curves, while surgery is more appropriate in more severe cases. Studies have shown that conservative treatment may improve scoliosis in some patients with mild to moderate curves but may fail to correct for severe cases. Surgery is also associated with nerve injury, malpositioned instruments, and wound infection, leading to 6% of patients needing a second operation [2], which is why timely assessment and proper treatment planning are important. Much of the existing literature studies adolescent scoliosis globally, and study populations and methods are not always comparable, which can lead to differences in findings. It is also needed to find research that brings together evidence on factors affecting Chinese adolescents. In this paper, we review the key factors contributing to scoliosis among adolescents in China and summarize the most well-known treatment interventions with the hope of facilitating discussion of prevention, screening, and standardized care.

2. Key factors influencing scoliosis

According to Chinese researchers, the incidence of scoliosis among Chinese adolescents is estimated to be about 2% to 8%, and idiopathic scoliosis is the most common form. 80% of scoliosis cases are considered idiopathic, and no single cause has been identified. Genes, age, sex, lifestyle, and physical activity are all known to be associated with scoliosis [3]. Genetic factors are also known to be involved in scoliosis. In addition, families with a family history of scoliosis may be at increased risk. In some studies, 14%-51% of adolescent patients had relatives with the condition [3]. There is no single genetic contribution to scoliosis, and it can develop through genetic susceptibility to the environment. There is also a prevalence on age. 3,972 studies and 1,149,330 participants were studied. The prevalence of scoliosis was found to be higher in adolescents aged 16-18 than in adolescents aged 10-15, suggesting that scoliosis is associated with adolescent growth and development [4]. Sex differences are also reported; girls have more scoliosis, and those with curves are more likely to develop it. Female adolescents are more commonly reported to be 8% of the population. These differences may be caused by skeletal development, hormonal changes, and rapid growth during puberty, but we have not yet established what is happening [3]. Lifestyle factors have also been discussed in relation to adolescent spinal health. Body mass index (BMI), excessive sitting time, poorly placed desk and chair heights, and lack of sleep, etc. In the years after the COVID-19 pandemic, some adolescents faced higher academic pressure and more sitting time, and less outdoor activity and exercise time. Reduced physical activity may affect trunk muscle strength and posture, but you should not take this as proof that lifestyle causes idiopathic scoliosis [4]. Study habits, activity levels, and daily routines are all modifiable aspects of health, and their correlation with scoliosis onset and development is an open question.

3. Main treatment methods for scoliosis

3.1. Conservative treatment

Conservative management is usually considered for selected patients with mild-to-moderate scoliosis, with a Cobb angle less than 40°. It can be non-surgical, with scoliosis-specific exercises and bracing, and should be done in the right way or not based on the curve severity, skeletal age, and progression risk. Physiotherapeutic scoliosis-specific exercises (PSSE) are the fundamental exercises that form the basis of conservative management. They are usually include three-dimensional self-correction, maintaining the corrected posture, patient education, and postural strategies that are used in daily life. A study of 128 adolescents with scoliosis at Peking Union

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Medical College Hospital compared PSSE and standard care for 6 months. The average change in spinal angle was 8.36 degrees in the PSSE group and 4.13 degrees in the standard therapy group. The PSSE group also showed an improvement in pelvic tilt [5]. PSSE could be beneficial, but one study should not be viewed as proof that PSSE is the most effective exercise-based method in all clinical settings. Bracing is another strategy that reduces curve progression. For those patients with curves below 40° who have not yet reached skeletal maturity, it is a good preventive measure [6]. The outcome of the process depends on how often the brace is worn, and stopping brace use is an important consideration. A study of 369 adolescents compared immediate brace discontinuation with gradual weaning after skeletal maturity. We found that curve magnitude had increased in both groups after 6 months of brace removal, with increases reported in 13.5% of the initial brace users and 15.3% of those who gradually decreased brace use, which was more pronounced in the latter group. Curvature also continued to increase after one year of brace removal [7]. Our results highlight the necessity for follow-up after bracing is done. The findings should be interpreted in the context of the study design and the patients involved and not as an indication that bracing itself is rarely successful.

3.2. Surgical treatment

Surgery can be pursued after the curve of an adolescent is about 45°-50°, depending on the situation [6]. Pedicle screws are commonly used to correct and stabilize the spine. Scoliosis changes the anatomy of the vertebrae, and screws can be difficult to place and might result in nerve or spinal-cord injury and other postoperative complications [2]. Robot-assisted methods can be used to place screws more accurately. In a meta-analysis with robotic systems, the accuracy rates were 92%–98% for placement, and the benefits of the surgical precision were discussed [2]. However, the overall impact of surgery, radiation exposure, complications, and recovery on operating time and clinical care does not necessarily improve in every case. For some patients with scoliosis, minimally invasive surgery may be a better option, in terms of smaller incisions and instrumentation to correct the spinal curve, and may be recommended for adolescents with moderate, flexible curves [8]. Compared to open surgery, the benefit is less tissue disruption and blood loss, but the technique is technically difficult and may involve longer exposure to radiation. In a study of 767 adolescents, minimally invasive surgery provided the same results as the conventional posterior surgery in terms of Cobb angle, lumbar curvature, and coronal balance. The blood loss was reduced with the minimally invasive approach (288.25 mL vs 517.19 mL), and transfusion volume was reduced by 77%, but the operative time was 88.80 minutes longer. The postoperative pain duration was also minimized, infection risk was lower, and cosmetic outcomes were better [8]. While there are some benefits for those patients with specific surgical conditions, the trade-offs and the right type of procedure have to be evaluated individually. More work is needed to explore how robots and artificial intelligence might play a role in scoliosis surgery.

4. Limitations of existing research

Because scoliosis may progress during periods of rapid growth, early screening, follow-up, and timely assessment are important. China has expanded school-based screening in recent years, and some regions have incorporated scoliosis checks into student health examinations [3]. The 2024 Chinese guideline on adolescent scoliosis screening sets out procedures for target populations, screening at home and in schools, referral, and diagnostic follow-up. It also emphasizes the need to raise awareness among parents, teachers, and students and to improve continuity of care after

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screening. An abnormal screening result should lead to an appropriate clinical assessment rather than being treated as a confirmed diagnosis. For adolescents diagnosed with scoliosis, management should take account of curve magnitude, skeletal maturity, and the risk of progression; options may include observation, exercise therapy, bracing, or surgery. Regular monitoring and adherence to professional advice are important. General measures such as physical activity and suitable study ergonomics may support overall health, but they should not be presented as proven ways to prevent idiopathic scoliosis [3].

Awareness and follow-up after screening remain important challenges. A Shanghai study reported that fewer than 58% of adolescents who screened positive for possible scoliosis during school health examinations proceeded to further diagnosis and treatment [3]. Follow-up may involve several steps, including specialist consultation, imaging, rehabilitation, and long-term monitoring. If patients do not complete these steps, opportunities for early assessment may be missed. The Chinese screening guideline notes that public awareness remains limited and identifies education for parents and teachers, together with home-based screening, as relevant ways to improve awareness and follow-up [3]. Screening methods also warrant further evaluation. Full-spine radiographs are widely used for diagnosis, but they involve exposure to ionizing radiation [3]. Research in Hong Kong has examined the use of the Angle of Trunk Rotation (ATR) and ultrasound to screen for curves below 20°; ultrasound may help reduce unnecessary radiographic exposure while maintaining diagnostic accuracy in the studied setting [9]. The extent to which such approaches can be adopted more widely in mainland China requires further assessment. Finally, the relationship between lifestyle and scoliosis remains uncertain. Although prolonged sitting, reduced outdoor activity, insufficient exercise, and poor posture are often discussed in relation to spinal health, a direct causal relationship with idiopathic scoliosis has not been established. A study described as being developed in Shanghai in 2026 proposes to examine outdoor activity, sedentary behavior, screen time, and sleep within a combined intervention framework; its effectiveness will need to be assessed once results are available [10]. Large prospective studies with long-term follow-up are needed to clarify these relationships.

5. Conclusion

This paper reviewed factors associated with adolescent scoliosis in China and summarized commonly used treatment approaches. The available evidence suggests that genetic susceptibility, age, sex, and growth and development are associated with scoliosis, while the role of lifestyle factors remains uncertain and the precise causes are not fully understood. Treatment options generally include conservative management and surgery. Scoliosis-specific exercises and bracing are used in selected patients with mild-to-moderate curves, whereas surgery may be considered for severe curves or those at high risk of progression. Robot-assisted and minimally invasive techniques may offer advantages in surgical precision or reducing blood loss for selected patients, but each approach also has limitations and should be evaluated in its clinical context. Several gaps remain, including limited evidence on the causal role of lifestyle factors and the need for longer follow-up in some studies. Future research should use large samples, prospective designs, and long-term follow-up to clarify modifiable risk factors and assess treatment outcomes. Improving screening coverage, follow-up, and the evaluation of radiation-free screening methods may also support earlier assessment and more consistent care for adolescents in China.

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