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Students' association of poor eye-use behavior with myopia: focus on study phase

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Abstract

Background To investigate the prevalence of poor eye-use behavior and myopia in Chinese students, and examine the associations of poor eye-use behavior with myopia, as well as its study phase differences.

Methods From March to July 2023, a total of 67 910 students were selected from 56 schools in 14 cities of China by stratified cluster sampling. The Eye-use Behavior Evaluation Scale for Students (EBESS) was adopted to investigate the eye-use behavior of students. Students underwent an uncorrected visual acuity examination and a non-cycloplegic autorefraction examination. The chi-square test was used to compare the prevalence of myopia between different groups. The binary logistic regression model was conducted to analyze the association of poor eye-use behavior with myopia.

Results The prevalence of poor eye-use behavior and myopia of students were 27.6% and 53.0%, respectively. The poorer the eye-use behavior of students, the higher the prevalence of myopia ($P < 0.001$). After adjusting for age, gender, sibling, parental myopia, parental education level, self-reported learning burden, mode of travel to school, physical education lesson, city, usage distance of mobile phone / iPad / game console, reading and writing distance, weekdays outdoor time, and weekends outdoor time, binary logistic regression model analysis results showed that the poor eye-use behavior was positively correlated with myopia (*OR* = 1.10, 95% *CI*: 1.03 ~ 1.19). According to the study phase and further stratified analysis, in primary school (*OR* = 1.35, 95% *CI*: 1.20 ~ 1.50) and senior high school students (*OR* = 1.28, 95% *CI*: 1.08 ~ 1.51), poor eye-use behavior was positively correlated with myopia. However, in kindergarten and junior high school students, there was no statistically significant difference ($P > 0.05$).

Conclusion Poor eye-use behavior was a potential risk factor for myopia in students, and this effect was significantly different between study phases. This suggests that future research should establish interventions to protect students from the effects of poor eye-use behavior.

Keywords Eye-use behavior, Myopia, Study phase

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Background

Myopia, a common refractive error disorder, refers to the condition in which rays of light parallel to the optic axis enter the refractive system and focus in front of the retina when ocular accommodation is relaxed [1]. It is predicted that by 2050, approximately 49.8% of the global population will have varying degrees of myopia, with roughly 9.8% of this group progressing to high myopia [2]. China is one of the countries with high prevalence of myopia among children and adolescents [3]. According to the latest statistics, the prevalence of myopia among children and adolescents in China is 51.9%, among which the myopia rates of primary school students, junior high school students, and senior high school students are 36.7%, 71.4%, and 81.2%, respectively [4]. Children and adolescents are not only more likely to develop high myopia, but also have an increased risk of eye diseases such as macular degeneration, glaucoma, cataracts, and chorio-retinal atrophy in adulthood, resulting in early vision impairment and even vision loss [5–8]. In addition, the global economic cost of myopia is estimated at $20.2 billion per year, with profound consequences for both individuals and society [9]. Therefore, it is crucial to reduce the prevalence of myopia in children and adolescents.

Both genetic and environmental factors play crucial roles in the development and progression of myopia, despite their precise mechanisms being unknown. Epidemiological studies have shown that factors such as increasing age, family history, and a larger amount of near work are related to the higher prevalence of myopia [10–12]. Poor eye use habits, prolonged sitting at a desk for homework, excessive eye use, frequent use of electronic devices, and other close-eye use behaviors can increase the risk of myopia, while, engaging in various outdoor activity can decrease the risk of myopia [13–15]. Similarly, studies have found that children and adolescents who spend more time outdoors are less likely to develop myopia [16–17]. This may be because outdoor light can effectively prevent myopia by stimulating the release of dopamine in the retina and inhibiting the elongation of the eye axis [18–19]. Sleep duration also plays a significant role in the development of myopia [20]. Children who slept for 7 h or less, or approximately 8 h per day, exhibited a higher risk of developing myopia compared to those who slept for 9 h or more each day [20]. Studies have demonstrated a strong correlation between the high incidence of axial myopia among children and adolescents and environmental factors, including the environment in which children develop and their lifestyle habits [21–22]. Thus, it is necessary to pay attention to eye-use behavior (such as reading and writing posture, electronic device use, outdoor activity time, and sleep…) and the living environment of children and adolescents.

Based on research evidence, it appears that maintaining good eye-use habits seems to be an important factor in preventing myopia, and these factors include sleeping, reading and writing habits, outdoor activity, time spent in outdoor light, electronic device use, near work, and other vision-related habits [12, 16–17, 23, 24, 25]. Therefore, we adopted the Eye-use Behavior Evaluation Scale for Students (EBESS) to evaluate the eye-use behavior of students from outdoor activity time, electronic device use, sleep, social jet lag, reading and writing posture, visual environment, eye relaxation behavior, and other aspects [26]. The EBESS developed by our team exhibits strong reliability and validity, and future studies will further report on its development and validation. Furthermore, the EBESS has been adopted by the National Disease Control and Prevention Administration in 2023 and incorporated into the "Technical Guide for Public Health Comprehensive Intervention in the Prevention and Control of Myopia in Children and Adolescents" [26]. The aim of the current study is twofold: (a) to describe the prevalence of poor eye-use behavior and myopia in Chinese students, (b) to examine the associations of poor eye-use behavior with myopia in Chinese students, as well as its study phase differences.

Methods

Participants

This research was conducted between March and July 2023. Participants were recruited from 14 cities in China including Anqing, Bengbu, Chizhou, Chuzhou, Fuyang, Ganzhou, Hefei, Huangshan, Jiujiang, Luan, Maanshan, Xuancheng, Yangzhou, and Zhongshan, using stratified cluster sampling. First, 14 cities were selected by convenience sampling. Then, 1 kindergarten, 1 primary school, 1 junior high school, and 1 senior high school were randomly selected for each city using stratified cluster sampling. Finally, all students from 56 schools were required to complete a questionnaire survey. Students completed the electronic questionnaire by using smartphones to scan the quick response code. The questionnaire for kindergarten and primary school grades 1 ~ 3 students was filled out by parents or other guardians, and the questionnaire for primary school grades 4 ~ 6, junior high school, and senior high school students was filled out by students. All students from 56 schools were required to complete an uncorrected visual acuity examination and a non-cycloplegic autorefraction examination. The exclusion criteria were as follows: having a history of ocular surgery and having an eye disease.

The Ethics Committee of Anhui Medical University approved this study (NO: 20210735). Both the adult participants and the parents / guardians of all under-18s provided written informed consent.

Sociodemographic data

The following sociodemographic characteristics were obtained: age, gender (boys, girls), ethnicity (Han-ethnicity, others), study phase (kindergarten, primary school, junior high school, senior high school), number of siblings (0, ≥ 1), parental myopia (none myopia, one myopia, both myopia), parental education level (middle school and below, senior high school, college and above), self-reported learning burden (a little, some, much), mode of travel to school (walk to and from school, take public transportation, take the electric bike, ride on a bicycle, take a car), physical education classes (1 time a day, 4 times a week, 3 times a week, 2 times a week, be unaware of), city (Anqing, Bengbu, Chizhou, Chuzhou, Fuyang, Ganzhou, Hefei, Huangshan, Jiujiang, Luan, Maanshan, Xuancheng, Yangzhou, and Zhongshan), usage distance of mobile phone / iPad / game console (< 20 cm, 20 ~ 30 cm, > 30 cm), reading and writing distance (< 20 cm, 20 ~ 30 cm, > 30 cm), weekdays outdoor time (< 1 h/d, 1 ~ 2 h/d, > 2 h/d), and weekends outdoor time (< 1 h/d, 1 ~ 2 h/d, > 2 h/d).

Eye-use behavior evaluation

The EBESS was used to assess eye-use behavior in students [26]. The EBESS was composed of 2 sub-scales, including 15 items for kindergarten and primary school grades 1 ~ 3 students scale (see Table S1) and 16 items for primary school grades 4 ~ 6, junior high school, and senior high school students scale (see Table S2). Each item was rated on a Likert-type scale: 0 = "I can't do it," 1 = "I sometimes do it," 2 = "I can do it." The higher the total score indicates the better the eye-use behavior. According to the score, eye-use behavior can be divided into 3 groups: poor (0 to 19 points), medium (20 to 27 points), and good (28 to 30 points) in kindergarten and primary school grades 1 ~ 3 students. Similarly, eye-use behavior can be divided into 3 groups: poor (0 to 18 points), medium (19 to 29 points), and good (30 to 32 points) in primary school grades 4 ~ 6, junior high school, and senior high school students.

Visual acuity examination

In the present study, the standard logarithmic visual acuity E chart (conforming to the National Standard of People's Republic of China, GB 11533–2011) was used to evaluate the students' visual acuity. This standard recommends a five-mark record for Chinese students, equivalent to five minus the logarithm of the minimum angle of resolution (LogMAR) [27]. Visual acuity is measured on a scale ranging from 4.0 to 5.3, where higher values indicate better visual acuity [28]. The standard logarithmic visual acuity E chart was positioned within an illuminated cabinet, maintaining a luminance range of 80–320 cd/m^2, and has been extensively used for screening reduced visual acuity in ophthalmology clinics and schools in China for over two decades [29]. The visual acuity examination was performed at a distance of 5 m from the standard logarithmic visual acuity E chart. It started with the right eye and then moved to the left eye, with the visual acuity of both eyes being recorded using the five-mark recording method. The procedure conformed to the International standard for recording visual acuity [30]. Prior to the visual acuity examination, students were instructed to remove their glasses or contact lenses. Then, uncorrected visual acuity (UCVA) was tested by opticians adhering to standard logarithmic vision testing procedures to ensure accurate and reliable inspection results. Finally, the values were transformed into logMAR for subsequent analyses (see Table S3) [30]. In this study, since the visual acuity of students' left and right eyes were highly correlated (r_{UCVA} = 0.828, $P < 0.001$), we used data from the right eye for the analysis.

Non-cycloplegic autorefraction examinations

Following the visual acuity examination, the refractive error of both eyes was accurately measured using an auto-refractor keratometer (KR-8800, Topcon, Tokyo, Japan) in a non-cycloplegic state. The device automatically obtained three measurements, which were then averaged. The refractive error was subsequently calculated as the spherical equivalent (SE) of the sphere plus half of the cylinder based on the auto-refraction results. If the SE refraction values of any two examinations differed by 0.50 diopters (D) or more, an additional measurement was conducted. In this study, since the refractive powers of students' left and right eyes were highly correlated (r_{SE} = 0.853, $P < 0.001$), we used data from the right eye for the analysis.

Definitions of reduced UCVA and myopia

In this study, reduced UCVA and myopia were defined according to the "Appropriate Technical Guidelines for Prevention and Control of Myopia in Children and Adolescents (Updated Edition)" issued by the National Health Commission of the People's Republic of China in 2021 [31]. Reduced UCVA was defined as UCVA ≥ 0.3 logMAR for children aged 3 years, UCVA ≥ 0.2 log MAR for children aged 4 years, UCVA ≥ 0.1 logMAR for children aged 5 years, and UCVA > 0.0 logMAR for children aged 6 years or older [31]. Myopia was defined as UCVA ≥ 0.3 logMAR and SE ≤ – 0.50 D for children aged 3 years, UCVA ≥ 0.2 logMAR and SE ≤ – 0.50 D for children aged 4 years, UCVA ≥ 0.1 logMAR and SE ≤ – 0.50 D for children aged 5 years, as well as UCVA > 0.0 logMAR and SE ≤ – 0.50 D for children aged 6 years or older [31].

Statistical analyses

Statistical analysis was performed using SPSS software (version 23.0). Categorical variables were presented as frequencies and percentages, and continuous variables as mean ± standard deviation (mean ± SD). A chi-square test was conducted to compare the prevalence of myopia between different groups. The binary logistic regression model was used to analyze the association of eye-use behavior with myopia, including myopia as outcomes, and eye-use behavior as predictors. Age, gender, sibling, parental myopia, parental education level, self-reported learning burden, mode of travel to school, physical education lesson, city, usage distance of mobile phone / iPad / game console, reading and writing distance, weekdays outdoor time, and weekends outdoor time as covariates. The odds ratio (*OR*) and 95% confidence interval (*CI*) were reported. $P < 0.05$ was considered to be statistically significant.

Results

Distribution of myopia among students with different characteristics

In this study, a total of 67 910 questionnaires were sent out, 50 299 were returned and 48 529 were valid. 25 595 were boys (52.7%), and 22 934 were girls (47.3%). The effective questionnaire rate was 96.5%. After the questionnaire and vision data were matched based on participants' unique identification, the final data represented 36 400 valid cases. As shown in Table 1. The mean age of the 36 400 students was 12.23 years (SD = 3.75), and 52.5% (19 102 / 36 400) were boys. The prevalence of myopia in students was 53.0%. The prevalence of myopia was higher in girls than in boys ($P < 0.001$). The majority of the 36 400 students in this sample were of Han ethnicity (98.2%, $n = 35\ 752$). The prevalence of myopia in kindergarten, primary school students, junior high school students, and senior high school students was 7.3%, 35.1%, 68.9%, and 81.1%, respectively ($P < 0.001$). Students without siblings have a higher prevalence of myopia compared to those with siblings ($P < 0.001$). Students whose parents were myopia have a higher risk of developing myopia ($P < 0.001$). The prevalence of myopia exhibited a significant increasing trend with decreasing parental education levels and increasing study burdens among students ($P < 0.001$). The prevalence of myopia in students was highest among those who take public transportation, followed by those who ride bicycles, those who take cars, those who walk to and from school, and those who take the electric bike ($P < 0.001$). The closer the distance when students use mobile phone, iPad, or game console, as well as the reading and writing distance, the higher the prevalence of myopia ($P < 0.001$). Similarly, the shorter the time students spend on outdoor activities on weekdays and weekends, the higher the prevalence of myopia ($P < 0.001$). Additionally, the overall prevalence of myopia among students within the groups experiencing reduced UCVA was 84.1% (see Fig. 1). In kindergarten, primary school, junior high school, and senior high school, the prevalence of myopia among students within the groups with reduced UCVA was 11.8%, 79.1%, 95.0%, and 95.2%, respectively (see Fig. 1).

Comparison of myopia among different eye-use behavior

As shown in Table 2. The prevalence of good, medium, and poor eye-use behavior of students was 27.7%, 44.7%, and 27.6%, respectively. The poorer the eye-use behavior of students, the higher the prevalence of myopia ($P < 0.001$). According to the study phase and further stratified analysis, the results indicate that in both primary school and senior high school students, the poorer the eye-use behavior of students, the higher the prevalence of myopia ($P < 0.001$). However, there was no statistically significant difference among kindergarten and junior high school students ($P > 0.05$).

Association of eye-use behavior with myopia

As shown in Table 3. Binary logistic regression model analysis results showed that medium and poor eye-use behavior was positively correlated with myopia, the *OR* values (95% *CI*) were 1.12 (1.06 ~ 1.17), and 1.65 (1.56 ~ 1.74), respectively. According to the study phase and further stratified analysis, in primary school students, the medium and poor eye-use behavior was positively correlated with myopia, the *OR* values (95% *CI*) were 1.25 (1.15 ~ 1.36), and 1.46 (1.33 ~ 1.61), respectively. In senior high school students, the medium and poor eye-use behavior was positively correlated with myopia, the *OR* values (95% *CI*) were 1.27 (1.09 ~ 1.49), and 1.63 (1.40 ~ 1.90), respectively. However, in kindergarten and junior high school students, there was no statistically significant difference ($P > 0.05$).

As shown in Table 4. After controlling for age, gender, sibling, parental myopia, parental education level, self-reported learning burden, mode of travel to school, physical education lesson, city, usage distance of mobile phone / iPad / game console, reading and writing distance, weekdays outdoor time, and weekends outdoor time. Binary logistic regression model analysis results showed that poor eye-use behavior was positively correlated with myopia (*OR* = 1.10, 95% *CI*: 1.03 ~ 1.19). According to the study phase and further stratified analysis, in primary school students, the medium and poor eye-use behavior was positively correlated with myopia, the *OR* values (95% *CI*) were 1.16 (1.06 ~ 1.27), and 1.35 (1.20 ~ 1.50), respectively. In senior high school students, the poor eye-use behavior was positively correlated with myopia (*OR* = 1.28, 95% *CI*: 1.08 ~ 1.51). However, in

Table 1 Distribution of myopia among students with different characteristics

Variable	*n* (%)	Myopia	χ^2 value	*P* value
Age (mean ± SD)	12.23 ± 3.75			
Sex			171.25	< 0.001
Boys	19,102(52.5)	9506(49.8)		
Girls	17,298(47.5)	9794(56.6)		
Ethnicity			2.94	0.087
Han-ethnicity	35,752(98.2)	18,978(53.1)		
Others	648(1.8)	322(49.7)		
Study phase			7860.72	< 0.001
Kindergarten	2830(7.8)	208(7.3)		
Primary school	14,757(40.5)	5178(35.1)		
Junior high school	10,995(30.2)	7573(68.9)		
Senior high school	7818(21.5)	6341(81.1)		
Number of siblings			52.23	< 0.001
0	11,728(32.2)	6540(55.8)		
≥ 1	24,672(67.8)	12,760(51.7)		
Parental myopia			18.60	< 0.001
None	19,874(54.9)	10,412(52.4)		
One	11,560(31.9)	6345(54.9)		
Both	4781(13.2)	2529(52.9)		
Paternal education level			745.13	< 0.001
Middle school and below	15,594(42.8)	9276(59.5)		
Senior high school	9697(26.6)	5281(54.5)		
College and above	11,109(30.6)	4743(42.7)		
Maternal education level			905.92	< 0.001
Middle school and below	17,049(46.8)	10,213(59.9)		
Senior high school	8833(24.3)	4743(53.7)		
College and above	10,518(28.9)	4344(41.3)		
Self-reported learning burden			1579.70	< 0.001
A little	4845(13.3)	1534(31.7)		
Some	24,006(66.0)	12,624(52.6)		
Much	7549(20.7)	5142(68.1)		
Mode of travel to school			662.71	< 0.001
Walk to and from school	10,080(27.7)	5420(53.8)		
Take public transportation	3496(9.6)	2468(70.6)		
Take the electric bike	16,015(44.0)	7621(47.6)		
Ride on a bicycle	1545(4.2)	933(60.4)		
Take a car	5264(14.5)	2858(54.3)		
Physical education lesson			1074.36	< 0.001
1 time a day	2107(5.8)	1401(66.5)		
4 times a week	5783(15.9)	2942(50.9)		
3 times a week	10,169(27.9)	5497(54.1)		
2 times a week	16,442(45.2)	9095(55.3)		
Be unaware of	1899(5.2)	365(19.2)		
City			1505.48	< 0.001
Anqing	1805(5.0)	912(50.5)		
Bengbu	2737(7.5)	1857(67.8)		
Chizhou	1688(4.6)	770(45.6)		
Chuzhou	4770(13.1)	2970(62.3)		
Fuyang	2161(5.9)	947(43.8)		
Ganzhou	3032(8.3)	1219(40.2)		
Hefei	3250(8.9)	2022(62.2)		
Huangshan	1612(4.4)	1062(65.9)		
Jiujiang	3520(9.7)	1378(39.1)		

Table 1 (continued)

Variable	*n* (%)	Myopia	χ^2 value	*P* value
Luan	1641(4.5)	543(33.1)		
Maanshan	1554(4.3)	915(58.9)		
Xuancheng	2471(6.8)	1301(52.7)		
Yangzhou	2315(6.4)	1288(55.6)		
Zhongshan	3844(10.6)	2116(55.0)		
Usage distance of mobile phone / iPad / game console			266.82	< 0.001
< 20 cm	18,755(51.5)	10,567(56.3)		
20 ~ 30 cm	10,187(28.0)	5362(52.6)		
> 30 cm	7458(20.5)	3371(45.2)		
Reading and writing distance			31.52	< 0.001
< 20 cm	16,972(46.6)	9144(53.9)		
20 ~ 30 cm	12,623(34.7)	6755(53.5)		
> 30 cm	6805(18.7)	3401(50.0)		
Weekdays outdoor time			48.55	< 0.001
< 1 h/d	15,170(41.7)	8328(54.9)		
1 ~ 2 h/d	11,021(30.3)	5571(50.5)		
> 2 h/d	10,209(28.0)	5401(52.9)		
Weekends outdoor time			259.04	< 0.001
< 1 h/d	12,482(34.3)	7332(58.7)		
1 ~ 2 h/d	10,933(30.0)	5590(51.1)		
> 2 h/d	12,985(35.7)	6378(49.1)		

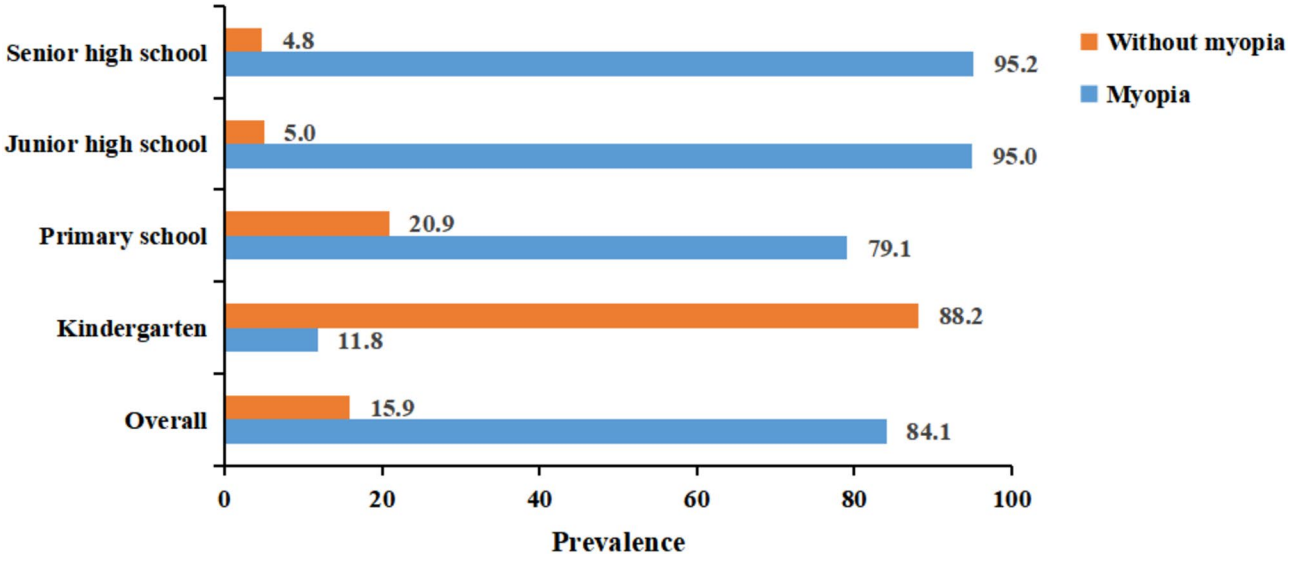

Fig. 1 The prevalence of myopia among reduced UCVA

kindergarten and junior high school students, there was no statistically significant difference ($P > 0.05$).

Discussion

The main findings of the present study were as follows: (a) the prevalence of poor eye-use behavior and myopia of students were 27.6% and 53.0%, respectively; (b) after adjusting for covariates, the poor eye-use behavior was positively correlated with myopia; and (c) according to the study phase and further stratified analysis, in primary school and senior high school students, the poor eye-use behavior was positively correlated with myopia, but not in kindergarten and junior high school students. This study can provide valuable information for the prevention and control of myopia in children and adolescents from the perspective of epidemiology.

In this study, the prevalence of myopia among students was 53.0%. The prevalence of myopia among kindergarten, primary school students, junior high school students, and senior high school students was 7.3%, 35.1%, 68.9%, and 81.1%, respectively. It was at a lower level compared with other studies. For instance, in a survey in

Table 2 Comparison of myopia among different eye-use behavior groups

Study phase	Eye-use behavior	*n* (%)	Myopia	χ^2 value	*P* value
Overall	Good	10,099(27.7)	4888(48.4)	348.42	< 0.001
	Medium	16,279(44.7)	8326(51.1)		
	Poor	10,022(27.6)	6086(60.7)		
Kindergarten	Good	1024(36.1)	85(8.3)	2.21	0.332
	Medium	1196(42.3)	80(6.7)		
	Poor	610(21.6)	43(7.0)		
Primary school	Good	4107(27.8)	1261(30.7)	61.78	< 0.001
	Medium	7313(49.6)	2605(35.6)		
	Poor	3337(22.6)	1312(39.3)		
Junior high school	Good	3603(32.8)	2504(69.5)	1.98	0.372
	Medium	4907(44.6)	3346(68.2)		
	Poor	2485(22.6)	1723(69.3)		
Senior high school	Good	1365(17.5)	1038(76.0)	41.35	< 0.001
	Medium	2863(36.6)	2295(80.2)		
	Poor	3590(45.9)	3008(83.8)		

Table 3 Eye-use behavior and myopia: results of binary logistic regression analysis

Study phase	Eye-use behavior	Myopia	
		OR value (95%CI)	*P* value
Overall	Good	1.00	
	Medium	1.12(1.06 ~ 1.17)	< 0.001
	Poor	1.65(1.56 ~ 1.74)	< 0.001
Kindergarten	Good	1.00	
	Medium	0.79(0.58 ~ 1.09)	0.150
	Poor	0.84(0.57 ~ 1.23)	0.363
Primary school	Good	1.00	
	Medium	1.25(1.15 ~ 1.36)	< 0.001
	Poor	1.46(1.33 ~ 1.61)	< 0.001
Junior high school	Good	1.00	
	Medium	0.94(0.86 ~ 1.03)	0.198
	Poor	0.99(0.89 ~ 1.11)	0.893
Senior high school	Good	1.00	
	Medium	1.27(1.09 ~ 1.49)	0.002
	Poor	1.63(1.40 ~ 1.90)	< 0.001

Ningbo, China, the prevalence of myopia among primary school students, junior high school students, and senior high school students was 61.49%, 81.43%, and 89.72%, respectively [32]. Similarly, a study of 34 644 students in Shenyang, China, found that the prevalence of myopia was 60.0%, with a prevalence of 42.0% for primary school students, 76.0% for junior high school students, and 88.0% for senior high school students [33]. Additionally, this study revealed that the prevalence of myopia increased with grade level, with the highest prevalence of 81.1% among senior high school students, which was related to the accumulation of myopia, but also to the increasing study tasks and more frequent use of eyes as the grade level increased.

At the same time, we found that poor eye-use behavior was positively correlated with myopia. In further analyses, we also found that poor eye-use behavior was positively correlated with myopia in primary school and senior high school students, but not in kindergarten and junior high school students. Similarly, a study of 4 798 senior high school students in Beijing, China, revealed that a higher prevalence of myopia was linked to shorter near-work distance, longer time spent near work, and lower frequency of active rest during studying [34]. Another study of 8 319 students from 26 primary schools in Shanghai, China, found that adequate instruction in reading and writing postures, outdoor activities during class recess or physical education class, and providing suitable desks and chairs might protect against pathological eye growth [35]. Furthermore, a study of 14 296 Chinese students aged 7 to 18 years found that increased risk of myopia in students due to excessive screen time, unhealthy lifestyles, and poor eyesight habits [36]. This is consistent with the findings of our study that poor eye use habits were associated with the development of myopia.

Table 4 The associations between eye-use behavior and myopia by adjusted binary logistic regression analysis

Study phase	Eye-use behavior	Myopia	
		OR value (95%CI)	*P* value
Overall	Good	1.00	
	Medium	1.04(0.98 ~ 1.11)	0.165
	Poor	1.10(1.03 ~ 1.19)	0.006
Kindergarten	Good	1.00	
	Medium	0.79(0.56 ~ 1.10)	0.162
	Poor	0.81(0.53 ~ 1.23)	0.323
Primary school	Good	1.00	
	Medium	1.16(1.06 ~ 1.27)	0.001
	Poor	1.35(1.20 ~ 1.50)	< 0.001
Junior high school	Good	1.00	
	Medium	0.99(0.90 ~ 1.10)	0.871
	Poor	1.00(0.88 ~ 1.13)	0.991
Senior high school	Good	1.00	
	Medium	1.12(0.95 ~ 1.31)	0.178
	Poor	1.28(1.08 ~ 1.51)	0.004

Note: Model adjusted for age, gender, sibling, parental myopia, parental education level, learning burden, mode of travel to school, physical education lesson, city, usage distance of mobile phone / iPad / game console, reading and writing distance, weekdays outdoor time, and weekends outdoor time

Our research has several limitations. First, self-report questionnaires were used to evaluate the eye-use behavior and learning burden of students. Thus, recall and reporting biases could not be avoided. Second, although it was well-established that cycloplegic refraction was better than non-cycloplegic autorefraction, our study did not use this method. This decision was primarily due to the substantial number of students involved and the constraints of available resources, making it challenging to conduct cycloplegic refraction. Third, we were not able to adjust for all possible covariates in our analysis and potential residual confounding could lead to bias in reported estimates. Fourth, some other factors affecting students' visual state may not be taken into account, such as daylight exposure time. Fifth, due to kindergarten students' limited ability to recognize the letter E, using a standard logarithmic visual acuity E chart for vision acuity screening may not reflect their true vision status. Sixth, due to the cross-sectional study design, this study does not allow to make assumptions about causal relationships. Seventh, time spent on near work is closely associated with myopia [12]. In the present study, the learning burden and some items in the EBESS scale both reflect students' close-range eye use behavior. However, neither of these two measurement methods can accurately reflect how long students spend in near work. Lastly, the poor correlation between eye use behavior and myopia observed in kindergarten and junior high school students may be attributed to the role of myopic shift from early stages, which has not yet progressed to a detectable level of myopia [37]. However, this phenomenon was not found in our study. Despite the above limitations, the strengths of our study include the large sample of participants, which may make our findings convincing. In addition, we use the EBESS to measure eye-use behavior in students. The EBESS was a comprehensive scale that included outdoor activity time, electronic device use, sleep, social jet lag, reading and writing posture, visual environment, eye relaxation behavior, and other aspects. It is an effective tool to evaluate the eye-use behaviors of students.

Conclusion

This research was the first to present evidence that poor eye use behavior was correlated with myopia among Chinese students. Our results suggest that poor eye-use behavior may be a potential risk factor for myopia in students. Therefore, future studies should establish interventions to protect students from the effects of poor eye-use behavior. Schools should strengthen eye use behavior education for students. Parents need to keep a close watch on their child's eye use behavior. If they find that the child exhibits poor eye use behavior, such as squinting, eye rubbing, etc., they should promptly correct and provide proper guidance.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12886-025-04072-1.

Supplementary Material 1

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Author contributions

Designed the experiments: Fangbiao Tao, Xiaoyan Wu. Conducted the experiments: Tingting Li, Peng Ding, Shaojun Xu, Shuman Tao. Analyzed the

data: Tingting Li. Contributed materials: Feng Yang, Xiaoling Liu, Caiyun Cao. Wrote the essay: Tingting Li.

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Data availability
The dataset for this study is kept in the School of Public Health, at Anhui Medical University, China and may be available upon request (Fangbiao Tao, taofangbiao@126.com).

Declarations

Ethics approval and consent to participate
The Ethics Committee of Anhui Medical University approved this study (NO: 20210735). All participants received written informed consent.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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