Yin et al. BMC Ophthalmology (2025) 25:211
https://doi.org/10.1186/s12886-025-03994-0

BMC Ophthalmology

RESEARCH

Open Access

Association between sleep disorders and myopia in Shanghai adolescents: a cross-sectional survey conducted among junior school students

Xiaoya Yin[1†], Xuelai Wang[1†], Zhe Zhang[1], Yani Zhai[1], Xinyi Zhou[1], Linlin Yuan[1], Shuman Li[1], Zhengzhong Wang[1], Lijing Sun[1*] and Chunyan Luo[1*]

Abstract

Background Numerous research suggest that longer sleep duration correlates with a reduced likelihood of myopia onset in adolescents. Does total sleep quality influence myopia? This study aims to examine the relationship between sleep disorders in adolescents and their effects on myopia and the risk of acquiring high myopia.

Methods Data from second-grade middle school students across 16 districts in Shanghai were studied. A total of 2,337 valid observations collected. Two study samples were established: the entire student population and students diagnosed with myopia. Propensity score matching (PSM) was conducted to equilibrate the confounding variables between the sleep disorder and non-sleep disorder groups in each sample. Odds ratios (OR) were computed to assess the effect size. A generalized additive model was used to analyze the relationship between SE and sleep disorder.

Results Prior to PSM, the likelihood of myopia among students was significantly correlated with a higher prevalence of sleep disorders (OR = 1.40, 95%CI: 1.02–1.91). but this significance diminished after matching (OR = 1.24, 95%CI: 0.82–1.85). In the examination of myopic students, before to PSM, sleep disorders were recognized as a potential risk factor for high myopia. Nonetheless, this correlation did not reach statistical significance (OR = 1.21; 95%CI:0.80–1.84). Comparable outcomes were achieved after the matching process (OR = 1.08; 95%CI:0.62–1.87). The modelling outcomes of the generalized additive model also revealed no correlation between sleep disrder and myopia or high myopia.

Conclusion This study found no significant correlation between myopia or high myopia and sleep disorder. However, the residual effect sizes post-PSM still indicate potential biological interactions.

Keywords Adolescent health, Myopia, Sleep disorder, PSM

†Xiaoya Yin and Xuelai Wang Co-first authors.

*Correspondence:
Lijing Sun
sunlijing@scdc.sh.cn
Chunyan Luo
luochunyan@scdc.sh.cn
[1]Institute of Child and Adolescent Health, Shanghai Municipal Center for Disease Control and Prevention, Shanghai 201107, China

Background

Axial myopia is a prevalent refractive error, defined by an excessive elongation of axial length in relation to the eye's refractive power. It typically manifests during childhood and adolescence, and when it does, it persists throughout life [1]. This issue has emerged as a major public health concern, endangering children's health and quality of life, especially in East Asian nations [2]. Holden et al. forecasted that by 2050, the worldwide prevalence of myopia will attain 50% [3]. The increasing rate of myopia prevalence among Chinese children and adolescents has decelerated in recent years. Nonetheless, monitoring data from Chinese Center for Disease Control and Prevention indicates that the prevalence of myopia remains above 50%. Myopia may result in complications like visual fatigue, headaches, and diminished concentration. Once high myopia manifests, the consequent health impairment is significantly more severe. High myopia is frequently linked to several severe ocular disorders, such as retinal detachment, glaucoma, and cataracts [4], all of which may eventually lead to blindness [5]. Among young individuals with high myopia, the prevalence of pathological myopia is approximately 8%, with rates of developing blindness and low vision reaching 22.4% and 32.7%, respectively [6]. In addition to adverse impacts on physical health, myopia and associated complications significantly diminish the quality of life for children and teenagers, leading to difficulties in social interactions, outdoor activities, and employment options [7]. Thus, mitigating the onset and advancement of myopia in children and adolescents constitutes a significant public health concern.

Sleep has been acknowledged as essential for the growth and development of adolescents. However, the potential impact of sleep on vision has only become a research focus in recent years. Research has analyzed numerous sleep aspects, with sleep duration being the most frequently studied. Numerous studies have identified insufficient sleep as a risk factor for myopia [8–10]. The relationship between sleep and vision, as a comprehensive indicator encompassing duration, depth, rhythm, and efficiency, involves the synergistic effects of various physiological mechanisms, including the melatonin secretion cycle, ciliary muscle repair, and neuromodulation [11, 12]. For example, retinal dopamine levels not only impact total sleep duration but also affect the transition between non rapid-eye-movement (NREM) and rapid-eye-movement (REM) sleep phases [13], with distinct sleep phases closely linked to overall sleep quality [14]. Analyzing sleep duration in isolation is challenging for understanding the biological effects of this multifaceted interaction, and the correlation between overall sleep quality and myopia must be taken into account.

Despite meeting the prescribed benchmark for sleep duration, individual variations persist in sleep latency, nighttime awakenings, and attentiveness upon awakening [15]. Xu, S's research indicated that irregular sleep-wake patterns may elevate the likelihood of self-reported myopia in children and adolescents [16]. Considering for sleep quality, a study utilized the Children's Sleep Habits Questionnaire (CSHQ) and found a significant correlation between sleep quality and the prevalence of myopia. This research involved 1,902 primary school students with an average age of 9.80 years, indicating that lower CSHQ scores were linked to a higher likelihood of developing myopia and high myopia [17]. He, Juan et al. identified a correlation between sleep quality and myopia at the genetic level, revealing a significant interaction between sleep disturbances and a heightened genetic predisposition to myopia, indicating that a high genetic risk of myopia may amplify children's sensitivity to sleep disorders [18].

Consequently, research regarding the correlation between sleep quality and myopia in the adolescent population is limited. This study aims to examine the correlation between sleep disorders and the heightened risk of myopia and high myopia in adolescents. During middle school, children transition into puberty, with heightened academic demands and an elevated risk of inadequate sleep quality [19]. The advancement of myopia also intensifies throughout this period [20, 21]. The middle school phase is a notably significant stage for adolescents. Consequently, we have chosen middle school students to investigate the correlation between myopia and sleep quality. This is a cross-sectional study that will thoroughly evaluate sleep quality by examining many dimensions of sleep, utilizing the Pittsburgh Sleep Quality Index (PSQI). This study is, to our knowledge, the first to compare mild myopia and high myopia among adolescents with myopia. Given the myriad factors affecting myopia and sleep, it is essential to adequately account for confounding variables in study. We will utilize propensity score matching to account for many significant confounding variables in order to isolate the independent effect of sleep quality on myopia.

Methods

Sample

The data was derived from the Common Disease Monitoring and Intervention Program for Students in Shanghai, an annual cross-sectional research initiative undertaken in the city. In each of Shanghai's 16 districts, one junior middle school was chosen, and all second-grade students at participated in physical examinations and questionnaire surveys. The research was finalized in September-October 2023. A total of 3,045 students participated in the survey, and the current analysis included

2,337 students with complete data for both ophthalmic tests and questionnaire surveys.

The data collection was approved by the Ethics Committee of the Shanghai Municipal Center for Disease Control and Prevention.

Measures

Myopia. The vision assessment comprises two components: distant uncorrected visual acuity (UCVA) evaluation and computerized optometry. Employing the Standard Logarithmic Visual Acuity E Chart (GB11533-2011) to assess the UCVA. Children and adolescents over the age of 6 with UCVA below 5.0 are classified as having poor vision. The refractive status of each subject was assessed using a desktop computerized optometry device without cycloplegia by an ophthalmologist. Both spherical and cylindrical components were documented. Each eye underwent three measurements, and the mean values were recorded. If the disparity between any two spherical power measurements was ≥ 0.50 D, supplementary measurements were performed, and the average results were recalculated. The equivalent spherical power (SE) was computed as follows: SE = Spherical power + 0.5 Cylinder power. Myopia was defined as a SE of any eye being ≤-0.5D, accompanied by UCVA < 5.0. Myopia was classified into mild myopia (-6D ≤ SE≤-0.5D) and high myopia (SE<-6D).

Sleep. The Pittsburgh Sleep Quality Index (PSQI) was employed to assess participants' sleep quality. The PSQI evaluated students' sleep retrospectively over one month via self-reports. The PSQI comprises seven components: sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, usage of sleep medications, and daytime dysfunction. Each component is rated from 0 to 3, yielding a maximum overall score of 21 [22]. Higher scores signify poorer sleep quality. The PSQI has demonstrated robust reliability and validity in its application among Chinese adolescents [23, 24]. Guo C disclosed that a score of 6.5 serves as the ideal cutoff for the Chinese version of the PSQI in diagnosing sleep disorders in non-clinical adolescents [25]. Thus, this study established a threshold score of 6.5.

Covariates. The myopia grade of the parent was reported by students and subsequently reviewed by the parents. According to the degree of myopia in parents, the myopic grade was categorized into three groups: non-myopic, mild myopia (-6D ≤ SE≤-0.5D), and high myopia (SE<-6D). The participants were asked about their typical daily homework duration on school days and weekends, screen time, and time spent for outside activities. Responses should be presented in hours and minutes format (e.g. On school days, I spend an average of 2 h and 10 min to homework). In the data processing phase, the responses were transformed into hours for a subsequent analysis. Participants were also asked to specify their participation in extracurricular tutoring classes and art-related classes. The alternatives for these two inquiries were a binary selection of "yes" or "no."

Data analysis

To accurately assess the impact of sleep disorders on myopia while accounting for additional contextual variables, we included potential confounding characteristics and developed a logistic regression model to calculate a propensity score for each participant. The propensity score was computed using observable factors and indicated the likelihood of each student developing sleep disorders. The subsequent step was matching. Given our two research objectives, we established two distinct matching samples. Initially, each student with a sleep disorder was individually paired with a student without sleep disorder to form matching sample 1. The objective was to examine the correlation between sleep disorders and myopia. Secondly, within the subset of myopic students, we conducted an additional round of matching to establish matching sample 2. The objective was to examine the correlation between sleep disorders and the degree of myopia. Both matching processes employed the nearest neighbor matching method. Propensity score matching (PSM) was performed utilizing the MatchIt package in R version 4.0.3.

The state of equilibrium across all covariates between the sleep disorder group and the non-sleep disorder group was validated post-matching. We used t-tests for continuous variables and chi-square tests for categorical variables.

In matching sample 1 and matching sample 2, we calculated the odds ratios (OR) for the two research objectives mentioned above. Further, we used a generalized additive model to investigate the correlation between SE and PSQI. The independent factors utilized in the modeling corresponded to the matching variables in PSM.

Results

A total of 2,337 valid samples were collected in this study population. Myopic students comprised 77.7% of the population, while those with high myopia constituted 8.0%. Students with sleep disorders constituted 12.9% (refer to Table 1). The results of the PSQI survey are displayed in Table 2. The average global score of the PSQI among all students was 3.74 ± 2.48, with the highest score recorded in the daytime dysfunction component (1.46 ± 0.84) and the lowest score in the sleep efficiency component (0.01 ± 0.16). The mean sleep duration for all subjects was 8.17 ± 0.85 h per night. The score distribution among students with varying degrees of myopia was analogous to the aforementioned results.

Table 1 The sleep and myopia status of the participants

		Female ($N=1172$)	Male ($N=1165$)	Total ($N=2337$)
Myopic grade	High myopia (%)	9.0	7.1	8.0
	Mild myopia (%)	72.2	67.1	69.7
	Non-myopic (%)	18.8	25.8	22.3
Sleep quality	Non-disordered sleep (%)	85.0	89.2	87.1
	Disordered sleep (%)	15.0	10.8	12.9

Table 2 The PSQI (Pittsburgh Sleep Quality Index) scores of the participants

Subscales	All students	Myopic grade		
		high myopia	mild myopia	no myopia
Global score	3.74 ± 2.48	3.89 ± 2.67	3.71 ± 2.46	3.82 ± 2.50
Quality	0.69 ± 0.72	0.69 ± 0.74	0.69 ± 0.71	0.72 ± 0.73
Latency	0.66 ± 0.82	0.71 ± 0.84	0.65 ± 0.81	0.71 ± 0.82
Duration	0.11 ± 0.37	0.15 ± 0.42	0.10 ± 0.36	0.13 ± 0.40
Efficiency	0.01 ± 0.16	0.01 ± 0.15	0.01 ± 0.17	0.01 ± 0.12
Disturbance	0.78 ± 0.63	0.81 ± 0.66	0.77 ± 0.62	0.80 ± 0.65
Medicine	0.03 ± 0.26	0.04 ± 0.32	0.03 ± 0.25	0.02 ± 0.25
Dysfunction	1.46 ± 0.84	1.47 ± 0.85	1.46 ± 0.84	1.43 ± 0.86

Table 3 displays the differences in matching factors between the two groups in sample 1. Students with sleep disorders spent 2.45 ± 1.59 h on homework per day on weekdays and 3.75 ± 2.50 h per day on weekends, both were significantly higher than students without sleep disorders (t=-4.06, $P=0.00$; t=-4.45, $P=0.00$). Additionally, students with sleep disorders spent 2.57 ± 2.50 h per day using electronic screens on weekends, which was also significantly higher than students without sleep disorders (t=-3.66, $P=0.00$). Table 4 presented the differences in matching factors between the two groups in sample 2, yielding similar results to sample 1.

Prior to PSM, the likelihood of myopia among students was significantly correlated with a higher prevalence of sleep disorders (OR = 1.40, 95%CI: 1.02–1.91). However, this correlation diminished and became statistically insignificant after matching (OR = 1.24, 95%CI: 0.82–1.85). In the examination of myopic students, before to PSM, sleep disorders were recognized as a potential risk factor for high myopia. Nonetheless, this correlation did not reach statistical significance (OR = 1.21; 95%CI:0.80–1.84). Comparable outcomes were achieved after the matching process (OR = 1.08; 95%CI:0.62–1.87). (Table 5)

The findings of the generalized additive model indicated no significant correlation between SE and PSQI, both among the entire students and myopic students (sample 1: $\beta=0$, $P=0.95$; sample 2: β=-0.01, $P=0.81$), thereby supporting the conclusions derived from the calculation of ORs. Among all students, only parental myopia

Table 3 Means and percentages on matching variables before and after PSM on sample 1 ($n=2337$)

Factor		All non-disordered sleep ($N=2035$)	Disordered sleep ($N=302$)	*p*_value	Propensity-matched non-disordered sleep ($N=302$)	*p*_ value
Continuous variables (mean ± sd)						
Daily homework time on weekdays		2.06 ± 1.28	2.45 ± 1.59	0.00*	2.52 ± 1.47	0.60
Daily homework time on weekends		3.07 ± 2.08	3.75 ± 2.50	0.00*	3.63 ± 2.35	0.56
Daily time of screen usage on weekdays		0.56 ± 0.95	0.64 ± 1.00	0.16	0.67 ± 1.17	0.79
Daily time of screen usage on weekends		2.03 ± 1.79	2.57 ± 2.50	0.00*	2.54 ± 2.37	0.85
Daily time of outdoor activities on weekdays		0.57 ± 0.79	0.50 ± 0.75	0.14	0.49 ± 0.80	0.87
Daily time of outdoor activities on weekends		1.72 ± 1.38	1.62 ± 1.54	0.28	1.54 ± 1.34	0.52
Categorical variables (%)						
GENDER	Female	48.94	58.28	0.00*	60.93	0.56
	Male	51.06	41.72		39.07	
Attending extra tutoring classes	NO	57.59	49.67	0.00*	49.01	0.94
	YES	42.41	50.33		50.99	
Attending art-related classess	NO	67.32	62.58	0.12	62.91	1.00
	YES	32.68	37.42		37.09	
Father's myopic grade	high myopia	4.42	5.96	0.33	4.64	0.28
	mild myopia	35.68	32.45		38.41	
	non-myopic	59.90	61.59		56.95	
Mother's myopic grade	high myopia	4.86	6.62	0.22	7.28	0.89
	mild myopia	35.04	37.75		36.09	
	non-myopic	60.10	55.63		56.62	

*$P<0.05$

Table 4 Means and percentages on matching variables before and after PSM on sample 2 ($n = 1817$)

Factor		All non-disordered sleep (*N* = 1568)	Disordered sleep (*N* = 249)	*p*_value	Propensity-matched non-disordered sleep (*N* = 249)	*p*_ value
Continuous variables (mean ± sd)						
Daily homework time on weekdays		2.07 ± 1.26	2.5 ± 1.60	0.00*	2.49 ± 1.42	0.98
Daily homework time on weekends		3.09 ± 2.11	3.73 ± 2.51	0.00*	3.75 ± 2.71	0.93
Daily time of screen usage on weekdays		0.53 ± 0.91	0.67 ± 1.04	0.00*	0.60 ± 1.01	0.41
Daily time of screen usage on weekends		2.01 ± 1.74	2.57 ± 2.43	0.00*	2.43 ± 2.17	0.51
Daily time of outdoor activities on weekdays		0.55 ± 0.77	0.51 ± 0.74	0.42	0.43 ± 0.69	0.24
Daily time of outdoor activities on weekends		1.68 ± 1.37	1.60 ± 1.51	0.42	1.72 ± 1.51	0.37
Categorical variables (%)						
GENDER	Female	51.28	59.44	0.00*	59.04	1.00
	Male	48.72	40.56		40.96	
Attending extra tutoring classes	NO	58.16	50.60	0.00*	47.39	0.53
	YES	41.84	49.40		52.61	
Attending art-related classes	NO	67.03	61.04	0.07	62.65	0.78
	YES	32.97	38.96		37.35	
Father's myopic grade	high myopia	4.85	6.43	0.26	7.23	0.94
	mild myopia	38.90	34.14		33.73	
	non-myopic	56.25	59.44		59.04	
Mother's myopic grade	high myopia	5.74	6.83	0.32	8.84	0.69
	mild myopia	37.44	41.37		41.37	
	non-myopic	56.82	51.81		49.80	

*$P < 0.05$

Table 5 The calculated odds ratios before and after matching

Sample 1								
Group	**Before matching**				**After matching**			
	Myopia	Non-myopic	OR	95%CI	Myopic	Non-myopic	OR	95%CI
Disordered sleep	249	53	1.4	1.02–1.91	249	53	1.24	0.82–1.85
Non-disordered sleep	1568	467			239	63		
Sample 2								
Group	**Before matching**				**After matching**			
	High myopia	Mild myopia	OR	95%CI	High myopia	Mild myopia	OR	95%CI
Disordered sleep	30	219	1.21	0.80–1.84	30	219	1.08	0.62–1.87
Non-disordered sleep	159	1409			28	221		

correlated with SE, with children's SE improving by and average of 0.85 diopters and 1.30 diopters when their fathers exhibited mild myopia or no myopia, in contrast to high myopia (β = 0.85, $P = 0.04$; β = 1.30, $P = 0.00$). likewise, when mother is not myopic, the child's SE improves by an average of 0.97 diopters (β = 0.97, $P = 0.01$). Among myopic students, the influence of parental myopia on SE yielded results analogous to those observed in sample 1 modeling. Moreover, students engaged in extracurricular tutoring classes exhibited an average reduction in SE of 0.38 diopters ((β=-0.38, $P = 0.03$), while each 0.03 h increment in weekend outdoor physical activity corresponded to an average increase in SE of 1 diopter (β = 0.03, $P = 0.01$). (Table 6)

Discussion

The myopia prevalence identified in this study is 77.7%, surpassing that of other cities in China based on cross-sectional comparisons [26, 27], and it also exceeds statistics from previous years in Shanghai when longitudinally analyzed [28]. The methodology utilized in this study for assessing refractive error was performed under non-cycloplegic conditions, perhaps resulting in an overestimation of myopia prevalence. Moreover, during the COVID-19 home quarantine, students dependence on electronic screens for online education has contributed to the advancement of myopia [29].

This study finds that the average sleep duration of adolescents is consistent with prior research, recorded at 8.17 h [30]. Middle school students continue to encounter the problem of inadequate sleep, as the Chinese Ministry of Education advises them to obtain a complete 9 h

Table 6 Results of the generalized additive models

Factor	Model 1 (Based on Sample 1)	Model 1 (Based on Sample 2)
	β (t-value) *p*-value	**β (t-value) *p*-value**
PSQI	0.00 (0.06) 0.95	-0.01 (-0.24) 0.81
GENDER-Male	0.20 (1.04) 0.30	0.16 (0.88) 0.38
Father's myopic grade-mild myopia	0.85 (2.01) 0.04*	1.02 (2.84) 0.00*
Father's myopic grade-no myopia	1.30 (3.21) 0.00*	1.46 (4.19) 0.00*
Mother's myopic grade-mild myopia	0.12 (0.30) 0.76	0.40 (1.21) 0.23
Mother's myopic grade-no myopia	0.97 (2.53) 0.01*	0.92 (2.78) 0.01*
Attending extra tutoring classes-YES	0.01 (0.05) 0.96	-0.38 (-2.16) 0.03*
Attending art-related classes-YES	-0.02 (-0.08) 0.94	0.23 (1.25) 0.21
Daily homework time on weekdays	-0.07 (-1.00) 0.32	-0.03 (-0.45) 0.66
Daily homework time on weekends	0.02 (0.50) 0.61	0.02 (0.38) 0.71
Daily time of screen usage on weekdays	-0.01 (-0.07) 0.95	-0.02 (-0.21) 0.84
Daily time of screen usage on weekends	-0.01 (-0.32) 0.75	0.02 (0.57) 0.57
Daily time of outdoor activities on weekdays	-0.13 (-1.00) 0.32	0.00 (-0.68) 0.50
Daily time of outdoor activities on weekends	0.03 (0.40) 0.69	0.03 (2.49) 0.01*

*$P < 0.05$

of sleep nightly. The average global PSQI score for the population in this study was 3.74, which aligns with a survey conducted in China in 2020 but lower than a survey conducted in 2015. Compared to other countries, the scores are relatively low. The average scores reported in other studies were 6.28 (Australia) [31], 4.21 (South Korea) [32], 5.11 (Spain) [33], 4.35 (Iceland) [33], and 4.98 (Estonia) [33]. The prevalence of sleep disorders was 12.9%, which is lower than the survey that utilized the same cutoff value of 6.5. Correspondingly, the daytime dysfunction emerged as the highest-scoring dimension, registering a score of 1.46 in this study. In 2021, the Ministry of Education of the People's Republic of China promulgated the "sleep regulation," which delineated explicit standards for three "critical times" concerning the requisite sleep duration for students, academic schedules, and nighttime bedtimes. It established prerequisites for extracurricular training, intending to guarantee that students attain the requisite sleep quality [34]. The successful execution of the policy may contribute to the decrease in the incidence of sleep disorders.

The propensity score matching process achieved enough balance between the disturbed sleep and non-disordered sleep comparison groups regarding significant demographic, general, and behavioral characteristics. This study endeavored to mitigate known confounding variables to the greatest extent feasible. A major factor contributing to the variability in prior research findings may be the management of variables. It is well-established that outdoor activities and near-work are significantly linked to the onset of myopia. Numerous longitudinal investigations have validated that increasing outdoor exercise time can diminish the incidence and advancement of myopia [35, 36]. The prevailing mechanistic explanation posits that outdoor activities facilitate the release of dopamine in the retina, hence regulating the growth and remodeling of the sclera [37]. The development of myopia was attributed to the cascading signals from retina sclera, which induced scleral remodeling [38]. Prolonged near-work activities, including reading, writing, and viewing television at close range, constitute a significant risk factor for myopia, exerting a greater influence on its initiation than on its advancement [35, 39]. As the popularity of smart electronic devices continues to rise, the increased usage of electronic screen has become a noteworthy risk factor for myopia [40–42]. To investigate the independent impact of sleep on myopia, it is crucial to control as many relevant covariates as possible and propensity score matching has been instrumental during the process.

This study found no significant correlation between sleep disorders and myopia. The finding corroborates the study by Pan et al., which also involved Chinese adolescents aged 13–14 and employed PSM for analysis [43]. Our analysis closely parallels Pan's research as we accounted for the same principal confounding variables [43]. The minor distinction is that we distinguished between weekdays and weekends regarding homework duration, screen time, and outside activities. Furthermore, we accounted for the variable of participation in extracurricular tutoring sessions. In 2021, the Chinese government implemented the "Double Reduction" strategy to mitigate the academic burden and extracurricular tutoring demands on students, providing a significant policy context for our study. Li et al.'s cross-sectional research of children aged 8–9 in Singapore similarly revealed no significant link between these two variables. Furthermore, Li investigated the correlation between several facets of sleep and myopia, although no substantial associations were detected [17]. The longitudinal study conducted by Stafford-Bell in Australia may yield more persuasive results. The researchers monitored the study group from childhood to adolescence, and both their unadjusted and completely adjusted analyses indicated that sleep issue behavior was not substantially correlated with changes in refractive error, axial length, or corneal radius [44]. Nonetheless, Stafford's study failed to consider two significant confounding variables: near-work duration and screen exposure.

In contrast, the study of Rong Li et al. indicated a substantial association. The Children's Sleep Habits Questionnaire (CSHQ) was employed to evaluate sleep quality in school-aged children (7–12 years) in China, revealing a strong correlation between various aspects of sleep, including duration, timing, consistency, and chronotype, and myopia [8]. The discrepancies in our findings may be attributable to the age variation within the studied population. The research conducted by Zhi Chen et al. revealed that the average age of beginning for myopia in Chinese children has diminished from 10.6 years in 2005 to 7.6 years in 2021 [45]. Rong Li's study, encompassing a demographic representative of the typical age of myopia onset, is more likely to identify significant impacts of sleep disturbances on myopia development. These researches' contradictory findings should be regarded cautiously. The analysis's null connection and generally equivocal evidence suggest that there is still little evidence linking sleep quality to myopia as a separate risk factor. It has been established that excessive use of electronic devices, extended reading sessions, and a lack of outdoor activities are risk factors for myopia. Sleep quality may be a mediator variable along the causal pathway between these risk factors and myopia, as these factors also affect sleep quality.

Also, the absence of a significant association between myopia and sleep quality in sample 1 following PSM indicates substantial confounding bias in the unmatched sample, suggesting that the matched variables likely influence the moderating pathway of the myopia-sleep relationship. In case of outdoor activities, sunlight's ability to stimulate retinal dopamine secretion may mitigate the adverse effects of sleep disruption by inhibiting ocular axis overgrowth [46]. Controlling for this variable elevated the threshold for the impact of sleep quality on myopia, leading to a reduced odds ratio following matching. The predictive validity of sleep quality on myopia may have been augmented when outdoor hours were limited in winter, elucidating the nature of the diminished association following PSM.

In the analysis of the myopic group in sample 2, both prior to and following propensity score matching, we did not identify a significant correlation between high myopia and sleep quality. A shortage of studies examining the correlation between high myopia development and sleep challenges comparisons with prior research. Research undertaken in Korea and China has revealed no correlation between sleep and high myopia [47, 48]. We evaluated multiple potential explanations for this outcome. A significant temporal window effect may exist in the correlation between sleep quality and myopia. Research indicates that sleep patterns in preschool-aged children significantly influence ocular axis development [49], however, this temporal sensitivity may diminish in populations with pre-existing myopia. Moreover, the highly myopic group may have experienced genetically-driven ocular pathological changes [50], resulting in elevated effect thresholds for behavioral and environmental factors, including sleep quality, which complicates the demonstration of statistical associations between conventional risk factors and high myopia. Finally, current evaluations of sleep quality predominantly depend on subjective scales, but maybe the advancement of myopia to high myopia may correlate with particular sleep stages? Subjective scales may inadequately measure those sleep parameters, such as the proportion of rapid eye movement sleep and the continuity of deep sleep. This represents a limitation of the current study, and future research could be conducted more comprehensively through the utilization of wearable devices.

This study's merits encompass the application of propensity score matching to equilibrate known confounding factors across groups and the differentiation between weekdays and weekends for certain significant confounding variables. Among all students, while the notable correlation between myopia and sleep disturbance diminished post-matching, the remaining effect sizes still indicated a possible biological interaction. The correlation between the onset of high myopia and sleep necessitates further investigation. Subsequent studies may explore the utilization of wearable devices to assess objective sleep indicators and to monitor alterations in sleep patterns throughout the progression of myopia.

This study possesses specific limitations. Owing to practical limitations, we could not conduct cycloplegic refraction on the study participants, which may have resulted in an exaggerated prevalence of myopia. The collection of sleep data depended exclusively on subjective self-reporting. Future research would benefit from the use of wearable devices for the objective collecting of sleep data, contingent upon resource availability.

Conclusions

This study found no significant correlation between myopia or high myopia and sleep disorder. However, the residual effect sizes post-PSM still indicate potential biological interactions.

Abbreviations

UCVA Uncorrected Visual Acuity
CSHQ Children's Sleep Habits Questionnaire
PSQI Pittsburgh Sleep Quality Index
PSM Propensity score matching
OR Odds ratio

Acknowledgements
I appreciate all my colleagues for their efforts and dedication during the on-site data collection process. I am grateful for my supervisor's guidance in writing. It is the collective effort of everyone that has added greater value to this data.

Author contributions
XY.Y conducted the data analysis and paper writing. XL.W revised the initial draft. Z.Z, YN.Z, XY.Z, LL.Y, SM.L, and ZZ.W collected on-site data and organized the questionnaires. LJ.S and CY.L were responsible for organizing on-site surveys and conducting the paper review. All authors have read the manuscript.

Funding
The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by the Shanghai Municipal Health Commission [Three-year action plan (2023–2025 Year) for strengthening the construction of the public health system in Shanghai (GWVI-11.2-XD14), Key Discipline Program of the Sixth Round of the Three-Year Public Health Action Plan (2023–2025 Year) of Shanghai (GWVI-11.1-31)].

Data availability
The datasets used during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The parents of the students have given their informed consent for this project to be implemented. The background, goals, and specific operations of the project will be explained at a parent meeting before the monitoring project of this research begins. Parents will receive information letters outlining the project in detail, and the investigation will only proceed with the parents' and guardians' informed consent.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Ethical considerations
The study research administered surveys following the acquisition of informed consent from the participants. This study was approved by the Ethical Review Committee of Shanghai Municipal Center for Disease Control and Prevention (approval no. 2022-13) on March 22, 2022.

Received: 9 December 2024 / Accepted: 18 March 2025
Published online: 15 April 2025

References

1. Chen M, Shu Q, Li F, et al. The whole life cycle myopia management. Asia-Pacific J Ophthalmol. 2025;100161. https://doi.org/10.1016/j.apjo.2025.100161.
2. Grzybowski A, Kanclerz P, Tsubota K, et al. A review on the epidemiology of myopia in school children worldwide. BMC Ophthalmol. 2020;20:27. https://doi.org/10.1186/s12886-019-1220-0.
3. Holden BA, Fricke TR, Wilson DA, et al. Global prevalence of myopia and high myopia and Temporal trends from 2000 through 2050. Ophthalmology. 2016;123:1036–42.
4. Williams K, Hammond C. High myopia and its risks. Community Eye Health. 2019;32:5–6. 2019/08/15.
5. Haarman AE, Enthoven CA, Tideman JWL, et al. The complications of myopia: a review and meta-analysis. Investig Ophthalmol Vis Sci. 2020;61:49–49.
6. Wong Y-L, Saw S-M. Epidemiology of pathologic myopia in Asia and worldwide. Asia-Pacific J Ophthalmol. 2016;5:394–402.
7. Congdon N, Burnett A, Frick K. The impact of uncorrected myopia on individuals and society. Community Eye Health. 2019;32:7–8. 2019/08/15.
8. Li R, Chen Y, Zhao A et al. Relationships between Sleep Duration, Timing, Consistency, and Chronotype with Myopia among School-Aged Children. *Journal of Ophthalmology* 2022; 2022: 7071801. https://doi.org/10.1155/2022/7071801
9. Jee D, Morgan IG, Kim EC. Inverse relationship between sleep duration and myopia. Acta Ophthalmol. 2016;94:e204–10.
10. Hu Y, Xu Q, Shi J, et al. Poor uncorrected visual acuity and association with sleep duration and screen time: A Dose-Response relationship study. Dose Response. 2021;19:15593258211042161. 2021/10/19.
11. WÅLINDER, P-E. TONUS OF THE CILIARY MUSCLE DURING, SLEEP. Acta Ophthalmol. 1969;47:1149–55. https://doi.org/10.1111/j.1755-3768.1969.tb02514.x.
12. Zisapel N. New perspectives on the role of melatonin in human sleep, circadian rhythms and their regulation. Br J Pharmacol. 2018;175:3190–9. https://doi.org/10.1111/bph.14116.
13. Kashiwagi M, Kanuka M, Tanaka K, et al. Impaired wakefulness and rapid eye movement sleep in dopamine-deficient mice. Mol Brain. 2021;14:170. https://doi.org/10.1186/s13041-021-00879-3.
14. Barbato GREM, Sleep. An unknown indicator of sleep quality. Int J Environ Res Public Health. 2021;18:12976.
15. Chung J, Goodman M, Huang T, et al. Multidimensional sleep health: concepts, advances, and implications for research and intervention. MedRxiv. 2021;2021(2004):2020–21255799.
16. Xu S, Zong Z, Zhu Y, et al. Association between sleep-wake schedules and myopia among Chinese school-aged children and adolescents: a cross-sectional study. BMC Ophthalmol. 2023;23:135. https://doi.org/10.1186/s12886-023-02874-9.
17. Li M, Tan CS, Xu L, et al. Sleep patterns and myopia among School-Aged children in Singapore. Front Public Health. 2022;10:828298. 2022/04/12.
18. He J, Lin Y-Y, Chen J, et al. Association of sleep quality with myopia based on different genetic risk levels. Int J Ophthalmol. 2022;15:1657.
19. Zhou H-Q, Yao M, Chen W-B, et al. High prevalence of irritable bowel syndrome with poor sleep quality in children and adolescents in Shanghai. Sleep Biol Rhythms. 2012;10:179–86.
20. Moore M, Lingham G, Flitcroft DI, et al. Myopia progression patterns among paediatric patients in a clinical setting. Ophthalmic Physiol Opt. 2024;44:258–69. https://doi.org/10.1111/opo.13259.
21. Verkicharla PK, Kammari P, Das AV. Myopia progression varies with age and severity of myopia. *PLoS One* 2020; 15: e0241759. 2020/11/21. https://doi.org/10.1371/journal.pone.0241759
22. Buysse DJ, Reynolds CF III, Monk TH, et al. The Pittsburgh sleep quality index: a new instrument for psychiatric practice and research. Psychiatry Res. 1989;28:193–213.
23. Tsai P-S, Wang S-Y, Wang M-Y, et al. Psychometric evaluation of the Chinese version of the Pittsburgh sleep quality index (CPSQI) in primary insomnia and control subjects. Qual Life Res. 2005;14:1943–52.
24. Zhou S-J, Wang L-L, Wang T-T, et al. Associations between experienced aggression, poor sleep, and suicide risk among Chinese adolescents. Sleep. 2022;45:zsac048.
25. Guo C. Assessing the Chinese version of Pittsburgh sleep quality index in non-clinical adolescents. Curr Psychol. 2023;42:24860–70.
26. Li T, Wei R, Du B et al. Prevalence of myopia among children and adolescents aged 6–16 during COVID-19 pandemic: a large-scale cross-sectional study in Tianjin, China. *British Journal of Ophthalmology* 2023: bjo-2023-323688. https://doi.org/10.1136/bjo-2023-323688
27. We X-X, Yu L-L, Majid A et al. Study on the prevalence of myopia and its associated factors in China: a systemic review. Eur Rev Med Pharmacol Sci 2023; 27.
28. He X, Sankaridurg P, Xiong S, et al. Prevalence of myopia and high myopia, and the association with education: Shanghai child and adolescent Large-scale eye study (SCALE): a cross-sectional study. BMJ Open. 2021;11:e048450. https://doi.org/10.1136/bmjopen-2020-048450.
29. Ma M, Xiong S, Zhao S, et al. COVID-19 home quarantine accelerated the progression of myopia in children aged 7 to 12 years in China. Invest Ophthalmol Vis Sci. 2021;62:37. 2021/09/01.

30. Chen H, Wang L-J, Xin F, et al. Associations between sleep duration, sleep quality, and weight status in Chinese children and adolescents. BMC Public Health. 2022;22:1136.
31. Raniti MB, Waloszek JM, Schwartz O, et al. Factor structure and psychometric properties of the Pittsburgh sleep quality index in community-based adolescents. Sleep. 2018;41. https://doi.org/10.1093/sleep/zsy066.
32. Park BK. The Pittsburg sleep quality index (PSQI) and associated factors in Middle-school students: A Cross-sectional study. Child Health Nurs Res. 2020;26:55–63. https://doi.org/10.4094/chnr.2020.26.1.55.
33. Galan-Lopez P, Domínguez R, Gísladóttir T, et al. Sleep quality and duration in European adolescents (The adoleshealth Study): A Cross-Sectional, Quantitative Study. Children. 2021;8:188.
34. China TMoEotPsRo. Notice on Strengthening Sleep Management for Primary and Secondary School Students. In: China TMoEotPsRo, editor. 2021.
35. French AN, Morgan IG, Mitchell P, et al. Risk factors for incident myopia in Australian schoolchildren: the Sydney adolescent vascular and eye study. Ophthalmology. 2013;120:2100–8.
36. Shah RL, Huang Y, Guggenheim JA, et al. Time outdoors at specific ages during early childhood and the risk of incident myopia. Investig Ophthalmol Vis Sci. 2017;58:1158–66.
37. Grzybowski A, Kanclerz P, Tsubota K, et al. A review on the epidemiology of myopia in school children worldwide. BMC Ophthalmol. 2020;20:1–11.
38. Tedja MS, Wojciechowski R, Hysi PG, et al. Genome-wide association meta-analysis highlights light-induced signaling as a driver for refractive error. Nat Genet. 2018;50:834–48.
39. Guo L, Yang J, Mai J, et al. Prevalence and associated factors of myopia among primary and middle school-aged students: a school-based study in Guangzhou. Eye. 2016;30:796–804.
40. Wong CW, Tsai A, Jonas JB, et al. Digital screen time during the COVID-19 pandemic: risk for a further myopia boom?? Am J Ophthalmol. 2021;223:333–7. https://doi.org/10.1016/j.ajo.2020.07.034. 2020/08/02.
41. AlShamlan FT, Bubshait LK, AlAhmad EA, et al. Myopia progression in school children with prolonged screen time during the coronavirus disease confinement. Med Hypothesis Discov Innov Ophthalmol. 2023;12:90–7. 2024/02/15.
42. Pardhan S, Parkin J, Trott M, et al. Risks of digital screen time and recommendations for mitigating adverse outcomes in children and adolescents. J Sch Health. 2022;92:765–73. 2022/03/08.
43. Pan C-W, Liu J-H, Wu R-K, et al. Disordered sleep and myopia among adolescents: a propensity score matching analysis. Ophthalmic Epidemiol. 2019;26:155–60. https://doi.org/10.1080/09286586.2018.1554159.
44. Stafford-Bell N, McVeigh J, Lingham G, et al. Associations of 12-year sleep behaviour trajectories from childhood to adolescence with myopia and ocular biometry during young adulthood. Ophthalmic Physiol Opt. 2022;42:19–27. 2021/10/23.
45. Chen Z, Gu D, Wang B, et al. Significant myopic shift over time: Sixteen-year trends in overall refraction and age of myopia onset among Chinese children, with a focus on ages 4–6 years. J Glob Health. 2023;13:04144. 2023/11/07.
46. McCarthy CS, Megaw P, Devadas M, et al. Dopaminergic agents affect the ability of brief periods of normal vision to prevent form-deprivation myopia. Exp Eye Res. 2007;84:100–7. https://doi.org/10.1016/j.exer.2006.09.018.
47. Qu Y, Yu J, Xia W et al. Correlation of Myopia with Physical Exercise and Sleep Habits among Suburban Adolescents. *J Ophthalmol* 2020; 2020: 2670153. 2020/08/11. https://doi.org/10.1155/2020/2670153
48. Jee D, Morgan IG, Kim EC. Inverse relationship between sleep duration and myopia. Acta Ophthalmol. 2016;94. e204-210.2015/06/03.
49. Rayapoullé A, Gronfier C, Forhan A, et al. Longitudinal association between sleep features and refractive errors in preschoolers from the EDEN birth-cohort. Sci Rep. 2021;11:9044.
50. National Academies of Sciences E and Medicine. Onset and progression of myopia. Myopia: causes, prevention, and treatment of an increasingly common disease. National Academies Press (US); 2024.

Publisher's note