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Prevalence and related factors of children myopia in Pudong New Area, Shanghai: a cross-sectional study

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ABSTRACT

Objectives This study aimed to assess the prevalence and related factors of myopia among school-aged children after COVID-19 pandemic.

Design Cross-sectional study.

Setting Pudong New Area, Shanghai.

Participants 1722 children aged 7–9 randomly selected from 8 primary schools were screened from 1 February 2023 to 30 April 2023.

Main outcome measures Children's height, weight and eye parameters were examined. Myopia was defined as a cycloplegic spherical equivalent ≤−0.50 dioptres in either eye. A vision-related behaviour questionnaire was applied to investigate the associations between myopia and its risk factors.

Results Of the 1722 individuals enrolled, 25.6% (456) had myopia. After adjusting other characteristics, the following factors were associated with an increased rate of myopia: age (9 years vs 7 years, adjusted OR (AOR) 1.84, 95% CI 1.18 to 2.85, p=0.007), parental myopia status (both myopia vs none, AOR 5.66, 95% CI 3.71 to 8.63, p<0.001; one myopia vs none, AOR 2.92, 95% CI 1.93 to 4.42, p<0.001), reading books too close (yes vs no, AOR 1.58, 95% CI 1.20 to 2.08, p=0.001), writing with a tilted head (yes vs no, AOR 1.37, 95% CI 1.05 to 1.77, p=0.019), sleep patterns (early to bed late to rise vs early to bed early to rise, AOR 1.52, 95% CI 1.02 to 2.26, p=0.039). By contrast, a higher monthly household income and the habit of reading while lying down were associated with lower risk of myopia.

Conclusions The prevalence of myopia is of concern among young school-aged children after COVID-19. Correcting eye use behaviour and improving sleep habits may reduce myopia. Also, gender differences should be considered in prevention strategies for children's myopia.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study assessed the prevalence of myopia in young school-aged children after COVID-19 pandemic with cycloplegic refraction.
⇒ In addition to outdoor activity and near screen time, this study investigated the associations of eye habits and sleep on children's myopia.
⇒ Gender stratification was used to conduct a thorough evaluation of the risk factors of myopia in school-aged children.
⇒ The cross-sectional study design limits our ability to determine a causal relationship between myopia and its risk factors, and questionnaire surveys has recall bias.

INTRODUCTION

Myopia is a growing global health issue,[1] and it is projected that by 2050, 50% of the total population will be affected.[2] Myopia is more prevalent in East Asian countries than in Europe and America, with rates as high as 90% among young people in China.[1] Myopia does not occur and develop suddenly, so it is crucial to prioritise the eye health of school-aged children. In China, the myopia rate for fourth grade primary school students was 37.1% in 2015, according to a national survey.[3] In Taiwan, a research report stated that the myopia rate for second grade primary school students was 36.4% in 2013.[4] In Guangzhou, a study found that the myopia rate for first to ninth grade students ranged from 0.2% to 68.4%, with the greatest difference between second and third grade (25.5%).[5]

In order to prevent and control myopia, many researchers have been making efforts. Watching near screen and outdoor activities played a role in myopia for school-aged children.[6 7] However, the sudden outbreak of COVID-19 in December 2019 increased their near screen time (online learning), and limited their outdoor activities (home quarantine). As per Zhou *et al*, myopia rates among primary school students in grades 2–4 increased during COVID-19 pandemic, with rates of 19.1%, 33.0% and 49.5% in 2021, respectively.[8]

Myopia in young pupils has increased rapidly. With COVID-19 entering the normal prevention and control stage, teaching order and outdoor activities have resumed. This study aims to understand the prevalence of myopia in school-aged children after COVID-19 pandemic and to assess related

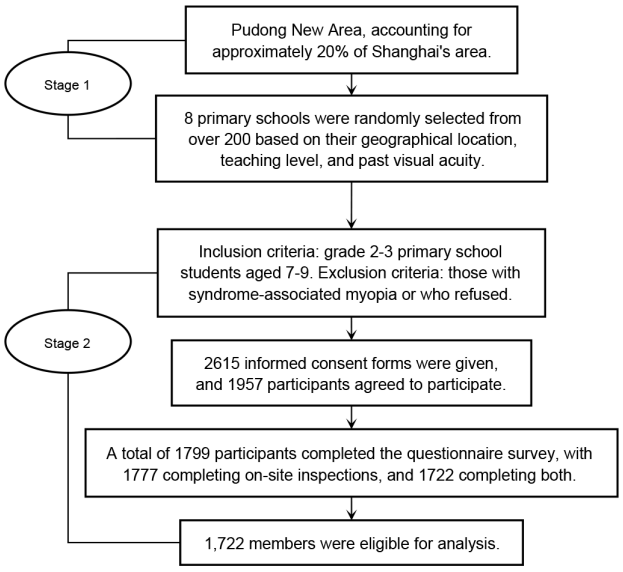

Figure 1 Study population selection.

risk factors, particularly the impact of eye habits and sleep on myopia.

METHODS

Study design and population

From 1 February 2023 to 30 April 2023, students of grades 2–3 enrolled in this cross-sectional study were randomly selected from 8 schools in Pudong New Area (covering an area of 1210 km^2 and with a permanent population of 5.77 million), Shanghai (figure 1). The schools were selected through random number method and 200 students were chosen through cluster sampling. If there were not enough students, new classes would be added. Students aged over 7–9 years or refusing cycloplegia (including unsuitable for cycloplegia due to other diseases) were excluded. School-aged children were engaged in conduct and dissemination plan of this research. These children and their parents (or legal guardians) were provided with information about the nature and extent of their involvement in the research and agreed to participate in. The final results will be shared with participants through the internet or smartphone.

Patient and public involvement

No patient involved.

Procedures

The on-site examination was completed in the school, including height (0.1 cm accuracy; C808, Carefully, China), weight (0.01 kg accuracy; Xiaomi Scale, MIUI, China), eye axis (IOL Master 500, Carl Zeiss Meditec AG, Germany), intraocular pressure (NT-510, Nidek, Japan), Slit lamp examination (YZ-5E, 66 Vision Tech, China), refraction (KR-800, Topcon, Japan). For cycloplegic refraction, we referred to the method of He *et al*.[9] Two drops of 1% cyclopentolate hydrochloride (Cyclogyl, Alcon, Belgium), with a 5 min interval, were used to induce cycloplegia (if insufficient then add another drop). Refraction assessment was performed after the pupils were >6 mm and without light reflex. Our data management system was directly linked to the refractive examination instrument, reducing recording errors. The inspectors and ophthalmologists involved in the on-site inspection had received systematic training and certification before entering the school.

Risk factor assessment

A vision-related behaviour questionnaire was applied to investigate the associations between myopia and its risk factors retrospectively (see online supplemental files 1 and 2 for details about the complete questionnaire). The self-administered paper questionnaires were taken home by students and completed under the guidance of their parents. Children's information mainly includes: name, age, gender, grade, preterm birth or not (yes/no), outdoor activity time (hours per day; weekday and weekend), near screen time (ie, time for mobiles, tablets, televisions and computers; hours per day; weekday and weekend), eye habits (ie, reading books too close (yes/no), watching a screen too close (yes/no), writing with a tilted head (yes/no) and reading while lying down (yes/no)), sleep status (referred to the Pittsburgh Sleep Quality Index[10]) for the past month (bedtime, wake-up time and sleep duration). Other information includes: parental age, parental education (less than high school/high or secondary vocational school/college or junior college/graduate or above), monthly family income (<¥10 000/¥10 001–¥20 000/¥20 001–¥50 000/>¥50 000), parental myopia status (none/one myopia/both myopia).

Definitions

The spherical equivalent (SE) of the refractive error was calculated by adding half of the cylindrical value to the spherical value. Myopia was defined as an SE≤−0.50 dioptres (D) in either eye and was categorised as low (−0.50 D≥SE>−3.00 D), moderate (−3.00 D≥SE>−6.00 D) or high (SE≤−6.00 D) based on the degree of refractive error. Emmetropia was defined as an SE within±0.50 D, while hyperopia was ≥+0.5 D.[11] Body mass index (BMI) was determined using the formula weight (kg) divided by height squared (m^2). BMI was categorised as overweight (P_{85}≤BMI< P_{95}), obese (BMI>P_{95}) or normal weight (BMI<P_{85}).[12] Parental education level refers to the highest level of education attained by either parent. Students were divided into two groups based on the median of monthly household income (yuan), bedtime, wake-up time and sleep duration (<P_{50},≥P_{50}). According to the median division of bedtime and wake-up time, we categorise students' sleep into four patterns (early to bed early to rise (EE), late to bed early to rise (LE), early to bed late to rise (EL) and late to be late to rise (LL)).[13] The analysis only included cases who completed questionnaire surveys and on-site inspections.

Statistical analysis

EpiData software V.3.1 (2008-01-27) was employed for questionnaire data dual entry and validation. All statistical

Table 1 Ocular parameters in different myopia status

Details	Hyperopia (SE≥0.50)	Emmetropia (0.50>SE>−0.50)	Low myopia (−0.50≥SE>−3.00)	Moderate myopia (−3.00≥SE>−6.00)
n (%)	997 (57.9)	269 (15.6)	403 (23.4)	53 (3.1)
SE (D)	0.87 (0.63, 1.25)	0.06 (−0.13, 0.19)	−1.00 (−1.50, −0.56)	−3.31 (−3.88, −2.97)
AL (mm)	22.99 (22.57, 23.45)	23.48 (22.96, 23.86)	23.79 (23.29, 24.29)	24.45 (23.75, 25.04)
AL/CR ratio	2.93 (2.89, 2.98)	3.00 (2.96, 3.04)	3.05 (3.00, 3.09)	3.18 (3.15, 3.23)

AL, axial length; CR, corneal radius; D, dioptres; SE, spherical equivalent.

analyses were performed using R software V.4.3.1 (2023-06-16). We calculated the percentages of students for the categorical data, expressed continuous data as median and IQR, and assessed the differences between groups using Wilcoxon and χ^2 tests. Multivariate logistic regression analysis was performed to estimate the ORs and 95% CIs of potential risk factors with myopia status (myopia/no myopia). Values of p<0.05 were considered statistically significant.

RESULTS

Information was available for 1722 primary students. Table 1 shows the details of ocular parameters in different myopia status. Of these enrolled, 25.6% had myopia and 3.1% had moderate myopia. Violin box plot shows the distribution of ocular parameters according to myopia status and gender (figure 2). Compared with female students, male students had a longer axial length (AL) (p<0.001) and a higher AL/corneal radius (CR) ratio (p<0.001). In the subgroup analysis for non-myopia students, girls' SE was higher than that of boys.

The myopes were, by comparison, older and more common among the girls (table 2). Myopes' parents had lower educational levels and higher myopia rates of myopia than non-myopes' parents. Myopes were more likely to read books too close, write with tilted heads and bad sleep habits than non-myopes. More non-myopes enjoyed reading while lying down, but this difference did not reach statistical significance in the univariate analysis.

Considering the differences in ocular parameters and myopia prevalence rates found between boys and girls, we performed multivariate analysis to test the associations between the risk factors and myopia status (myopia/no myopia) in different models (table 3). Students with myopic parents had higher myopia risk compared with those without myopic parents, and students with both parents having myopia had almost double the risk compared with those with one myopic parent. In model 2, male myopes were more likely to watch screen too close (yes vs no; adjusted OR (AOR) 1.67, p=0.010), write with a tilted head (yes vs no; AOR 1.69, p=0.006) and have bad sleep patterns (LL vs EE; AOR 1.92, p=0.020). For girls, older age (9 years vs 7 years; AOR 2.18, p=0.017) and near-distance reading (yes vs no; AOR 2.45, p<0.001) contributed to higher myopia risk, whereas a higher monthly family income reduced the risk. The habit of reading while lying down (yes vs no; AOR 0.68, p=0.037) and EL sleep pattern (EL vs EE; AOR 1.52, p=0.039) had an impact on myopia in the overall analysis (model 1), but their impact was not significant in the subgroup analysis.

DISCUSSION

After COVID-19 pandemic, the prevalence of myopia in primary school students aged 7–9 in Pudong New Area

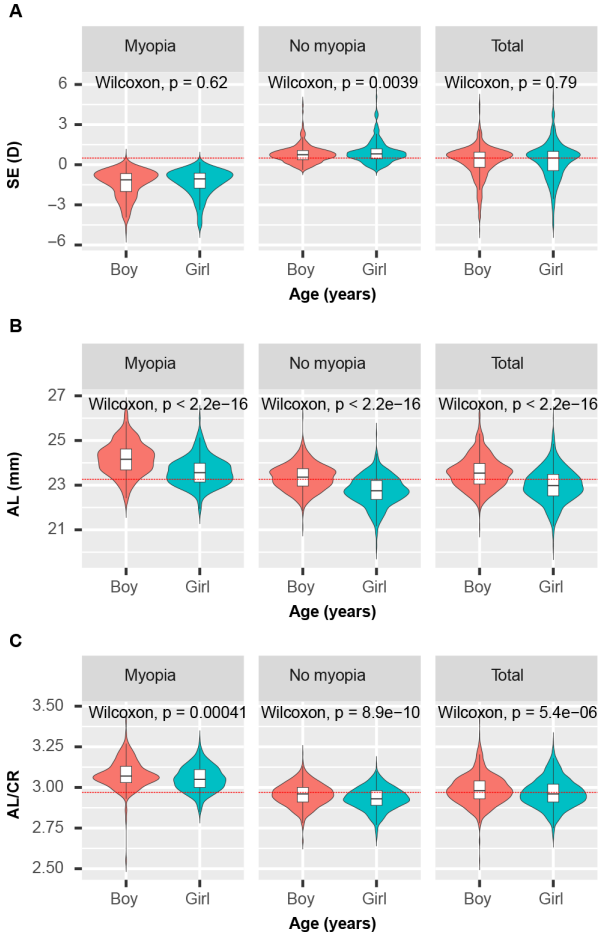

Figure 2 Distribution of ocular parameters by myopia status and gender. (A) Spherical equivalent. (B) Axial length. (C) The ratio of axial length/corneal radius. The red dashed line marks the median level of all participants. AL, axial length; CR, corneal radius; D, dioptres; SE, spherical equivalent.

Table 2 Characteristics of study participants

Characteristic	No myopia n (%)	Myopia n (%)	Total n	P value
Overall	1266 (73.5)	456 (26.5)	1722	
Gender				**0.030**
Boy	683 (75.7)	219 (24.3)	902	
Girl	583 (71.1)	237 (28.9)	820	
Age (years)				**0.035**
7	334 (75.4)	109 (24.6)	443	
8	771 (74.3)	267 (25.7)	1038	
9	161 (66.8)	80 (33.2)	241	
Body mass index				0.163
Normal	840 (75.0)	280 (25.0)	1120	
Overweight	157 (71.0)	64 (29.0)	221	
Obese	269 (70.6)	112 (29.4)	381	
Preterm birth				0.553
Yes	79 (76.0)	25 (24.0)	104	
No	1140 (73.3)	415 (26.7)	1555	
Parental education level				**0.006**
High school or less	227 (80.2)	56 (19.8)	283	
College or more	1030 (72.3)	394 (27.7)	1424	
Monthly household income (yuan)				0.366
<10 001 (P_{50})	322 (72.4)	123 (27.6)	445	
≥10 001 (P_{50})	845 (74.6)	288 (25.4)	1133	
Parental myopia				**<0.001**
None	380 (88.6)	49 (11.4)	429	
One myopia	461 (74.1)	161 (25.9)	622	
Both myopia	352 (62.0)	216 (38.0)	568	
Outdoor activity time (hours per day)				0.593
<2.0	795 (73.1)	292 (26.9)	1087	
≥2.0	412 (74.4)	142 (25.6)	554	
Near screen time (hours per day)				0.888
<1.0	809 (73.3)	295 (26.7)	1104	
≥1.0	396 (73.6)	142 (26.4)	538	
Reading books too close				**<0.001**
Yes	709 (69.7)	308 (30.3)	1017	
No	548 (79.1)	145 (20.9)	693	
Watching a screen too close				0.132
Yes	653 (72.0)	254 (28.0)	907	
No	604 (75.2)	199 (24.8)	803	
Writing with a tilted head				**0.004**
Yes	562 (70.3)	238 (29.8)	800	
No	695 (76.4)	215 (23.6)	910	
Reading while lying down				0.106
Yes	231 (77.3)	68 (22.7)	299	
No	1026 (72.7)	385 (27.3)	1411	
Sleep patterns				**0.027**
Early to bed early to rise	333 (78.7)	90 (21.3)	423	

Continued

Table 2 Continued

Characteristic	No myopia n (%)	Myopia n (%)	Total n	P value
Late to bed early to rise	185 (73.7)	66 (26.3)	251	
Early to bed late to rise	292 (70.0)	125 (30.0)	417	
Late to bed late to rise	448 (72.0)	174 (28.0)	622	
Sleep duration (hours)				0.682
<9.0 (P_{50})	263 (74.3)	91 (25.7)	354	
≥9.0 (P_{50})	995 (73.2)	364 (26.8)	1359	

Bold font data indicate p<0.05. Proportions were tested using the Pearson $\chi 2$ test.

was 25.6% (7 years: 24.6%; 8 years: 25.7%; 9 years: 33.2%) based on cycloplegic refraction. This was higher than the myopia rates found in a cross-sectional study in Nantong, where children aged 7–9 had a myopia rate ranging from 10.1% to 23.7% without cycloplegic refraction in 2022.[14] The myopia rate in Shanghai 10 years ago differs from what was found in our study. Among 7-year-old students, the rate is 14.3%, while for 8-year-old students, it is 30.8%, and for 9-year-old students, it is 41.4%.[15] In addition to time for outdoor activity and near screen, student age, monthly household income, parental myopia status, child eye habits and sleep status were associated with an increased risk of myopia. In particular, gender differences in myopia risk factors were observed among school children aged 7–9 years old, and the habit of reading while lying down was associated with a lower myopia risk.

In the univariate analysis, we found that female students had a higher myopia rate than male students (28.9% vs 24.3%), but this difference was not statistically significant in the multivariate logistic regression model. Female students had a higher risk of myopia than male students, as shown by a study on second-grade primary school children in Taiwan, and this was confirmed through both univariate (OR 1.22, p<0.001) and multivariate (OR 1.24, p<0.001) analyses.[4] We also found that male students had a longer AL (p<0.001) and a higher AL/CR ratio (p<0.001) than female students, but their SE levels showed no significant difference. Unlike us, Zhou *et al* found that the SE level of female students was consistently lower than that of male students from 2019 to 2022, and SE decreased with grade for primary and junior school students.[8] This seems to suggest that if we do not take action, the overall visual condition of girls will worsen, despite finding that non-myopic girls had higher SE levels than non-myopic boys in subgroup analysis. As for BMI, Theophanous *et al*[16] did not find any impact on myopia,[17] but two studies targeting young men found an association between BMI and myopia.[17 18] Preterm birth increased the risk of congenital myopia,[19] but we found no association between preterm birth and myopia.

The association between parental characteristics and myopia has been described among children in different studies.[16 20 21] Our data support the notion that myopia has a strong genetic component, as evidenced by previous researches. A cohort study on preschool children found that parental myopia increased the risk of myopia in preschool children from different countries.[20] Additionally, parental myopia was associated with higher AL/CR ratio and more myopic refractive error, even in children without myopia.[20] Hsu *et al* found that second grade primary school students with one nearsighted parent had an increased risk of myopia, while those with two nearsighted parents had a higher risk.[4] The relationship between parental education level and children's myopia status was unstable. A correlation was found in The Hong Kong Children Eye Study, suggesting that higher parental education levels were associated with a higher risk of myopia in children. However, this association disappeared after accounting for other variables.[21] Hsu *et al* found an association between maternal education level and myopia, while Saxena *et al* found the association became insignificant after adjusting for other variables.[4 22] The association between family income and children's myopia status has been less mentioned in most studies. Our study found that higher monthly household income was associated with a lower risk of myopia in children, particularly among girls.

As per Rudnicka *et al*,[23] the increase in myopia prevalence in Asians suggests genetics is not the dominant cause, studies on preventing and controlling myopia are focusing on environmental and behavioural factors, especially in outdoor activities and near screen. In our study, we observed insignificant associations between time for outdoor activities or near screen and myopia. Although associations between outdoor activity time and near screen time with myopia had been found in some cross-sectional studies, this association was not robust and became insignificant in the multivariate regression models.[4 21] A school-based cluster randomised trial suggested that increased outdoor time was associated with a reduced risk of myopia onset and myopic shifts, with the protective effect being influenced by the duration of exposure and light intensity.[9] The related leading hypothesis is that light triggers dopamine release in the retina, which prevents eye elongation during development. Close work might still make some effect, but exposure to bright light is what mattered most.[1] In addition, exploring alternative methods to improve children's

Table 3 Related factors for myopia

Variables	Model 1 for total		Model 2 for boys		Model 3 for girls	
	AOR (95% CI)	P value	AOR (95% CI)	P value	AOR (95% CI)	P value
Child characteristics						
Gender (girl/boy (ref.))	1.21 (0.93 to 1.57)	0.151	—	—	—	—
Age (8 years/7 years (ref.))	1.10 (0.81 to 1.50)	0.533	0.96 (0.62 to 1.47)	0.846	1.27 (0.81 to 2.00)	0.305
Age (9 years/7 years (ref.))	**1.84 (1.18 to 2.85)**	**0.007**	1.59 (0.84 to 3.00)	0.156	**2.18 (1.15 to 4.13)**	**0.017**
BMI (overweight/normal (ref.))	1.24 (0.84 to 1.82)	0.284	1.49 (0.84 to 2.66)	0.173	1.13 (0.66 to 1.92)	0.667
BMI (obese/normal (ref.))	1.25 (0.90 to 1.72)	0.177	1.35 (0.87 to 2.09)	0.181	1.04 (0.63 to 1.70)	0.883
Preterm birth (yes/no (ref.))	0.97 (0.59 to 1.62)	0.919	1.27 (0.62 to 2.58)	0.513	0.78 (0.37 to 1.64)	0.504
Parental characteristics						
Family education level (college or more/high school or less (ref.))	0.86 (0.55 to 1.34)	0.496	0.75 (0.41 to 1.37)	0.348	1.10 (0.56 to 2.16)	0.782
Monthly household income (yuan)(≥10 001/<10 001 (ref.))	**0.66 (0.48 to 0.89)**	**0.008**	0.68 (0.43 to 1.07)	0.093	**0.59 (0.38 to 0.92)**	**0.020**
Parental myopia (one myopia/none (ref.))	**2.92 (1.93 to 4.42)**	**<0.001**	**3.33 (1.85 to 5.98)**	**<0.001**	**2.42 (1.33 to 4.38)**	**0.004**
Parental myopia (both myopia/none (ref.))	**5.66 (3.71 to 8.63)**	**<0.001**	**6.05 (3.32 to 11.03)**	**<0.001**	**5.04 (2.75 to 9.26)**	**<0.001**
Time for outdoor activity and near screen (hours per day)						
Outdoor activity (≥2.0/<2.0 (ref.))	0.97 (0.74 to 1.28)	0.843	0.91 (0.62 to 1.35)	0.653	1.00 (0.67 to 1.49)	0.994
Near screen (≥1.0/<1.0 (ref.))	1.16 (0.87 to 1.54)	0.312	1.33 (0.89 to 1.99)	0.170	1.01 (0.67 to 1.53)	0.957
Eye habits						
Reading books too close (yes/no (ref.))	**1.58 (1.20 to 2.08)**	**0.001**	1.08 (0.73 to 1.58)	0.711	**2.45 (1.62 to 3.69)**	**<0.001**
Watching a screen too close (yes/no (ref.))	1.24 (0.95 to 1.62)	0.121	**1.67 (1.13 to 2.47)**	**0.010**	0.92 (0.62 to 1.36)	0.668
Writing with a tilted head (yes/no (ref.))	**1.37 (1.05 to 1.77)**	**0.019**	**1.69 (1.16 to 2.47)**	**0.006**	1.16 (0.80 to 1.69)	0.424
Reading while lying down (yes/no (ref.))	**0.68 (0.48 to 0.98)**	**0.037**	0.68 (0.42 to 1.12)	0.133	0.65 (0.38 to 1.10)	0.109
Sleep status						
Sleep patterns (LE/EE (ref.))	1.33 (0.85 to 2.10)	0.215	1.23 (0.61 to 2.49)	0.564	1.45 (0.78 to 2.68)	0.241
Sleep patterns (EL/EE (ref.))	**1.52 (1.02 to 2.26)**	**0.039**	1.74 (0.98 to 3.12)	0.060	1.47 (0.83 to 2.58)	0.185
Sleep patterns (LL/EE (ref.))	1.40 (0.97 to 2.02)	0.075	**1.92 (1.11 to 3.33)**	**0.020**	1.08 (0.65 to 1.80)	0.777
Sleep duration (hours) (≥9.0/<9.0 (ref.))	1.30 (0.91 to 1.85)	0.147	1.19 (0.72 to 1.98)	0.503	1.46 (0.88 to 2.41)	0.141

Model 1 included child characteristics, parental characteristics, outdoor activity time, near screen (ie, mobiles, tablets, televisions and computers) time, eye habits and sleep status. Model 2 for boys and model 3 for girls include all variables in model 1 except gender.
Bold font data indicate p<0.05.
AOR, adjusted OR; BMI, body mass index; EE, early to bed early to rise; EL, early to bed late to rise; LE, late to bed early to rise; LL, late to bed late to rise.

visual acuity may be necessary due to challenges in implementing effective outdoor activities for myopia prevention.

Children's eye habits accompany their growth, and the impact on their vision cannot be ignored. Our data indicated that reading books too close, watching a screen too close and writing with a tilted head were associated with myopia in school-aged children, with a gender difference in the strength of this association. Close reading may contribute to myopia for girls, while watching a screen too close and writing with a slanted head may increase myopia risk for boys. Higher myopia was connected with shorter reading distance in girls, according to a Finland's longitudinal study.[24] In 2014, a survey conducted in Guangzhou with students (ranging from grades 1–9) by Guo *et al*, they found that close reading was correlated with a higher risk of myopia for all students. However, they only found a higher risk of myopia from close television viewing among female students.[5] We believe that the emergence of such differences is reasonable. The time gap between the two studies is approximately 10 years and China's socioeconomic development has led to increased access to mobile phones, tablets and computers. Televisions may no longer be the primary medium for children's electronic screen usage. Even, providing children with mobile phones can temporarily reduce their frequent interruptions to their parents. We had not found any relevant descriptions in other studies regarding writing with a slanted head. Surprisingly, we also found that reading while lying down may be relevant to a lower risk of myopia among these children. So, we reviewed previous studies on the association between lying down reading and myopia risk. Zhuang *et al* suggest that reading while lying down was related to myopia,[25] but the essence of 'reading' here is 'watching screens'; Shi *et al*'s study defined poor reading pose as reading while lying down, walking or in a moving car, and they found a association between it and myopia.[26] Finland's study provided the closest definition to reading while lying down in our study. They found that sitting posture during reading associated with higher myopic progression, while reading face up associated with lower progression.[24] Here, based on our results, we propose a bold idea—lying down and training, and in a right way (ie, appropriate distance and posture, limited time and rotating eyeballs)—may be able to block eye elongation during development.

In our study, myopia risk was higher in the EL sleep pattern group compared with the EE sleep pattern group for all students (AOR 1.52, p=0.039). However, the LL sleep pattern group only had a higher myopia prevalence than the EE sleep pattern group among boys (AOR 1.92, p=0.020; p=0.075 in total (close to 0.05)). We did not observe a significant association between sleep duration and myopia. Recently, a systematic review found that there is still much to learn about the relationship between children myopia and sleep (including duration, quality, timing and efficiency). More accurate evaluation methods are needed.[27] Nevertheless, our data suggest that sleep patterns have a more significant impact on myopia in boys compared with girls.

Our study has limitations. The cross-sectional study design limits our ability to determine a causal relationship between myopia and its influencing factors. Although we evaluated students' myopia by using cycloplegic refraction data, the assessment of children's outdoor activities, close range videos, eye habits and sleep status relied on children and their parents. Also, cross-sectional design carries a risk of confounding bias and questionnaire surveys has recall bias. Correlation was found between lying down reading and lower myopia risk among school-going children aged 7–9 years, but details of reading while lying down was not specified, and with no restrictions on reading distance or time. More research is needed to determine the relationship between near work activities, such as lying reading and myopia in school-aged children of various age groups.

In conclusion, this study evaluated myopia prevalence in school-aged children after COVID-19 pandemic. Correcting eye use behaviour and improving sleep habits may reduce myopia. And gender differences should be considered in prevention strategies for children's myopia.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and this study was approved by the Medical Ethics Committee of Eye and Dental Diseases Prevention and Treatment Center of Pudong New Area, Shanghai (No. PDYYF-LLSC-202101-SP) and adhered to the tenets of the Declaration of Helsinki. Participants and their parents signed written informed consent forms before conducting questionnaire surveys and on-site examinations. Participants gave informed consent to participate in the study before taking part.

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