The Prevalence of Scoliosis Screening Positive and its Influencing Factors: A School based Cross-sectional Study in Zhejiang Province, China

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Research

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Abstract

Background: Early detection of scoliosis is of great significance to patients with scoliosis and the whole society. This paper aims to learn the prevalence of scoliosis screening positive among students in primary and secondary schools, and to explore the influencing factors.

Methods: In 2019, a stratified cluster sampling technique was employed in this school based cross-sectional study. Sampling covers all prefecture level cities in Zhejiang Province. Based on the whole class, at least 80 students in each grade of primary school, junior high school and senior high school were selected. Physical examination and scoliosis screening were performed in the school-based investigation. Distribution of demographic characteristics and nutritional status of children and adolescents with scoliosis screening positive were explored.

Results: A total of 45547 students were screened. The overall prevalence of children and adolescents with scoliosis screening positive were 3.9%. Higher prevalence of scoliosis screening positive was found in students living in urban area (4.1%), female students (4.1%), students with low weight (5.3%) ($p < 0.05$), and the prevalence increased with age ($p < 0.05$). In logistic analysis, we found age (OR=1.145), gender (OR=1.118) and low weight (OR=1.480) were the influencing factors for prevalence of scoliosis screening positive ($p < 0.05$).

Conclusions: There were no disparities between living areas, but there was significant difference between genders, among different ages, and among different nutritional status of children and adolescents with or without scoliosis screening positive. In multi analysis, age, gender, and low weight were the influencing factors for prevalence of scoliosis screening positive. Age and gender specific scoliosis screening strategy and nutritional public health policies for children and adolescent are need.

Background

Scoliosis seriously affects the physical and mental health of children and adolescents. Especially in the period of vigorous growth and development, the development of scoliosis deformity is faster. If there is no treatment intervention, the degree of deformity will increase, and the labor capacity will decline. Even there will be cardiopulmonary complications, back pain and even paraplegia, which will also lead to social and psychological problems[1–2]. Much has yet to be learned about the general health, quality of life, and self-image as well as prevention of students with scoliosis[3]. In China, scoliosis is the main type of spinal curvature abnormality, accounting for 82% of spinal curvature abnormality, and recent study showed the incidence rate for scoliosis was 1.80%[4–5]. Evidence showed that bad posture in adulthood is often formed from the childhood, and individuals with severe incorrect posture may be associated with the progress of scoliosis[6]. Therefore, early detection (school-based screening) are of great significance to patients with scoliosis and the whole society.

Scoliosis screening is an assessment procedure to identify children with spinal curvature at early stages. Many countries have national screening programs for scoliosis in children and adolescents. Scoliosis school screening was first carried out in Delaware in the 1960s, and then extended to all parts of the United States, Canada, Europe and other countries and regions. However, it is controversial whether to implement compulsory screening[7]. The United States systematically evaluated AIS (adolescent idiopathic scoliosis) screening, including 14 studies covering 448276 people, and found that screening can detect AIS. Bracing and possibly exercise treatment can interrupt or slow progression of curvature in adolescence[8]. Australia supports scoliosis screening in schools to facilitate early treatment[7]. The study in Denmark confirms that in a health care system without school screening, patients with AIS referred for evaluation by general practitioners have larger curve sizes compared to systems with school screening[9]. A population-based study with a long-term follow-up in Singapore indicated that a scoliosis screening program can have sustained clinical effectiveness in identifying patients with adolescent idiopathic scoliosis needing clinical observation. As the prevalence of adolescent idiopathic scoliosis increases, scoliosis screening should be continued as a routine health service in schools or by general practitioners if there is no scoliosis screening policy[10]. In recent years, some regions in China have carried out epidemiological survey of scoliosis, but scoliosis screening has not been included in the physical examination of primary and secondary schools by governments and education departments[11]. In addition, there was few scoliosis investigations carried out domestic, and in the investigation carried out, due to the differences in screening methods, it is difficult to compare and evaluate each other. By the limited investigation in China, the influencing factors of scoliosis screening positive have not been explored and analyzed. This paper aims to learn the prevalence of scoliosis screening positive among students and its influencing factors.

Methods

Study design and data sources

Stratified cluster sampling method were used in this study. In 2019, sampling covers all prefecture level cities in Zhejiang Province. Samples were stratified to urban areas and rural areas. In each prefecture level city, 8 schools in the urban area (2 primary schools, 2 junior high schools, 2 senior high schools and1 vocational high school), 5 schools in the rural area (2 primary schools, 2 junior high schools and 1 senior high school) were selected. Based on the whole class, at least 80 students in each grade of primary school, junior high school and senior high school are selected, that is, at least 480 students are selected from each primary school and 240 students are selected from each junior high school, senior high school.

All methods were performed in accordance with the relevant guidelines and regulations, and this study was approved by the Ethics Committee of Zhejiang Provincial Center for Disease Control and Prevention（T-043-R20180515）. The parents or guardians of the participants provided consent to participate on behalf of the minors.

Screening of spinal curvature abnormality

Physical examination and scoliosis screening were performed in the school-based investigation by trained doctors and nurses from local community health center. Boys and girls were examined separately. Scoliosis screening and evaluation was based on the screening of spinal curvature abnormality of children and adolescents (GB/T 16133-2014). The exclusion criteria for this study were as follows: students who are unable to perform Adam's forward bending test due to any reasonable cause. General examination for scoliosis screening including examination of shoulder asymmetry, scapula prominence, unequal waistline or arm span and abnormalities involving the trunk or spine, such as humps in the ribs or lumbar regions. Thereafter, Adam's forward bending test was used to screen scoliosis in the population. The measurement was performed in the standing position during forward bending of the trunk[12].Evaluation of scoliosis (screening positive or negative) were based on the result of general examination combined with Adam's forward bending test.

Anthropometrical measurement and data collection

Children and adolescents' sex and age were collected by general information questionnaire. Anthropometrical measurements were conducted by well-trained health workers of local community health center. Height was measured without shoes to the nearest 0.2 cm using a portable SECA stadiometer, and weight was measured without shoes and in light clothing to the nearest 0.1 kg on a calibrated beam scale. Body mass index (BMI) was calculated as weight (kg)/height (m)^2. According to "Screening for overweight and obesity among school-age children and adolescents"[13], we judged overweight and obesity of children aged 6-17 years old by boundary value. According to "Screening standard for malnutrition of school-age children and adolescents"[14], we judged low weight of children aged 6-17 years old.

Statistical analysis

All the data were analyzed with SAS9.4(SAS Institute Inc, Cary, NC, USA). Category variables were present in the form of number and percentage. Chi-square test were used to explore the association factors of scoliosis screening positive. Multiple logistic regression was used to analyze the influencing factors of the prevalence of scoliosis screening positive.

A two-side *p value* <0.05 was considered as statistically significant.

Results

Subject characteristics

A total of 45547 students aged 6-17 were investigated and screened with scoliosis, including 23706 males and 21841 females. The overall prevalence of scoliosis screening positive among students were 3.9%. The prevalence of low weight, overweight and obesity among the participants were 6.6%, 14.3% and 12.4%, respectively.

Prevalence by age and living area

Urban areas can include town and cities while rural areas include villages. The prevalence of scoliosis screening positive among children and adolescents in urban area was 4.1%, which was higher than that in rural area（p<0.05）(Table1). Especially, the difference existed among children and adolescents aged 7,11,15,16 and 17years old（p <0.05）.

In urban area, the prevalence of scoliosis screening positive was 6.8% among children and adolescents aged 17, while in rural area, the prevalence was 5.4% among children and adolescents aged 12, both higher than that of other ages, respectively（p <0.05） (Figure 1).

Prevalence by age and gender

The prevalence of scoliosis screening positive among female children and adolescents was 4.1%, which was higher than that of males（p <0.05）(Table 2). Especially, the difference existed among children and adolescents aged 8,10,11 and 16 years old（p <0.05）.

The prevalence of scoliosis screening positive increased with age both in males and females（p <0.05）(Figure 2). When we divided age into two groups (6-10 years old & 11-17 years old), we found that the prevalence of scoliosis screening positive of students aged 11-17 were higher than that aged 6-10(c^2=305.261, p <0.001).

Prevalence by age and nutritional status

We classified the nutritional status as low weight, eutrophic, overweight, obese. According to "Screening for overweight and obesity among school-age children and adolescents", we judged overweight and obesity. According to "Screening standard for malnutrition of school-age children and adolescents", we judged low weight. The prevalence of scoliosis screening positive among children and adolescents with low weight was 5.3%, which was higher than that without low weight（p <0.05）(Table 3). Especially, the difference existed among children and adolescents aged 9,10,11,12,13,14,15,16 and 17 years old（p <0.05）.

The prevalence of scoliosis screening positive was 12.8% among children and adolescents aged 13 with low weight, while that was 4.0% among children and adolescents aged 14 with obesity, both higher than that of other ages, respectively (Figure 3) （p <0.05）.

Influencing factors for the prevalence

In multi factor regression analysis, we found age (OR=1.145, 95%CI: 1.128,1.162), gender (OR=1.118, 95%CI:1.016, 1.230) and low weight (OR=1.480, 95%CI:1.250, 1.751) were the influencing factors for prevalence of scoliosis screening positive ($p < 0.05$) (Table4) .

Table 1

The prevalence of scoliosis screening positive among students stratified by living area

Age	Urban area			Rural area			Chi square	p
	N	Scoliosis screening positive	Positive rate	N	Scoliosis screening positive	Positive rate		
6	1672	16	1.0%	1669	24	1.4%	1.634	>0.05
7	1911	16	0.8%	1934	55	2.8%	21.354	<0.001
8	1948	29	1.5%	1867	42	2.2%	3.022	>0.05
9	1842	36	2.0%	1808	53	2.9%	3.661	>0.05
10	1984	41	2.1%	2036	58	2.8%	2.559	>0.05
11	1930	50	2.6%	1999	85	4.3%	8.17	<0.01
12	1901	85	4.5%	1950	106	5.4%	1.9	>0.05
13	1906	122	6.4%	1998	100	5.0%	3.544	>0.05
14	1992	116	5.8%	1996	103	5.2%	0.844	>0.05
15	2734	167	6.1%	1171	51	4.4%	4.78	<0.05
16	2785	168	6.0%	905	24	2.7%	15.824	<0.001
17	2712	184	6.8%	897	35	3.9%	9.828	<0.01
Total	25317	1030	4.1%	20230	736	3.6%	9.394	<0.01

Table 2

The prevalence of scoliosis screening positive among students stratified by gender

Age	Male			Female			Chi square	p
	N	Scoliosis screening positive	Positive rate	N	Scoliosis screening positive	Positive rate		
6	1718	22	1.3%	1648	18	1.1%	0.208	>0.05
7	2020	39	1.9%	1825	32	1.8%	0.166	>0.05
8	2019	27	1.3%	1796	44	2.4%	6.442	<0.05
9	1951	45	2.3%	1674	44	2.6%	0.306	>0.05
10	2071	34	1.6%	1949	65	3.3%	11.986	<0.01
11	2051	48	2.3%	1878	87	4.6%	15.525	<0.001
12	1957	94	4.8%	1894	97	5.1%	0.207	>0.05
13	2027	127	6.3%	1877	95	5.1%	2.635	>0.05
14	2005	99	4.9%	1983	120	6.1%	0.383	>0.05
15	2050	106	5.2%	1855	112	6.0%	1.389	>0.05
16	1932	114	5.9%	1758	78	4.4%	3.998	<0.05
17	1905	121	6.4%	1704	98	5.8%	0.569	>0.05
Total	23706	876	3.7%	21841	890	4.1%	5.38	<0.05

Table 3

The prevalence of scoliosis screening positive among students stratified by nutritional status

	Low weight			Eutrophic			Overweight			Obesity			Chi square	p
	N	Scoliosis screening positive	Positive rate	N	Scoliosis screening positive	Positive rate	N	Scoliosis screening positive	Positive rate	N	Scoliosis screening positive	Positive rate		
6	192	2	1.0%	2161	27	1.2%	476	8	1.7%	512	3	0.6%	2.918	>0.
7	327	2	0.6%	2480	53	2.1%	529	9	1.7%	509	7	1.4%	4.592	>0.
8	354	6	1.7%	2480	54	2.2%	450	7	1.6%	531	4	0.8%	6.183	>0.
9	252	13	5.2%	2333	55	2.4%	503	9	1.8%	562	12	2.1%	9.011	<0.
10	242	6	2.5%	2589	75	2.9%	446	10	2.2%	743	8	1.1%	8.064	<0.
11	253	11	4.3%	2480	96	3.9%	655	20	3.1%	541	8	1.5%	8.583	<0.
12	226	16	7.1%	2567	139	5.4%	585	24	4.1%	473	12	2.5%	11.085	<0.
13	195	25	12.8%	2634	159	6.0%	624	24	3.8%	451	14	3.1%	28.654	<0.
14	211	19	9.0%	2746	162	5.9%	606	21	3.5%	425	17	4.0%	12.514	<0.
15	228	11	4.8%	2730	176	6.4%	594	21	3.5%	353	10	2.8%	13.904	<0.
16	241	22	9.1%	2600	137	5.3%	542	25	4.6%	307	8	2.6%	12.134	<0.
17	277	26	9.4%	2561	157	6.1%	490	30	6.1%	281	6	2.1%	12.996	<0.
Total	2998	159	5.3%	30361	1290	4.2%	6500	208	3.2%	5688	109	1.9%	7.739	<0.

Table 4

Logistic analysis of influencing factors for prevalence of scoliosis screening positive among students

Variables	Wald	p	OR	95% C.I.for EXP(B)	
				Lower	Upper
Age	306.651	<0.001	1.145	1.128	1.162
Gender (Male/Female)	5.203	<0.05	1.118	1.016	1.230
Living area (Urban area/Rural area)	0.606	>0.05	1.040	0.942	1.148
Low weight (Yes/No)	20.784	<0.001	1.480	1.250	1.751

Discussion

The present study illustrates the prevalence of scoliosis screening positive among students, and compared the disparities between genders, between living areas, among different ages, and among different nutritional status in students with or without scoliosis screening positive. We found age, gender and low weight were the influencing factors for prevalence of scoliosis screening positive.

In this study, we found the prevalence of scoliosis screening positive among students was 3.9%, which was lower than a report from Guangzhou with 6.56% [15], while higher than a report from Wuxi with 2.6%[16]. Our study covers primary and junior high school students. There are other studies which found different prevalence because of differential ages of the subjects. And, because of the sampling method, it will also lead to the bias caused by selection. Another study also reported that screening of 13–15 years old girls identified a significant number who could benefit from preventive treatment[13]. Penha also reported that prevalence of scoliosis was higher during puberty years of age[17]. Fong reported that a scoliosis screening program can have sustained clinical effectiveness in identifying patients with scoliosis needing clinical observation[11]. Scoliosis typically develops in late childhood, and with more than 4% of adolescents between the ages of 11–17 years old showing spinal malformation[17–18]. The scoliosis Research Society recommends screening children and adolescent annually to prevent spina deformation and identifies symptoms at an early stage[18]. Similar to these literature, we found that the prevalence of scoliosis screening positive of students aged 11–17 were higher than that aged 6–10. This founding suggests that in areas without mandatory screening and with limited resources, we should prefer to provide screening service for students aged 11–17 years.

Female students should be paid more attention. Previous study in China reported that girls had a higher prevalence in each age subgroup compared with boys[19]. Another study carried out in Chongming Island (China) found the prevalence was 2.52 %, higher in girls (3.11 %) than in boys (1.96 %)[20]. Similar to the previous studies, we found that the prevalence of scoliosis screening positive among female students was higher than that of male students. Adamczewska reported that age, sex, and risk of developing angle of trunk rotation are very closely associated[21], suggesting that females may have different scoliosis progress and prognosis compared with males.

We also found that the prevalence of scoliosis screening positive among students in urban area was higher than that in rural area. But in the multi factor analysis,, the influence of living area had no significant effect on the prevalence of scoliosis screening positive. Students with scoliosis screening positive must have more probability to be diagnosed scoliosis after they were referred to the hospital. Golboni reported the rural area residents suffered more from low functional health literacy, compared with their urban counterparts[22]. Health literacy is lower in the rural population although this difference is explained by known confounders, and community and societal level factors should be focused to promoting health care[23–24]. Scoliosis is a serious clinical problem which requires a systematic physical therapy and control of body balance-treatment from the moment of achieving skeletal maturity by a child. In general, child and adolescents living in urban area could benefit from the health literacy and receive more attention of healthy behavior lifestyle from their families. Latalski reported there is a relationship between the economic standard of the family and engagement in the treatment of a child with scoliosis[25]. So, the health education for the children and adolescents who screened positive, especially the referral and thereafter interventions for those lived in the rural area, should be paid more attention.

A system review demonstrates that patients with AIS are significantly more likely to have a low BMI compared to the general population[26]. Sun reported that low body mass index can be predictive of bracing failure in patients with adolescent idiopathic scoliosis[27]. Xu reported that BMI was an important indicator for pulmonary function in scoliosis patients[28]. Low BMI is not only related to treatment and intervention, but also to scoliosis prevalence. KIM reported that the prevalence of thin students with scoliosis could increase by up to four times depending on the BMI criteria[29]. Jeon reported that low weight and the risk of developing scoliosis are very closely associated[30]. A study in China found that compared with healthy students, those with scoliosis were taller, had lower weight and BMI[5]. Similar to these literature, we found the prevalence of scoliosis screening positive was high in students with low weight. Also, in this study, we found the prevalence of low weight among students was 6.6%. However, with the rapid economic transformation and development in recent years, more attention has been paid to child obesity, while the problem of low weight has been overlooked. Reasonable diet and balanced nutrition should be advocated and maintenance of appropriate and normal weight should be encouraged to prevent and reduce the risk of scoliosis.

In addition, the methodological limitations of the study are that SAS software is not able to analyze the interactions between factors on the response variable, so the interaction effects of age, gender, weight, and other independent variables on the scoliosis screening positive should be explored in further studies.

Conclusions

The prevalence of scoliosis screening positive among students was 3.9% in this study. There were no disparities between living areas, but there was significant difference between genders, among different ages, and among different nutritional status of children and adolescents with or without scoliosis screening positive. In multi analysis, age, gender, and low weight were the influencing factors for prevalence of scoliosis screening positive. Age and gender specific scoliosis screening strategy and nutritional public health policies for children and adolescent are need.

Abbreviations

AIS: adolescent idiopathic scoliosis; BMI:Body mass index;

Declarations

Acknowledgments

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Authors’ contributions

Conceptulization, YZ and RZ; methodology, YZ and YL; software, JM and FG; investigation, JL and JM; resources,YZ and RZ; writing, YZ; project administration, YZ. The authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethic Approval and consent to participate

All methods were performed in accordance with the relevant guidelines and regulations, and this study was approved by the Ethics Committee of Zhejiang Provincial Center for Disease Control and Prevention.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

Figure 1

The prevalence of scoliosis screening positive among children and adolescents stratified by living area

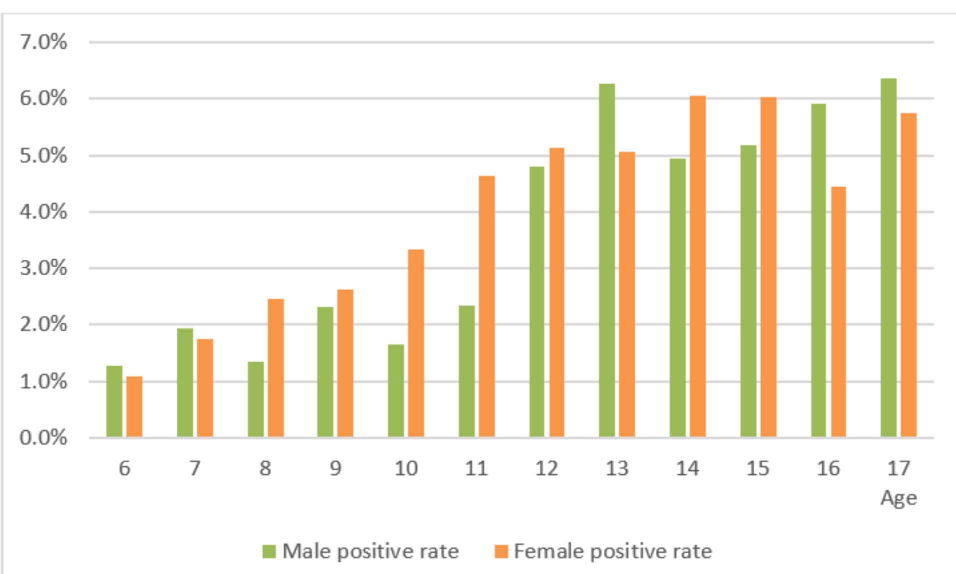

Figure 2

The prevalence of scoliosis screening positive among children and adolescents stratified by gender

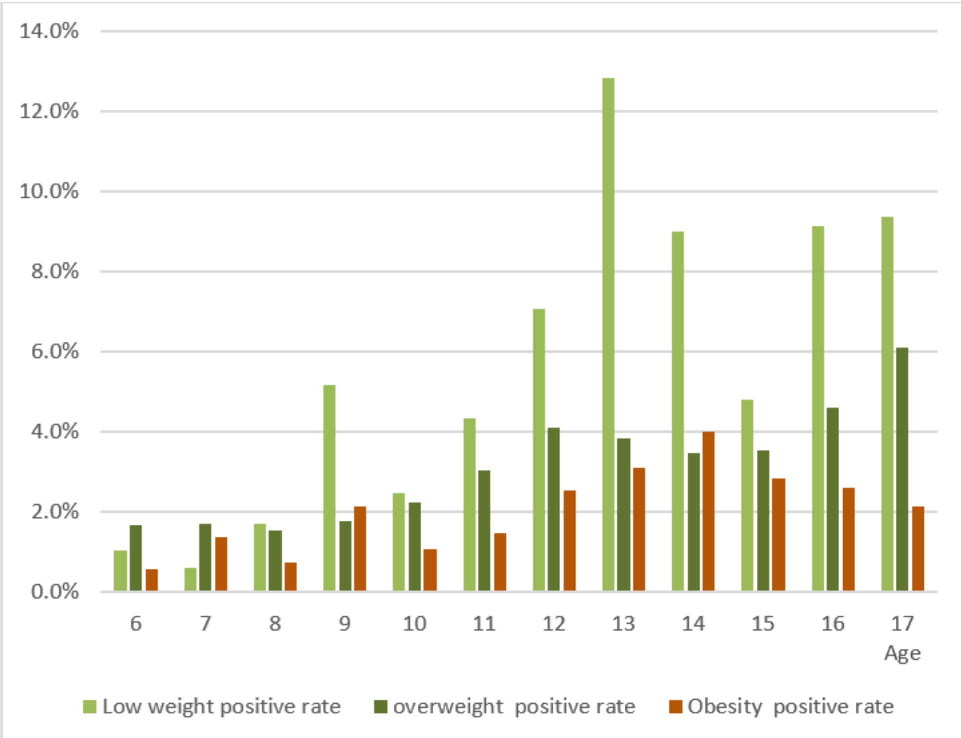

Figure 3

The prevalence of scoliosis screening positive among children and adolescents stratified by nutritional status