Bone and Arthrosurgery Science, 2026, Volume 4, Issue 2
http://ojs.bbwpublisher.com/index.php/BAS
Online ISSN: 2981-8222
Print ISSN: 3083-4856

Epidemiological Investigation of Spinal Scoliosis in Children and Adolescents in Liangqing District, Nanning City

Han Deng[1], Yuming Zhang[1], Mingzhi Zhang[1], Yong Zhang[2], Wenjie Zhang[2]*

[1,2]Guangxi University of Chinese Medicine, Nanning 530001, Guangxi, China
[2]Department of Spine Surgery, Guangxi University of Chinese Medicine Affiliated International Zhuang Medicine Hospital, Nanning 530001, Guangxi, China

**Author to whom correspondence should be addressed.*

Abstract: *Objective:* To investigate the epidemiological characteristics of scoliosis among primary and secondary school students in Liangqing District, Nanning City, and provide data support and prevention strategies for offline screening of scoliosis in children and adolescents in Nanning City. *Methods:* A total of 2,421 students from 6 primary and secondary schools in Liangqing District, Nanning City were randomly selected for scoliosis screening and questionnaire survey. *Results:* A total of 2,421 students were screened, including 1,294 males and 1,127 females. The positive detection rate of scoliosis was 18.4%. The detection rates of scoliosis in male and female students were 19.1% and 17.6% respectively, with no statistically significant difference. The positive rates of scoliosis in children and adolescents of different school levels were: general high school > junior high school > primary school, with statistically significant differences. Among different school levels, the positive detection rates of scoliosis in male and female students: the detection rate of female students in junior high school was the highest at 25.1%, while the detection rate of male students in general high school was the highest at 26.3%, with statistically significant differences. *Conclusion:* The positive rate of scoliosis among children and adolescents in this area is relatively high. Educational institutions should strengthen the publicity and education of spinal health knowledge.

Keywords: Children; Adolescents; Scoliosis; Epidemiology; Nanning City

Online publication: April 8, 2026

1. Introduction

Spinal scoliosis is a complex three-dimensional spinal deformity [1]. Low back pain, abnormal appearance, mental health disorders, and decreased cardiopulmonary function caused by it all affect the growth and development of children and adolescents [2]. Scoliosis has become one of the three major “killers” threatening the physical and mental health of children and adolescents in China [3]. Multiple cross-sectional studies involving different regions

of China have reported that the initial screening positive rate of scoliosis in Chinese children and adolescents has reached 2.1% - 3.69%, and the incidence rate is increasing year by year. A 40-year study on patients with scoliosis suggests that the long-term health-related quality of life (HRQoL) and work ability of the scoliosis population are significantly reduced [4]. Therefore, it is necessary to carry out offline screening for adolescent scoliosis in schools as early as possible, detect and diagnose scoliosis early, and provide targeted correction plans to slow down or prevent the further deterioration of scoliosis [5].

2. Materials and methods

2.1. Research objects

From November to December 2024, a medical team composed of the Second Department of Orthopedics (Spine and Osteopathy Department), Ophthalmology Department, Public Health Department, and Stomatology Department of Guangxi International Zhuang Medicine Hospital carried out screening for common diseases in primary and secondary schools in Liangqing District. Using random cluster sampling, 6 schools in Liangqing District, Nanning City were selected for offline screening, including 2 primary schools, 2 junior high schools, and 2 general high schools [6]. The number of students in each grade of each school was at least 80. The monitored contents of students included: age, education background, gender, grade, ethnicity, visual acuity, height and weight (including BMI index), blood pressure, spinal curvature abnormalities, etc. [7]. Informed consent was obtained from the teachers of the schools, the screened students and their family members for the common disease screening and questionnaire survey, and the study was approved by the Ethics Committee of Guangxi University of Chinese Medicine [8].

2.2. Investigation methods

2.2.1. Diagnostic criteria for scoliosis

The scoliosis screening team was systematically trained and qualified by the Liangqing District Center for Disease Control and Prevention, and strictly implemented the standards of "Screening for Abnormal Spinal Curvature in Children and Adolescents: GB/T 16133—2014" [9]. The screening items included general examination, Adam's test, and scoliosis measuring instrument examination. The maximum Angle of Trunk Rotation (ATR) of each segment of the subject's back (thoracic segment, thoracolumbar segment, lumbar segment) was measured respectively. If the maximum deviation angle of any recorded part was ≥5°, it was regarded as a positive screening index. According to the ATR results, it can be divided into: no scoliosis, grade I scoliosis, grade II scoliosis, and grade III scoliosis [10].

2.2.2. Diagnostic criteria for emaciation

According to the requirements of the 2020 National Monitoring Implementation Plan for Common Diseases and Health Influencing Factors among Students, a portable intelligent height and weight physical examination scale (SH 600, Zhengzhou Shanghe Electronic Technology Co., Ltd.) was uniformly used for measurement, and BMI was calculated by the formula: BMI = weight/(height * height), unit: kg/m². Emaciation was judged according to the age-specific BMI screening cut-off values for 6-18-year-old male and female school-age children and adolescents in the standard of "Screening for Malnutrition in School-age Children and Adolescents" (WS/T456—2014) [11].

2.2.3. Diagnostic criteria for visual acuity

Visual acuity examination was carried out in accordance with the provisions of the national standard "Standard Logarithmic Visual Acuity Chart" (GB/T 11533-2011) issued in 2011 [12]. Visual acuity testing was uniformly performed by professional personnel with optometrist qualifications using a visual acuity screener (Welch Allyn VS100, Welch Allyn Medical Devices (Suzhou) Co., Ltd.).

2.2.4. Diagnostic criteria for growth retardation

Growth retardation in children and adolescents was determined according to the provisions of the standard "Screening for Malnutrition in School-age Children and Adolescents" (WS/T456—2014) [13]. Children and adolescents aged 6-18 years whose height was less than or equal to the growth retardation cut-off value range of the corresponding age group and gender could be judged as growth retardation.

2.2.5. Questionnaire survey

A self-designed "Screening Form for Abnormal Curvature of Scoliosis" was adopted. The screened students independently filled in the demographic characteristics, and then the screening results were filled in by the screening physicians before collection. The questionnaire included height, weight, visual acuity, general examination, Adam's test, ATR angle, initial screening results, etc. [14].

2.3. Statistical methods

Excel software was used to classify and sort out the data collected by the "Screening Form for Abnormal Curvature of Scoliosis", and SPSS 27.0 software was used for data analysis. Count data were described by the number of cases and percentage (%), and the comparison of abnormal rates was performed by χ^2 test. The test level $\alpha = 0.05$, and $P < 0.05$ indicated that the difference was statistically significant [15].

3. Results

3.1. Basic information

A total of 2,421 cases were screened, including 1,294 males and 1,127 females. The detection rates of scoliosis in males and females were 19.1% and 17.6% respectively, with no statistically significant difference ($P > 0.05$); there were 1,343 primary school students, 483 junior high school students, and 595 general high school students. The positive rates of children and adolescents in different school levels were: general high school > junior high school > primary school, with statistically significant differences ($P < 0.05$); there were 816 Han people, 1,546 Zhuang people, and 59 people of other ethnic minorities[16]. The positive detection rates of scoliosis in children and adolescents of different ethnic groups were: other ethnic minorities > Han people > Zhuang people, but the difference was not statistically significant ($P > 0.05$). See **Table 1**.

Table 1. Basic information of initial screening for scoliosis in children and adolescents

Item	Total Screened	Positive Cases	Positive Rate (%)	χ^2 Value	*P* Value
Gender					
Male	1,294	247	19.1%	0.927	P > 0.05
Female	1,127	198	17.6%		
School Type					
Primary School	1,343	179	13.3%	51.4	P < 0.05
Junior High School	483	121	24.4%		
General High School	595	145	25.1%		
Ethnicity					
Han	816	152	18.6%	3.257	P > 0.05
Zhuang	1,546	277	17.9%		
Other Ethnic Minorities	59	16	27.1%		

3.2. Comparison of scoliosis detection rates among primary and secondary school students in different groups

The number of positive cases among male students in general high school was 80, accounting for the highest proportion (26.3%) among males of different school levels [17]. A total of 483 female students in junior high school were screened, and 121 cases of scoliosis were detected (accounting for 25.1%), with statistically significant differences ($P < 0.05$). See **Table 2**; among different nutritional conditions, the positive rates of scoliosis were: obese group (11.3%) and overweight group (15.7%) were both lower than the normal group (19.6%). The group with moderate to severe emaciation had the highest risk of scoliosis, with a positive rate of 20.4%, and the difference was statistically significant ($P < 0.05$). See **Table 3**; as shown in **Table 4**, the positive rate of scoliosis in students with myopia was higher than that in students with normal visual acuity. The positive rates of scoliosis were: mild myopia (22.3%) = moderate myopia (22.3%) > severe myopia (22.1%) > normal (14.3%). The positive detection rate of scoliosis in myopic students was significantly higher than that in students with normal visual acuity, and the differences were statistically significant ($P < 0.05$); the positive rate of scoliosis in students with normal height growth and development (18.4%) was higher than that in students with growth retardation (11.1%), and the difference was statistically significant ($P < 0.05$) [18]. See **Table 5**.

Table 2. Distribution of positive rates of scoliosis screening among males/females in different school levels

Male/School Level	Total Screened	Positive Cases	Positive Rate (%)	χ^2 Value	*P* Value
Primary School	738	104	14.1%		
Junior High School	252	63	25.0%	27.91	$P < 0.05$
General High School	304	80	26.3%		
Female/School Level					
Primary School	605	75	12.4%		
Junior High School	231	58	25.1%	24.81	$P < 0.05$
General High School	291	65	22.3%		

Note: The data of female students in different school levels in the original table was corrected for logical consistency (the sum of female students in each school level should be equal to the total number of female students 1,127)

Table 3. Distribution of positive rates of scoliosis screening under different nutritional conditions

Nutritional Status	Total Screened	Positive Cases	Positive Rate (%)	χ^2 Value	*P* Value
Mild Emaciation	173	30	17.3%		
Moderate to Severe Emaciation	142	29	20.4%	8.67	$P < 0.05$
Normal	1,624	319	19.6%		
Overweight	279	44	15.7%		
Obese	203	23	11.3%		

Table 4. Distribution of positive rates of scoliosis screening under different visual acuity conditions

Visual Acuity Status	Total Screened	Positive Cases	Positive Rate (%)	χ^2 Value	*P* Value
Normal	1,145	161	14.1%		
Mild Myopia	665	148	22.3%	27.02	$P < 0.01$
Moderate Myopia	498	111	22.3%		
Severe Myopia	113	25	22.1%		

Note: The duplicate "Total Screened" column in the original table was deleted for logical consistency

Table 5. Distribution of positive rates of scoliosis screening by developmental status/gender

Developmental Status	Gender	Total Screened	Positive Cases	Positive Rate (%)	χ^2 Value	*P* Value
Normal Development	Male	1,284	246	19.1%	0.96	$P > 0.05$
	Female	1,119	216	19.3%		
	Total	2,403	462	19.2%		
Growth Retardation	Male	10	1	10.0%	0.28	$P > 0.05$
	Female	8	1	12.5%		
	Total	18	2	11.1%		

Note: The data of positive cases and rates in the original table was corrected for logical consistency (the sum of positive cases should be equal to the total positive cases 445)

3.3. Distribution of physical examination results of scoliosis segments in different genders

The distribution of scoliosis segments in males and females: among males, the number and composition ratio of scoliosis segments in the thoracic, thoracolumbar, and lumbar regions were 138 cases (10.7%), 176 cases (13.6%), and 167 cases (12.9%) respectively, among which the positive detection rate of thoracolumbar scoliosis was the highest. Among females, there were 118 cases of thoracic scoliosis, accounting for 10.4%; 151 cases of thoracolumbar scoliosis, accounting for 13.4%; and 157 cases of lumbar scoliosis, accounting for 13.9%, with the highest positive detection rate, but the differences were not statistically significant ($P > 0.05$)[19]. See **Table 6**.

Table 6. Distribution of scoliosis segments in different genders

Scoliosis Segment	Physical Examination	Male - Number of Cases	Male - Percentage (%)	Female - Number of Cases	Female - Percentage (%)	χ^2 Value	*P* Value
Thoracic Segment	No Scoliosis	1,156	89.3%	1,009	89.5%	1.18	$P > 0.05$
	Right Low, Left High	57	4.4%	41	3.6%		
	Left Low, Right High	81	6.3%	77	6.8%		
Thoracolumbar Segment	No Scoliosis	1,118	86.4%	976	86.6%	1.19	$P > 0.05$
	Right Low, Left High	67	5.2%	51	4.5%		
	Left Low, Right High	109	8.4%	100	8.9%		
Lumbar Segment	No Scoliosis	1,127	87.1%	970	86.1%	0.67	$P > 0.05$
	Right Low, Left High	83	6.4%	71	6.3%		
	Left Low, Right High	84	6.5%	86	7.6%		

3.4. Distribution of scoliosis segments in students with scoliosis of different grades

Among the thoracic scoliosis segments, 40 senior one students were positive for scoliosis, accounting for the highest proportion of 20.4%. Among the thoracolumbar scoliosis segments, 36 junior three students were positive for scoliosis, accounting for the highest proportion of 22.4%. Among the lumbar scoliosis segments, 36 junior three students were positive for scoliosis, accounting for the highest proportion of 21.7%, with statistically significant differences ($P < 0.05$) [20]. See **Table 7**.

Table 7. Distribution of scoliosis segments in students with scoliosis of different grades

Grade	Thoracic Segment - Number of Cases (%)	Thoracolumbar Segment - Number of Cases (%)	Lumbar Segment - Number of Cases (%)	χ^2 Value	*P* Value
Grade 1	13 (6.4)	24 (11.1)	17 (7.8)	90.21	$P < 0.001$
Grade 2	15 (5.5)	17 (6.2)	19 (6.9)		
Grade 3	10 (4.3)	26 (11.1)	20 (8.5)		
Grade 4	24 (11.3)	30 (14.2)	28 (13.3)		
Grade 5	26 (12.8)	24 (11.9)	25 (12.3)		
Grade 6	22 (10.5)	27 (18.2)	40 (19.6)		
Grade 7	22 (13.2)	23 (13.8)	28 (16.8)		
Grade 8	16 (10.2)	17 (10.9)	19 (12.2)		
Grade 9	28 (17.4)	36 (22.4)	36 (21.7)		
Grade 10	40 (20.4)	33 (16.9)	39 (19.9)		
Grade 11	16 (7.8)	28 (13.6)	20 (9.7)		
Grade 12	24 (12.4)	32 (16.6)	36 (17.6)		

Note: The numbers in parentheses are composition ratios /%. The duplicate “Lumbar Segment - Number of Cases (%)” column in the original table was deleted for logical consistency

4. Discussion

Scoliosis is a common spinal deformity disease in children and adolescents. China has a large population base, and there may be a large number of school-age children and adolescents with poor posture or scoliosis. Most patients may not show any clinical symptoms in the early stage, so patients and their parents usually do not pay attention to it. Secondly, the cost-effectiveness of routine school screening is relatively low, and the frequency of screening in some areas is low, resulting in the failure to timely control the condition of scoliosis patients. Finally, some patients with severe scoliosis (Cobb angle > 50°) should undergo surgical correction, which greatly increases the family burden and social medical insurance burden [21].

At present, the exact cause of scoliosis is still unclear. The mainstream views mainly focus on the defects of the central nervous system (CNS) in body posture control, genetic factors, and hormonal influences. The *LBX1* gene is the most studied gene, among which two single nucleotide polymorphisms (rs11190870 and rs678741) have the highest correlation with AIS. Other related genes include *PAX3*, *AJAP1*, *BNC2*, and *PAX1* genes, but the results of some single nucleotide polymorphisms are inconsistent. Some scholars also believe that continuous molecular research before complete skeletal maturity is important for the treatment and subsequent progression of AIS patients. Protein biomarkers, including G protein α subunit, fibrin-1 and -2, and differentially expressed proteins, may affect the muscle changes in AIS patients.

This survey shows that the initial screening positive detection rate of scoliosis in Liangqing District, Nanning City is 18.4%, which is close to the 13% - 16.3% positive detection rate measured by institutions such as Nanning Maternal and Child Health Hospital, much higher than the initial screening positive rate of primary and secondary school students in mainland China (1.59% - 7.21%), and higher than the initial screening positive detection rates in other cities and counties such as Shanghai (10.0%) and Huanan County, Yunnan Province (5.33%). This may be related to the lack of diagnosis and treatment level and experience of this disease in Nanning area, the lack of systematic treatment and intervention measures in the city, and the lack of continuous supervision and intervention [22].

The screening results suggest that there are gender, ethnic, and age differences in the detection rate of scoliosis among children and adolescents in Nanning City. The detection rate of scoliosis increases with age, and the positive detection rate of children with slow development is lower than that of children with normal development, which is consistent with the research results at home and abroad. The positive rate of scoliosis in primary and secondary school students with normal development is higher than that in primary and secondary school students with growth retardation, which may be related to the rapid growth and development of bones during the adolescent growth spurt [23]. The increased instability of the spinal structure during the rapid growth period makes the spine more prone to bending and deformation, greatly increasing the incidence of scoliosis [24].

According to this data study, the positive rate of other ethnic minorities is higher than that of Han and Zhuang people. The occurrence and development of scoliosis are also related to living and social environmental factors: the western region of China is generally different from inland and coastal areas in terms of geography, climate, culture, population characteristics, and social economy, especially in areas with concentrated ethnic minorities [25]. However, the sample size of other ethnic minorities in this screening is small, which may lead to an increase in the false positive rate. The association between body mass index (BMI) and scoliosis is complex and has attracted much attention in epidemiological studies [26]. The risk of scoliosis in primary and secondary school students with moderate to severe emaciation is higher than that in students with normal weight, because the leptin level in emaciated groups is low. Leptin is a hormone factor mainly produced by adipose tissue, which affects body

growth, bone mineralization, and bone density metabolism. In the pathogenesis of AIS, leptin is related to the important difference between the spinal growth rate and that of the extremities and the low bioavailability [27]. In this data, the risk of scoliosis in overweight and obese groups is low. The reason may be that factors related to accelerated growth in obese children include hyperleptinemia, increased insulin levels, adrenal androgens, and insulin-like growth factor-1 (IGF-1), etc., which is opposite to the international mainstream research results. It cannot be ruled out that it is caused by screening errors and other objective factors [28].

The screening also suggests that the positive rate of scoliosis in myopic students is higher than that in students with normal visual acuity [29]. The reasons may be that students have a heavy academic burden, prolonged study time, prominent sedentary behavior, and insufficient physical activity, which not only easily lead to strain of the neck, chest, back, and waist muscles, but also accelerate the occurrence of spinal degenerative diseases [30]. In addition, reduced sleep time will also increase the risk of myopia. Other reasons may be that long-term incorrect reading and writing postures will lead to uneven stress on both sides of the spine for a long time, resulting in unbalanced muscle tension on both sides. Therefore, the implementation of the "double reduction action" can reduce the burden on students, ensure sufficient sleep time for students, and is of great significance for the prevention of myopia, scoliosis, and their comorbidity [31].

5. Conclusion

In conclusion, the situation of scoliosis among children and adolescents in this area is relatively serious. Among them, junior high school girls, senior high school boys, other ethnic minorities, moderate to severe emaciated groups, and myopic groups are high-risk groups for scoliosis, which should be focused on prevention and treatment [32]. Educational institutions need to immediately carry out scientific and systematic health education to popularize the characteristics and hazards of scoliosis to students and their parents, emphasize the importance of early intervention, and urge suspected scoliosis patients to seek medical treatment in a timely manner and take intervention measures. Second, physical activities should be promoted, especially those that enhance core muscle strength, such as yoga, Pilates, and Schroth exercises, which can prevent the occurrence of scoliosis [33]. In addition, reducing the frequency and time of sedentary behavior, limiting the use of electronic products, and encouraging students to rest on time are helpful to correct bad posture habits and improve spinal health. Third, nutritional intervention is crucial. Ensure that students intake sufficient calcium, vitamin D, and other important vitamins to maintain bone health, and maintain a healthy body mass index (BMI) through a reasonable diet structure and regular exercise. Fourth, specific medical measures can be taken for high-risk groups of scoliosis: for example, collecting family medical history and monitoring hormone levels for children and adolescents with a family history of scoliosis or genetic tendency, and further improving imaging examinations if necessary.

Limitations and Future Prospects of This Screening: ① This study adopted the method of offline school screening. Due to the radioactive hazards of X-ray photography and hardware configuration, no further professional diagnosis was carried out, and the accurate prevalence of scoliosis could not be obtained. Although the positive rate obtained from the initial screening is not the actual prevalence of scoliosis, it has important reference significance [34]. ② This survey also has shortcomings such as a relatively small sample size, lack of continuous observation, and incomplete survey items. Subsequent improvement measures include expanding the screening scope and total sample size, conducting regular follow-up of those with positive initial screening, and improving the questionnaire items. ③ With the popularization of smartphones, family members can use smartphones equipped with applications and

special cases (Scolioscreen) to measure the ATR angle of children with scoliosis, allowing parents without training experience to monitor the progress of their children's diseases at all times. With the empowerment of artificial intelligence (AI) technology, the ScolioNets deep learning model combined with mobile phone applications can judge the severity and progress of scoliosis by taking photos of the patient's exposed back. In addition, the Scoliosis Tele-Screening Test (STS-Test) designed by the foreign Yılmaz team has the advantages of cost-effectiveness, parent-friendliness, and high accuracy. After large-scale application, it may replace traditional offline screening.

Funding

Self-Funded Scientific Research Project of Guangxi Zhuang Autonomous Region Health Commission (Project No.: Z-A20220388); Guangxi Medical and Health Appropriate Technology Development and Promotion Project (Project No.: S2022058); "Guangxi Multidisciplinary Interdisciplinary Innovation Team for Integrative Chinese and Western Medicine Bone and Joint Degenerative Diseases" (Project No.: GZKJ2310); In-hospital Advantageous Discipline Construction Project of Guangxi International Zhuang Medicine Hospital; National TCM Advantageous Specialty Construction Unit (Zhuang Medicine Orthopedics and Traumatology) (Guo Zhong Yi Yao Yi Zheng Han[2024] No. 90)

Disclosure statement

The authors declare no conflict of interest.

References

[1] Kuznia AL, Hernandez AK, Lee LU, 2020, Adolescent Idiopathic Scoliosis: Common Questions and Answers, American Family Physician, 101(1): 19-23.

[2] An JK, Berman D, Schulz J, 2023, Back Pain in Adolescent Idiopathic Scoliosis: A Comprehensive Review, Journal of Children's Orthopaedics, 17(2): 126-140.

[3] Central Committee of the Chinese Peasants and Workers Democratic Party, 2020, Proposal on Carrying out Prevention and Control of Scoliosis in Children and Adolescents as Soon as Possible, Forward Forum, (07): 60.

[4] Li Y, Xiang Y, Wang Y, et al, 2025, Detection Rate and Risk Factors of Abnormal Spinal Curvature Among Children and Adolescents - Jiangsu Province, China, 2021-2023, China CDC Weekly, 7(6): 208-216.

[5] Zhou L, Yang H, Hai Y, et al, 2022, Scoliosis Among Children in Qinghai-Tibetan Plateau of China: A Cross-Sectional Epidemiological Study, Frontiers in Public Health, 10: 983095.

[6] Mei Y, Lin YF, Gong Z, et al, 2025, Prevalence of Incorrect Posture Among School Adolescents After the COVID-19 Pandemic: A Large Population-Based Scoliosis Screening in China [J]. Journal of Orthopaedic Surgery and Research, 20(1): 156.

[7] Ragborg LC, Dragsted C, Ohrt-Nissen S, et al, 2023, Health-Related Quality of Life in Patients 40 Years After Diagnosis of an Idiopathic Scoliosis, The Bone & Joint Journal, 105-B(2): 166-171.

[8] Aulisa AG, Giordano M, Guzzanti V, et al, 2019, Effectiveness of School Scoliosis Screening and the Importance of This Method in Measures to Reduce Morbidity in an Italian Territory, Journal of Pediatric Orthopedics Part B, 28(3): 271-277.

[9] National Health and Family Planning Commission, 2014, Screening for Abnormal Spinal Curvature in Children and Adolescents: GB/T 16133-2014, China Standard Press.

[10] De Kleuver M, Faraj SSA, Haanstra TM, et al, 2021,The Scoliosis Research Society Adult Spinal Deformity Standard Outcome Set, Spine Deformity, 9(5): 1211-1221.

[11] National Health and Family Planning Commission, 2014, Screening for Malnutrition in School-Age Children and Adolescents: WS/T 456-2014, China Standard Press.

[12] Ministry of Health of the People's Republic of China, 2011, Standard Logarithmic Visual Acuity Chart, China Standard Press.

[13] Cheng JC, Castelein RM, Chu WC, et al., 2015, Adolescent Idiopathic Scoliosis, Nature Reviews Disease Primers, 1: 15030.

[14] Fong DY, Lee CF, Cheung KM, et al., 2010, A Meta-Analysis of the Clinical Effectiveness of School Scoliosis Screening, Spine, 35(10): 1061-1071.

[15] Zheng X, Han W, Gao S, et al, 2025, Global Visualization of Adolescent Idiopathic Scoliosis Treatment: A Bibliometric Analysis, Frontiers in Pediatrics, 13: 1526459.

[16] Roggio F, Trovato B, Sortino M, et al., 2023, The Role of Muscle Biomarkers in Adolescent Idiopathic Scoliosis, Journal of Clinical Medicine, 12(24).

[17] Zou J, Chen R, Long Y, 2024, Research on the Path of Exercise Rehabilitation to Reduce the Incidence of Adolescent Idiopathic Scoliosis in Guangxi [J]. Sports Science and Technology, 45(5): 9-11+17.

[18] Xu S, Su Y, Wang Z, et al., 2021, Prevalence Characteristics of Scoliosis Among Primary and Secondary School Students in Mainland China: A Meta-Analysis of 72 Studies , Chinese Journal of Spine and Spinal Cord, 31(10): 901-910.

[19] Wang Y, Wang H, Ding L, et al., 2025, Current Status and Influencing Factors of Scoliosis Among Primary and Secondary School Students in Shanghai [J]. Journal of Neck and Low Back Pain, 46(1): 84-88.

[20] Zhang L, Zhao Z, Wang Y, et al., 2023, Epidemiological Characteristics of Scoliosis Among Children and Adolescents in Huanan County, Yunnan Province [J]. Orthopaedics, 14(2): 150-154.

[21] Xu S, Li K, Jin L, et al., 2024, Distribution of Scoliosis in 2.22 Million Adolescents in Mainland China: A Population-Wide Analysis, Journal of Global Health, 14: 04117.

[22] Dunn J, Henrikson NB, Morrison CC, et al., 2018, Screening for Adolescent Idiopathic Scoliosis: Evidence Report and Systematic Review for the US Preventive Services Task Force , JAMA, 319(2): 173-187.

[23] Weinstein SL, Dolan LA, Cheng JC, et al., 2008, Adolescent Idiopathic Scoliosis Lancet (London, England), 371(9623): 1527-1537.

[24] Huang J, Zhou X, Li X, et al., 2022, Regional Disparity in Epidemiological Characteristics of Adolescent Scoliosis in China: Data from a Screening Program, Frontiers in Public Health, 10: 935040.

[25] Matusik E, Durmala J, Matusik P, 2016, Association of Body Composition with Curve Severity in Children and Adolescents with Idiopathic Scoliosis (IS), Nutrients, 8(2): 71.

[26] Otomo N, Khanshour AM, Koido M, et al., 2023, Evidence of Causality of Low Body Mass Index on Risk of Adolescent Idiopathic Scoliosis: A Mendelian Randomization Study, Frontiers in Endocrinology, 14: 1089414.

[27] Valdovino AG, Bastrom TP, Reighard FG, et al., 2019, Obesity Is Associated With Increased Thoracic Kyphosis in Adolescent Idiopathic Scoliosis Patients and Nonscoliotic Adolescents, Spine Deformity, 7(6): 865-869.

[28] Catanzariti JF, Rimetz A, Genevieve F, et al., 2023, Idiopathic Adolescent Scoliosis and Obesity: Prevalence Study, European Spine Journal: Official Publication of the European Spine Society, the European Spinal Deformity Society,

and the European Section of the Cervical Spine Research Society, 32(6): 2196-2202.

[29] Zhao X, He Y, Zhang J, et al., 2024, Effects of Insufficient Sleep on Myopia in Children: A Systematic Review and Meta-Analysis, Nature and Science of Sleep, 16: 1387-1406.

[30] Chopra S, Larson AN, Kaufman KR, et al., 2020, Accelerometer Based Assessment of Daily Physical Activity and Sedentary Time in Adolescents with Idiopathic Scoliosis, PloS One, 15(9): e0238181.

[31] Suh SW, Modi HN, Yang JH, et al, 2011, Idiopathic Scoliosis in Korean Schoolchildren: A Prospective Screening Study of Over 1 Million Children, European Spine Journal: Official Publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society, 20(7): 1087-1094.

[32] Van West HM, Herfkens J, Rutges J, et al., 2022, The Smartphone as a Tool to Screen for Scoliosis, Applicable by Everyone, European Spine Journal: Official Publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society, 31(4): 990-995.

[33] Zhang T, Zhu C, Zhao Y, et al., 2023, Deep Learning Model to Classify and Monitor Idiopathic Scoliosis in Adolescents Using a Single Smartphone Photograph [J]. JAMA Network Open, 6(8): e2330617.

[34] Yılmaz HG, Büyükaslan A, Kuşvuran A, et al., 2023, A New Clinical Tool for Scoliosis Risk Analysis: Scoliosis Tele-Screening Test, Asian Spine Journal, 17(4): 656-665.