Scientific Research Publishing

Advances in Physical Education, 2024, 14, 1-13
https://www.scirp.org/journal/ape
ISSN Online: 2164-0408
ISSN Print: 2164-0386

Correlation between Postural Scoliosis and Physical Fitness: A Study of 775 Chinese Primary Students

Zengyu Chen, Lianxiang Fan

School of Physical Education, South China University of Technology, Guangzhou, China
Email: chenzengyu77@163.com

How to cite this paper: Chen, Z. Y., & Fan, L. X. (2024). Correlation between Postural Scoliosis and Physical Fitness: A Study of 775 Chinese Primary Students. *Advances in Physical Education, 14,* 1-13.
https://doi.org/10.4236/ape.2024.141001

Received: November 29, 2023
Accepted: December 26, 2023
Published: December 29, 2023

Abstract

Postural scoliosis is a common disease that poses a threat to the physical and mental health of children and adolescents, resulting from long-term poor posture. However, its symptoms are often hidden and easily overlooked. In order to investigate the effects of postural scoliosis on the physical fitness of primary school students, a physical fitness test and posture assessment was conducted on 775 primary students in Yangjiang City, comparing the physical fitness levels of students with different degrees of postural scoliosis. The following results were observed: 1) The overall physical fitness assessment of primary students is good, but there is a serious lack of excellence and the qualified rate decreases with age. 2) The detection rate of postural scoliosis increases with age and stage. 3) Postural scoliosis has a significant negative impact on the physical function and physical quality of primary students, early intervention and special education are key factors in improving body posture and increasing physical fitness levels. 4) There are three groups of primary students that need special attention in physical fitness tests: stage one children with low 50-meter run scores, underweight children with low sit-up scores, and overweight children with low sit-and-reach scores.

Keywords

Postural Scoliosis, Body Posture, Physical Fitness, Physical Fitness Test

1. Introduction

The healthy physique is a typical indicator of children's health and development level, as well as the foundation for their robust growth and improvement of physical fitness (Zhen, 2020). The primary school is a period of reserve before the rapid growth phase of adolescence, during which the development of mus-

cles lags behind that of bones, leading to a lack of corresponding muscle support in the body, making it prone to posture issues (Li & Diao, 2013). Among these, scoliosis has become one of the most common and severe posture problems.

Spinal curvature has become the third major "killer" threatening the health of children and adolescents, following obesity and myopia (Sun et al., 2021). The detection rate of scoliosis among primary and secondary school students is approximately 4.4% (Xu et al., 2021), with an estimated number of over 5 million affected individuals in China, and this number is increasing annually. It not only leads to external deformities such as hunchback, uneven shoulders, unequal leg lengths, and asymmetric skeletal development, but also causes internal organ deformities and functional impairments and in severe cases it may even pose a threat to life (Baird et al., 2022).

Postural scoliosis is a type of scoliosis caused by long-term poor posture, accounting for nearly 80% of childhood scoliosis cases in China. It is a non-structural curve without bone structural changes such as vertebral rotation and spinal distortion, but it can affect the posture and body shape of children. In the early stages, postural scoliosis may cause fatigue and discomfort in the back. Without intervention, it may progress to structural scoliosis, leading to worsened spinal deformity (Chen, 2022). Due to its insidious early symptoms and the severity insufficient to warrant medical intervention, there is inadequate attention from parents, schools, and hospitals. As a result, some pediatric patients' symptoms rapidly progress during adolescence, causing a delay in the optimal intervention time (Khosravi et al., 2016).

Compare the physical fitness levels of primary students with different postural scoliosis symptoms and investigate the effects of postural scoliosis on the physical well-being of primary students. Conducted from the perspective of physical health, this study is based on the methods outlined in the "Screening for Abnormal Spine Curvature in Children and Adolescents" and the "National Student Physical Health Standards (Revised in 2014)", 775 primary students were measured and evaluated for postural scoliosis symptoms and physical fitness in order to explore whether there is a certain degree of correlation between the two. The aim is to provide theoretical and practical support for early school screening and intervention efforts for postural scoliosis.

2. Methodology

A random cluster sampling method was used to select the experimental subjects, and a total of 775 students (422 boys and 353 girls) in grades 1 - 6 were selected from two primary schools in Yangjiang City, China as the subjects of this research (**Table 1**). Prior to testing, informed consent forms were signed by the children's parents or guardians. Statistical analysis was conducted using SPSS 26.0 to analyze the age, gender, height, weight, BMI, prevalence of scoliosis, and physical fitness test scores of the primary students. The normality of the data distribution was verified for each group using the Kolmogorov-Smirnov test ($P > 0.05$). Descriptive statistics for the data were expressed as the mean ± stan-

dard deviation ($\overline{x}$ ± SD). The comparison of the detection rate of postural scoliosis was analyzed using the chi-square test; and independent sample t-tests were used to compare postural scoliosis and physical fitness. The impact of postural scoliosis on physical fitness levels was analyzed using Pearson correlation. Differences were considered significant at $P < 0.05$ and highly significant at $P < 0.01$.

According to the "Curriculum Plan and Curriculum Standards for Compulsory Education (2022 Edition)" (Chinese Ministry of Education, n.d.a) issued by the Chinese Ministry of Education, the six grades of primary school are divided into three stages: Grades 1 and 2 belong to Stage One, Grades 3 and 4 belong to Stage Two, and Grades 5 and 6 belong to Stage Three, as shown in Table 2 for the number of students in each stage.

2.1. Measurement of Postural Scoliosis

The screening method of postural scoliosis used in this study is based on the general examination of schools, the Adams forward bending test, and measurements with a scoliometer. These screening and assessment methods are consistent with the "Screening for Spinal Deformities in Children and Adolescents" (Chinese National Health and Family Planning Commission, n.d.) method jointly issued by the National Health and Family Planning Commission and the National Standardization Commission in 2014. Following the general examination and Adams test, the scoliometer is used to measure the various segments of the spine (thoracic, thoracolumbar, lumbar), and the maximum angle of trunk rotation (ATR) and its location are recorded. If the most severe asymmetry of the back exceeds 5˚, there is a high suspicion of postural scoliosis.

Table 1. Basic information of research objects.

Age	Number	Height/cm	Weight/kg	BMI/(kg·m^{-2})
6	10	122.40 ± 2.88	21.72 ± 0.97	14.58 ± 1.16
7	125	122.02 ± 5.66	22.97 ± 3.69	15.37 ± 1.81
8	110	124.95 ± 5.75	24.14 ± 4.71	15.44 ± 2.60
9	166	128.22 ± 6.90	27.19 ± 6.71	16.53 ± 3.76
10	163	136.32 ± 7.10	29.76 ± 6.72	15.91 ± 2.70
11	155	140.83 ± 6.04	32.59 ± 7.32	16.39 ± 3.33
12	46	142.80 ± 6.37	33.29 ± 5.28	16.32 ± 2.27

Table 2. Stage information of research objects.

Stage	Number	Percentage
One	176	22.71
Two	315	40.64
Three	284	36.65

2.2. Measurement of Physical Fitness

According to the requirements of the National Student Physical Health Standards (Revised in 2014) issued by the Chinese Ministry of Education, primary students undergo testing in three major areas (Chinese Ministry of Education, n.d.b): physical shape (height, weight, BMI), physical function (vital capacity (VC), sit-and-reach), and physical quality (50-meter run, 1-minute rope skipping, 1-minute sit-ups, 50 m × 8 shuttle run). The total score is 100, with scores of 90.0 and above considered "excellent", 80.0 - 89.9 considered "good", 60.0 - 79.9 considered "passing", and scores below 59.9 considered "failing". Refer to the specific details in Table 3 below, the testing items and scoring methods for students in different stages are not entirely the same.

3. Results

3.1. Physical Fitness Assessment of Primary Students

The physical fitness test of primary students is assessed in three aspects: physical shape, physical function, and physical quality. The total score for physical fitness is 100, categorized into four levels: excellent, good, passing, and failing. A score of pass or above is considered as qualified. It can be observed from Table 4 that the overall qualified rate for physical fitness testing is 91.39%, with a very low rate of "excellent" (1.44%). There is a significant difference in the rate of "excellent" in comprehensive physical fitness assessment between different levels of stage ($\chi^2 = 17.045$, $P = 0.000 < 0.01$). The failing percentage is 8.61%, while 13.16% of primary students have a good level of physical health, and 76.79% of students have achieved a passing level.

It can be observed that there are gender and stage differences in the physical health status of primary school students (Table 5). The overall qualified rate for stage three is the lowest among the three stages. Female students' overall physical fitness assessment is better than that of male students, with higher rates of excellent and good, and lower rates of failing.

3.2. Postural Scoliosis Assessment of Primary Students

After initial and follow-up screening, a total of 65 primary students were diagnosed with postural scoliosis, including 36 boys and 29 girls. The overall detection rate of postural scoliosis is 8.39% (Table 6).

The detection rate of postural scoliosis in boys (8.53%) was slightly higher than in girls (8.22%), but the gender difference was not significant ($P > 0.05$) (Table 7).

From the perspective of age (Table 8), the detection rate of postural scoliosis is lowest in 6-year-old primary students and highest in 11-year-old (12.93%). The detection rate in 6 - 9-year-old students shows an increasing trend with age, indicating the necessity and urgency of posture education for school-age children to develop correct posture habits and correct abnormal body postures during this critical period.

Table 3. Indicators and individual scores for each stage in physical fitness test.

Stage	Indicator (Score)	Stage	Indicator (Score)	Stage	Indicator (Score)
One	BMI (15) VC (15) 50 m run (20) sit-and-reach (30) rope skipping (20)	Two	BMI (15) VC (15) 50 m run (20) sit-and-reach (20) rope skipping (20) sit-ups (10)	Three	BMI (15) VC (15) 50 m run (20) sit-and-reach (10) rope skipping (10) sit-ups (20) 50 × 8 shuttle run (10)

Table 4. Comprehensive levels of fitness test in different stages.

Stage	Excellent		Good		Passing		Failing		Total		Qualified/%
	N	PP	N	PP	N	PP	N	PP	N	PP	
One	6	5.45	35	31.82	62	56.36	7	6.36	110	100	93.64
Two	0	0	20	12.35	132	81.48	10	6.17	162	100	93.83
Three	0	0	0	0	127	86.99	19	13.01	146	100	86.99
Total	6	1.44	55	13.16	321	76.79	36	8.61	418	100	91.39

Note. Due to uncontrollable reasons, a total of 418 primary students have completed all fitness test items and are eligible for physical fitness total score computation.

Table 5. Comprehensive levels of fitness test in different genders.

Gender	Excellent		Good		Passing		Failing		Total		Qualified/%
	N	PP	N	PP	N	PP	N	PP	N	PP	
Male	2	0.93	23	10.65	170	78.70	21	9.72	216	51.67	90.28
Female	4	1.98	32	15.84	151	74.75	15	7.43	202	48.33	92.57
Total	6	1.44	55	13.16	321	76.79	36	8.61	418	100	91.39

Table 6. The overall detection rate of postural scoliosis in primary school students.

Normal		Abnormal	
Number	Rate/%	Number	Rate/%
710	91.61	65	8.39

Table 7. Comparison of detection rate of postural scoliosis among primary students of different genders.

Male (N = 422)		Female (N = 353)		χ^2	*P*-Value
Number	Detection Rate/%	Number	Detection Rate/%		
36	8.53	29	8.22	0.025	0.875

Table 8. Comparison of detection rate of postural scoliosis among primary school students of different ages.

Age	Number	Detection Rate/%	χ^2	*P*-Value
6 (N = 10)	0	0.00		
7 (N = 125)	6	4.80		
8 (N = 110)	9	8.18		
9 (N = 166)	15	9.03	5.42	0.491
10 (N = 163)	14	8.59		
11 (N = 155)	18	11.61		
12 (N = 46)	3	6.52		

From the perspective of stage (Table 9), the rates were 7.39% for stage one, 8.25% for stage two, and 9.15% for stage three. The detection rate of postural scoliosis among primary school students increases with the school stage, but there is no significant difference ($P > 0.05$).

From the perspective of BMI, according to the "National Student Physical Health Standards", BMI divides students into four different groups: underweight group, normal group, overweight group, and obese group. Table 10 shows that the detection rate of postural scoliosis is highest among obese group children (17.14%), suggesting that obesity may be one of the factors causing postural scoliosis in primary school.

3.3. The Relationship between Postural Scoliosis and Physical Fitness

Independent sample t-tests were utilized to analyze the differences in total physical fitness test scores and individual physical fitness test scores between primary students with postural scoliosis and normal primary students.

From Table 11, it can be observed that the BMI, vital capacity, 50-meter run, sit-and-reach, 1-minute sit-up, and total physical fitness score of primary school students with postural scoliosis are all lower than those of the normal group. Notably, there is a significant between-group difference in total physical fitness score ($P = 0.021 < 0.05$). The aforementioned results indicate that postural scoliosis has a substantial impact on the overall physical fitness level of primary students.

The trunk rotation angle (ATR) measured by a scoliometer reflects to a certain extent the severity of postural scoliosis, with a larger ATR indicating more severe symptoms. Pearson correlation analysis was utilized to assess the correlation between ATR and the physical fitness of primary students. From Table 12, it is evident that the ATR angle is significantly negatively correlated with the total physical fitness score of primary students, indicating that as ATR increases, the students' total physical fitness score decreases.

Table 9. Comparison of detection rate of postural scoliosis among primary school students of different stages.

Stage	Number	Detection Rate/%	χ^2	*P*-Value
One (N = 176)	13	7.39		
Two (N = 125)	26	8.25	0.455	0.797
Three (N = 284)	26	9.15		

Table 10. Comparison of detection rate of postural scoliosis among primary school students with different BMI levels.

Stage	Number	Detection Rate/%	χ^2	*P*-Value
Underweight (N = 151)	14	9.27		
Normal (N = 553)	43	7.78	4.29	0.232
Overweight (N = 36)	2	5.55		
Obese (N = 35)	6	17.14		

Table 11. The relationship between postural scoliosis and physical fitness.

Indicator	Normal (N = 710)	Postural Scoliosis (N = 65)	t	*P*-Value
Height (cm)	131.62 ± 9.66	133.45 ± 10.03	−1.410	0.163
Weight (kg)	27.89 ± 7.06	29.10 ± 7.14	−0.682	0.495
BMI (score)	93.55 ± 10.97	91.38 ± 13.21	1.225	0.225
VC (score)	69.34 ± 15.37	67.73 ± 21.05	0.537	0.593
50-meter run (score)	66.73 ± 22.24	64.82 ± 20.51	0.584	0.559
Sit-and-reach (score)	77.31 ± 13.20	75.16 ± 17.66	1.081	0.280
Rope skipping (score)	65.98 ± 18.02	67.87 ± 16.03	−0.684	0.494
Sit-ups (score)	72.28 ± 9.22	72.26 ± 13.04	0.013	0.989
50 × 8 shuttle run (score)	72.26 ± 15.71	72.31 ± 6.78	−0.012	0.991
Total Score	71.67 ± 8.75	68.59 ± 6.78	2.409	0.021*

Note: * represents $P < 0.05$; ** represents $P < 0.01$.

Table 12. The relationship between ATR and physical fitness.

Indicator	r	*P*-Value
Height (cm)	0.078	0.031*
Weight (kg)	0.062	0.085
BMI (score)	−0.023	0.526
VC (score)	−0.066	0.084
50-meter run (score)	−0.039	0.319
Sit-and-reach (score)	−0.064	0.094
Rope skipping (score)	−0.027	0.484
Sit-ups (score)	−0.058	0.225
50m*8 shuttle run (score)	0.095	0.255
Total Score	−0.103	0.035*

Note: * represents $P < 0.05$; ** represents $P < 0.01$.

From the above results, postural scoliosis can affect the overall physical fitness level of primary school students. However, will these differences be reflected in specific school stages and/or in specific physical fitness test items? Will these differences be helpful for early screening and assessment of scoliosis in schools? To further explore these questions, the study analyzed the differences in physical fitness between the two groups of primary students in more detail, according to stage and BMI levels (Tables 13-15), and some more results were yielded.

From Table 13, it can be seen that the 50-meter run and 1-minute rope skipping scores of the primary school students with postural scoliosis in stage one are lower than those of the normal stage one students. The score for the 50-meter run shows significant differences ($P = 0.01$), indicating that particular attention should be paid to the low scores of the 50-meter run in the physical fitness test for first and second grade primary students, early school scoliosis screening can be conducted for these children.

The analysis in Table 14 and Table 15 focused on underweight and overweight primary students. From Table 14, it is evident that the sit-up scores of underweight students with postural scoliosis are significantly lower than those of low-weight students with normal posture ($P = 0.000$). Similarly, the sit-and-reach scores of overweight students with postural scoliosis are significantly lower than those of overweight students with normal posture.

Finally, using Pearson correlation analysis, the severity of symptoms in primary students with postural scoliosis was found to have a significant correlation with their physical fitness test scores (Table 16). The analysis revealed that postural scoliosis has a considerable impact on the physical function and quality of affected students. ATR was found to have a highly significant negative correlation with vital capacity, 50-meter run and sit-ups scores ($P < 0.01$), a significant negative correlation with sit-and-reach scores ($P < 0.05$). This indicates that as the symptoms worsen, the lung capacity, short-distance running, sitting trunk flexion, and sit-up abilities of these students decline. Therefore, it suggests that core strength, flexibility, and lower limb explosive power training should be emphasized during physical education classes for primary school students with postural scoliosis.

Table 13. The relationship between postural scoliosis and the physical fitness of primary students in stage one.

Indicator	Normal (N = 163)	Postural Scoliosis (N = 13)	t	*P*-Value
Height (cm)	122.71 ± 5.62	124.31 ± 8.74	−0.649	0.528
Weight (kg)	23.25 ± 4.39	23.84 ± 4.21	−0.466	0.642
BMI (score)	95.95 ± 9.73	96.92 ± 7.51	−0.352	0.725
VC (score)	71.20 ± 14.29	78.38 ± 21.59	−0.927	0.383
50-meter run (score)	77.49 ± 21.65	53.33 ± 31.23	2.607	0.010*
Sit-and-reach (score)	73.64 ± 14.80	74.43 ± 5.65	−0.140	0.889
Rope skipping (score)	67.50 ± 18.73	66.00 ± 19.59	0.218	0.828
Total Score	76.13 ± 9.62	68.78 ± 3.30	1.699	0.092

Note: * represents $P < 0.05$; ** represents $P < 0.01$.

Table 14. The relationship between postural scoliosis and the physical fitness of underweight primary school students (N = 151).

Indicator	Normal (N = 137)	Postural Scoliosis (N = 14)	t	*P*-Value
Height (cm)	133.52 ± 8.47	135.71 ± 7.91	−0.928	0.355
Weight (kg)	23.49 ± 3.38	23.86 ± 2.61	−0.401	0.689
VC (score)	65.77 ± 17.07	63.42 ± 19.40	0.452	0.652
50-meter run (score)	65.91 ± 20.10	70.00 ± 5.72	−0.505	0.616
Sit-and-reach (score)	76.62 ± 15.81	76.27 ± 14.70	0.071	0.944
Sit-ups (score)	74.02 ± 9.96	32.20 ± 8.05	12.82	0.000**
Total Score	68.46 ± 7.32	66.53 ± 6.39	0.720	0.474

Note: * represents $P < 0.05$; ** represents $P < 0.01$.

Table 15. The relationship between postural scoliosis and the physical fitness of overweight primary school students (N = 36).

Indicator	Normal (N = 34)	Postural Scoliosis (N = 2)	t	*P*-Value
Height (cm)	129.04 ± 9.94	122.00 ± 0.00	4.134	0.000**
Weight (kg)	34.21 ± 7.61	27.75 ± 0.35	4.682	0.000**
VC (score)	67.21 ± 20.89	45.00 ± 7.10	1.481	0.148
50-meter run (score)	61.20 ± 20.81	-	-	-
Sit-and-reach (score)	75.72 ± 11.22	66.00 ± 0.00	4.901	0.000**
Sit-ups (score)	73.43 ± 12.88	-	-	-
Rope skipping (score)	65.61 ± 17.19	65.00 ± 7.10	0.049	0.961
Total Score	76.13 ± 9.62	68.78 ± 3.30	0.511	0.621

Note: * represents $P < 0.05$; ** represents $P < 0.01$. The missing data is due to the failure to test sit-ups and the 50 m × 8 shuttle run for some overweight primary school students in stage one.

Table 16. The relationship between ATR and physical fitness test scores in primary students with postural scoliosis (N = 35).

Indicator (score)	r	*P*-Value
BMI	0.166	0.185
VC	−0.432	0.002**
50-meter run	−0.413	0.003**
Sit-and-reach	−0.281	0.048*
Rope skipping	0.092	0.528
Sit-ups	−0.328	0.018**
50 m × 8 shuttle run	0.206	0.501
Total Score	0.196	0.281

Note: * represents $P < 0.05$; ** represents $P < 0.01$.

4. Discussion

4.1. The Overall Physical Fitness Status of Primary Students

In this study, the overall physical fitness status of primary school students is relatively good. The overall qualified rate of physical fitness tests for 775 primary school students reached 91.39%. However, with increasing age, there is a declining trend in the rate, with stage three having the lowest overall qualified rate among the three stages (86.99%). The conclusion regarding the rate of excellent physical fitness is shocking, with only 1.44% meeting the criteria for excellent. In stage two, none of the 132 students achieved an excellent rating, and in stage three, none of the 127 students achieved excellent or good ratings. As students enter the critical period of transitioning to junior high school in the fifth and sixth grades, academic pressure increases, leading to a likely reduction in time allocated for physical exercise, potentially resulting in a decline in physical fitness among these primary school students. Both schools and families need to effectively reduce the academic burden on primary students, ensuring that they have at least 1 hour of physical activity both inside and outside of school each day, while also actively promoting physical exercise activities at home (Ji & Ma, 2019).

4.2. The Overall Postural Scoliosis Status of Primary Students

4.2.1. The Detection Rate of Postural Scoliosis Increases with Age and Stage

Research has indicated that the peak age for the onset of scoliosis is 10 years old, particularly for girls within one to two years after menarche (Ye & Wang, 2022). In this study, the detection rate of postural scoliosis among primary students in Yangjiang City showed an increasing trend from 6 to 9 years of age, with fluctuations and a peak at 11 years (12.93%). Similarly, the detection rate increased across academic stages, with the highest rate (9.15%) observed in stage three, consistent with existing research findings.

Given the prominence of posture issues, especially spinal scoliosis, among primary students, and the strong musculoskeletal plasticity of school-age youth (Wilczyński et al., 2020), it is recommended to incorporate posture education into the physical education curriculum and integrate it into physical education and daily routines. It is also important to emphasize school-based screening for scoliosis, with regions and schools with the necessary resources ideally conducting regular annual screenings. Furthermore, in school screenings, particular attention should be given to students in the 10 - 11 years old.

4.2.2. Obesity May Be Associated to Some Extent with Postural Scoliosis

According to the National Student Physical Health Standards, students are divided into four groups based on their body mass index (BMI). Study found that the detection rate of postural scoliosis was highest in the obese group, reaching 16.67%. At the same time, the average body weight of primary students with postural scoliosis was higher than that of the normal weight group. This indi-

cates that there may be some degree of association between obesity and postural scoliosis, potentially making it one of the causes of it in elementary school students.

4.2.3. Postural Scoliosis Has a Profound Impact on the Physical Health Level of Primary Students

The BMI, vital capacity, 50-meter run, sit-and-reach, and 1-minute sit-up scores of primary students with postural scoliosis were lower than those of normal students, and the differences in their overall physical fitness scores were significant ($P < 0.05$). Correlation analysis showed a negative correlation between ATR and students' overall physical fitness scores ($P < 0.05$), indicating that the more severe the symptoms, the lower the level of physical fitness. These results are consistent with the findings of Walaszek et al., confirming the negative impact of poor posture, such as spinal scoliosis, on the growth and development of elementary school students (Walaszek et al., 2019).

Primary students with postural scoliosis had significantly lower scores in the 50-meter run compared to those with normal posture ($P < 0.05$). In a normal posture, the muscles of the body are in a perfect balance, allowing for safe and efficient movement (Karaleić et al., 2014). However, when there are postural issues in certain parts of the body, an imbalance in strength may occur, leading to compensation in some muscles and bones. This compensation can easily cause structural and functional imbalances. Scoliosis may lead to problems such as unequal leg lengths and pelvic tilt in primary students, affecting lower limb strength and explosiveness. Over time, this can cause structural damage to the body. Therefore, in school physical fitness tests, special attention should be given to the low scores in the 50-meter run of stage one elementary students. Early scoliosis screening for these children at school should be considered.

The sit-up scores of underweight primary students with postural scoliosis were significantly lower than those of underweight students with normal posture ($P < 0.01$). The sit-up test assesses the core strength of students, and scoliosis can cause an imbalance in the back muscles on both sides of the spine, leading to instability in the spine (Yin & Wang, 2023). In this study, underweight students with postural scoliosis may have scored low in sit-ups due to insufficient core strength, therefore it is important for schools and teachers to pay special attention to underweight students with poor sit-up test performance, as this may indicate an imbalance in spine or even scoliosis. In regular physical education classes, these affected students should be given additional training to strengthen their core muscles, balance the imbalanced muscle strength on both sides of the spine, and adjust poor posture through the combined action of superficial and deep muscles to correct spinal deformity development (Qi et al., 2022).

The sit-and-reach score of overweight students with postural scoliosis was significantly lower than that of overweight students with normal posture ($P < 0.01$). Sit-and-reach is an important indicator for measuring the flexibility of primary and secondary school students and measures the potential range of mo-

tion of the body in a static state, reflecting the extensibility and elasticity of joints, ligaments, and muscles. Research has found that scoliosis can have adverse effects on spinal flexion, lateral flexion, rotation, and extension, thereby affecting the overall mobility of patients (Chen & Wang, 2021). In this study, the sit-and-reach scores of overweight students with postural scoliosis may be due to reduced thoracolumbar mobility caused by the scoliosis. Therefore, particular attention should be paid to these students in physical fitness testing, as they may be at risk of scoliosis.

Among the affected primary students, the difference in ATR indicates the severity of postural scoliosis. The more severe the symptom, the lower the score of vital capacity, sit and reach and 1-minute sit-up, and the two have a very significant negative correlation ($P < 0.01$). Therefore, personalized and precise teaching should be done in physical education class, and corresponding intensive training should be given to these students to help them gradually return to normal posture.

5. Conclusion

The overall physical fitness assessment of primary students is good, but there is a serious lack of the "excellent" and the qualified rate decreases with age.

The detection rate of postural scoliosis increases with age and stage.

Postural scoliosis has a significant negative impact on the physical function and physical quality of primary students.

There are three groups of primary students that need special attention in physical fitness tests: 1) stage one children with low 50-meter run scores; 2) underweight children with low sit-up scores; 3) overweight children with low sit-and-reach scores.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Baird, C., Archer, J., Gardner, A., Rushton, A., & Heneghan, N. R. (2022). Outcomes Evaluating Quality of Life and Their Measurement Properties in Early-Onset Scoliosis: A Systematic Review. *Journal of Pediatric Orthopaedics, 42,* e917-e924. https://doi.org/10.1097/BPO.0000000000002161

Chen, C. (2022). Research on the Abnormal Body Posture of Adolescents and Policy Suggestions for Prevention and Control. *China Sport Science and Technology, 58,* 35-39.

Chen, X, Q., & Wang, X. J. (2021). Effects of Aerobic Physical Training Combined with Health Education on Spinal Functional Pain and Quality of Life in Children with Idiopathic Scoliosis. *Maternal and Child Health Care of China, 36,* 3360-3363.

Chinese Ministry of Education (n.d.a). *Curriculum Plan and Curriculum Standards for Compulsory Education (2022 Edition).* http://fx.xwapp.moe.gov.cn/article/202204/6260ba231916aa00012eb112.html

Chinese Ministry of Education (n.d.b). *Notice about National Student Physical Health Standards (Revised in 2014).* http://www.moe.gov.cn/s78/A17/twys_left/moe_938/moe_792/s3273/201407/t20140708_171692.html

Chinese National Health and Family Planning Commission (n.d.). *Screening for Spinal Deformities in Children and Adolescents (GB/T 16133-2014).* http://www.nhc.gov.cn/wjw/pqt/201504/41bc1b2d2ba949f8882619a744f7b131.shtml

Khosravi, G., Sharif, M. R., Khosravi, E., Kardan, F., Kashani, H. H., & Sayyah, M. (2016). A Study to Determine the Frequency Rate of Scoliosis Disorder and Compare the Anthropometric Characteristics of Normal versus the Scoliosis Diagnosed Students. *Global Journal of Health Science, 8,* 288-293.

Ji, L., & Ma, D. H. (2019). Research on the Reform and Development of Chinese School Sports in the New Era. *China Sport Science, 39,* 3-12.

Karaleić, S., Vesko, M., & Savić, Z. (2014). The Influence of Physical Education Curriculum on the Correction of Bad Body Posture and Changes of Motor Status in Adolescence Period of Schoolgirls. *Activities in Physical Education & Sport, 4,* 92-94.

Li, J., & Diao, Y. C. (2013). A Comparative Study of Fundamental Motor Skill of Children Aged 3 to 10 Years Old. *China Sport Science and Technology, 49,* 129-132.

Qi, K. X., Fu, H. D., & Yang, Z. (2022). Effects of Core Stabilization Training on the Cobb Angle and Pulmonary Function in Adolescent Patients with Idiopathic Scoliosis. *Journal of Environmental and Public Health, 2022,* Article ID: 4263393. https://doi.org/10.1155/2022/4263393

Sun, Y., Liu, W. J., Xiong, L. H., Li, M., Chen, S. Y., He, W. Y. et al (2021). Scoliosis and Associated Factors among Middle School Students in Guangzhou City. *Chinese Journal of School Health, 42,* 1867-1870+1873.

Walaszek, R., Sterkowicz, S., & Chwala, W. (2019). Assessment of Body Posture with the Moire's Photogrammetric Method in Boys Practising Judo versus Their Non-Sports-Practising Peers. *Science & Sports, 34,* e187-e194. https://doi.org/10.1016/j.scispo.2018.08.009

Wilczyński, J., Lipińska-Stańczak, M., & Wilczyński, I. (2020). Body Posture Defects and Body Composition in School Age Children. *Children, 7,* Article 204. https://doi.org/10.3390/children7110204

Xu, S., Su, Y. J., & Wang, Z. B. (2021). The Prevalence and Characteristics of Primary and Middle-School Students in China: A Meta-Analysis Based on 72 Epidemiological Research. *Chinese Journal of Spine and Spinal Cord, 31,* 901-910.

Ye, H. Y., & Wang, Z. F. (2022). Progress of Epidemiological Study on Adolescent Idiopathic Scoliosis. *Systems Medicine, 7,* 192-196.

Yin, D., & Wang, H. (2023). Effect of BSPTS Combined with Core Strength Training on Mild Adolescent Idiopathic Scoliosis. *Journal of Henan Normal University (Natural Science Edition), 51,* 140-148.

Zhen, Z. P. (2020). Evaluation of Physical Development Characteristics of Children with Different Postures in Beijing from the Perspective of the Integration of Sports and Education. *Journal of Beijing Sport University, 10,* 68-81.