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ORIGINAL RESEARCH

Gender Difference of the Association Between Sleep Duration and Myopia Among Children and Adolescents

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Purpose: With girls typically exhibiting higher rates of myopia than boys, however, the mechanisms behind this gender difference remain unclear. This study aims to investigate the gender disparities in the relationship between myopia, sleep duration, physical activity, and BMI.

Patients and Methods: A total of 3138 primary and secondary school students were included. Mplus 8.3 was used to perform the multiple mediation analysis.

Results: Sleep duration was indicated to directly affect myopia (β=0.273, 95% CI=0.184−0.356) and through physical activity, BMI, physical activity and BMI three significantly mediation pathways, respectively. In terms of gender, the mediating direct effect of sleep duration on myopia of boys was 66.96%, which is much higher than that of girls' 50.91%. And the mediating indirect effect of sleep duration on myopia through physical activity and BMI are 32.65% and 12.10% respectively among girls, both of which are significantly higher than that of boys.

Conclusion: The study found that there are significant differences in the impact of sleep duration on myopia in children and adolescents of different genders. In this regard, while paying attention to the sleep duration of children and adolescents, special attention should also be paid to the indirect impact of girls' physical activity and BMI on myopia, and targeted measures should be formulated according to children of different genders to effectively protect the eye health of children and adolescents.

Keywords: myopia, children and adolescents, sleep duration, physical activity, BMI, gender difference

Introduction

In recent years, there has been a discernible surge in the prevalence of myopia, accompanied by a downward shift in age.[1,2] As a mounting public health concern, it is estimated that by 2050, barring effective interventions, nearly five billion individuals worldwide will be affected, with almost a fifth experiencing high myopia and related ocular complications.[3,4] Myopia, being irreversible, with potential blindness risk in high myopia cases, is known to trigger anxiety and depression in children and adolescents, degrade vision-associated quality of life, and exert significant socioeconomic impacts.[5–8] While myopia is a polygenic disease, resulting from hereditary, environmental, and lifestyle factors, a genome-wide association study identified only 336 genetic loci associated with ametropia, explaining a mere 18.4% of the heritability, thus implying a substantial contribution from environmental factors and lifestyle to the swift increase in myopia prevalence recently.[9]

Sleep, a vital physiological process, plays an important role in ensuring the healthy development of children and adolescents.[10] Yet, a prior study[11] revealed that Chinese children and adolescents aged 6–17 sleep for an average of 8.45 ± 0.03 hours per day, indicating a high prevalence of sleep deficiency. Given that both myopia and sleep deprivation are

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common health issues in this demographic, investigating their interrelationship is crucial. The Korean National Health and Nutrition Examination Survey examined 3675 adolescents aged 12–19 and found the refractive error increased by 0.10 diopter per 1 hour increase in sleep duration in 2008–2012.[12] A study[13] in Japan reported that compared with children without myopia or mild myopia, children with high myopia slept for the shortest time. A survey[14] on the risk factors of myopia in 15316 children and adolescents aged 6–18 years old in Beijing showed that the rate of myopia with sleep time of < 7h/d, 8h/d and > 9h/d were 68.45%, 56.08% and 34.80%, respectively, demonstrating that the longer the sleep time, the lower the prevalence of myopia. Another study[15] showed that sleep length ≥ 8h/d was the protective factor of suspected myopia in children and adolescents aged 15–16 years old which investigated 8030 children and adolescents in Anhui Province. However, a study[16] of 376 3-year-olds in Singapore showed that the total daily sleep time and the number of night wakes at the age of 1 had nothing to do with the refractive errors of children at the age of 3. And a study[17] followed up 1887 primary school students aged 5 to 9 years in Anyang for 4 years and found that sleep duration was not related to myopia progression and axial prolongation. Although the relationship between myopia and sleep duration has been widely studied, but it is still controversial in both cross-sectional studies and cohort studies, and the mechanism of sleep affecting myopia is unclear.[18]

In addition to the above epidemiological associations between sleep and myopia, there were also studies[19] that pointed out how sleep affects vision in physiological and anatomical aspects through the muscular and fascial networks. Studies[20–23] indicated that sleep quality was closely related to the pathogenesis of many comorbidities. Among them, the causal relationship between temporomandibular disorders and sleep disorders has been confirmed, and this relationship was mediated by the myofascial system. First of all, poor sleep quality will lead to a decrease in muscle mass, causing muscle tension, which in turn affects the plasticity of the eyeball and damages vision.

However, a number of other factors have been identified as common influencers of myopia and sleep. Many studies have indicated that there is a significant correlation between outdoor physical activity and myopia.[24] The study[25] of 2367 12-year-old students showed that outdoor physical activity was significantly related to their diopter and the prevalence of myopia. After controlling the factors such as close visual work and parental myopia, the longer the total time of physical activity, the lower the prevalence of myopia and the higher the diopter. In addition, a study on the association between myopia and BMI in 1359153 adolescents showed that there was a J-shaped correlation between BMI and myopia, and both low BMI or high BMI were significantly correlated with myopia.[26] Meanwhile, outdoor physical activity and BMI were also found to be significantly correlated with sleep duration.[1,27] But, so far, no study has comprehensively explored the association between sleep duration, physical activity, BMI and myopia among Chinese children and adolescents. Therefore, we think that sleep duration may have an indirect effect on myopia through outdoor physical activity and BMI, In doing so, we put forth three hypotheses that constitute the proposed model for our study: (1) sleep duration mediates myopia via physical activity; (2) BMI is a mediator in the relationship between sleep duration and myopia; (3) physical activity and BMI serve as tandem mediators in the link between sleep duration and myopia.

In addition, a large number of previous studies[28] have shown that there is a significant gender differences in the prevalence of myopia among children and adolescents, that is, the prevalence of myopia in girls is higher than that in boys, and the reason for this phenomenon is not only the physiological difference between boys and girls in the growth and development stage, but it may also be that boys spend more time on outdoor activities and physical exercise, but this mechanism is not yet clear. The aim of the present study was to explore the association between sleep duration, physical activity, BMI and myopia and gender differences among children and adolescents, and to clarify the mechanism and differences of sleep duration, physical activity and BMI on myopia by different genders, so as to provide a reference for the formulation of targeted myopia prevention and control measures for children and adolescents.

Material and Methods

Sampling

We employed a multi-stage stratified cluster random sampling method to sample primary and middle school students in Qingdao City, Shandong Province. Initially, based on urban-rural stratification, we randomly selected a district and a county considering the population proportionality, geographical distribution, and economic development level. In the second phase, twelve primary and secondary schools (five primary schools, seven secondary schools) were conveniently sampled. Each primary school had five/six grades and each secondary school had three/four grades. For the final stage, 50 students from each primary school grade and 100 from each secondary school grade were randomly selected for a questionnaire survey and diopter examination. In total, we disseminated 3800 questionnaires, receiving 3138 valid responses, a response rate of 82.6%.

And before the study, we calculated the sample size, taking the overall myopia rate of children and adolescents as 50%, and the minimum sample size was 400.

Data Collection

Data collection took place in Qingdao City, China, in December 2022 and encompassed online survey questionnaire data and diopter examination via autorefractor. We used the electronic tool "Questionnaire Star" (https://www.wjx.cn/) to conduct an online questionnaire survey, disseminating anonymous survey links via WeChat.[29] Before conducting the survey, the purpose and main contents of the study were explained to each participant or their guardians and they signed an informed consent form. Voluntary participation was assured with no penalties for non-participation. Only responses from individuals without mental disorders or abnormalities and without obvious logical errors in their answers were included. The platform's ability to allow a unique entry per IP address ensured data confidentiality and reliability. Autorefraction, without cycloplegia, was performed by experienced, uniformly trained optometrists and ophthalmologists using the ARK-510 autorefractor. Three continuous measurements were taken for each eye, with the average being recorded for the spherical (S) and cylindrical (C) equivalents. The spherical equivalent (SE) was calculated using the formula: SE=S+C/2. According to the "Guidelines for Appropriate Technology for Myopia Prevention and Control in Children and Adolescents",[30] myopia is defined as naked eye visual acuity <5.0 and SE ≤-0.5D with non-cycloplegic refraction. In this study, the left eye SE of the study population was included.[31]

This study was conducted in accordance with the Declaration of Helsinki, and the study protocol was approved by the Ethics Committee of Qingdao Eye Hospital of Shandong First Medical University (approval number: [2022] 60). We obtained informed consent from the patients and their respective guardians.

Measures

Sociodemographic Characteristics

In this study, the sociodemographic characteristics included gender (male, female), age (years), Height (cm), Weight (kg), and economic status. Economic status[32] was estimated by household income. It was divided into four types based on percentile including the first quartile to the fourth quartile. 1st quartile was the poorest and 4th was the richest.

Sleep Duration

Sleep duration was measured as the average sleep hours per day using a self-reported method.[33] The children and adolescents were asked respectively: (1) "On average, how long do you sleep from Monday to Friday in the past month?". (2) "On average, how long do you sleep on weekends in the past month?" The answers include five options: <7 hours, 7–8 hours, 8–9 hours, 9–10 hours, and >10 hours. The sleep duration reported in this study consists of the average sleep time from Monday to Friday and the average sleep time on weekends. That is, the average daily sleep duration is (question (1)*5+question (2)*2) / 7.

Physical Activity

Physical activity was estimated as the total time of outdoor physical activity every day, average hours per day. The children and adolescents were asked: "On average, how long is your daily physical activity (including walking, cycling, physical exercises, etc.) in the past month?". The answers include five options: 0 hour, <1 hour, 1–2 hours, 2–4 hours, and >4 hours.

Body Mass Index (BMI)

The body mass index (BMI)[34] was calculated as follow: weight (kg)/height (m)^2. The height and weight were measured while the children and adolescents were wearing light clothes without shoes. And the quality was controlled by educating the participants before the investigation. In our study, we analyze BMI as a continuous variable.

Statistical Analysis

Mplus 8.3 and SPSS 24.0 and Amos 21.0 were used to performed the statistical analysis. Descriptive analysis was used to present demographics, followed by Chi-square tests and Mann–Whitney *U*-tests to compare myopia prevalence across subgroups. The relationships between sleep duration, physical activity, BMI, and myopia were examined via Spearman correlation analysis. Then, we used Mplus 8.3 to test our proposed multiple mediation model, analyzing the relationship between sleep duration and myopia, considering physical activity and BMI as mediating variables. Finally, Amos 21.0 was used to test the Critical Ratio (CR) of sleep duration on myopia in children and adolescents of different genders. Bootstrap method was employed to examine the multiple mediating effects of physical activity and BMI between sleep duration and myopia, conducting repeated sampling 2000 times.

Results

Basic Characteristics

Table 1 details the participant' information. The study included 3138 primary and secondary students with an average age of 12.08±2.122 years, of which 51.5% were boys and 48.5% were girls. All of respondents, 2513 (80.1%) were defined

Table 1 Description and Univariate Analysis of Myopia Among the Students (N=3138)

Characteristics	N(%)	Myopia		χ^2/*Z*	*p*-value
		No(%)	Yes(%)		
Observations	3138	625(19.9)	2513(80.1)		
Gender				6.244	0.012
Boys	1617(51.5)	350(21.6)	1267(78.4)		
Girls	1521(48.5)	275(18.1)	1246(81.9)		
Age (years)	12.08±2.122	10.58±2.418	12.48±1.862	21.135	<0.001
Grade				347.861	<0.001
Primary school	927(29.5)	375(40.5)	552(59.5)		
Secondary school	2211(70.5)	250(11.3)	1961(88.7)		
Height (cm)	159.15±13.37	149.72±15.88	161.49±16.53	21.050	<0.001
Weight (kg)	48.72±16.63	40.58±15.75	50.75±16.22	14.103	<0.001
BMI (kg/m^2)	18.84±4.74	17.57±4.48	19.15±4.75	7.526	<0.001
Economic status[a]				1.753	0.625
1st quartile	493(15.7)	92(18.7)	401(81.3)		
2nd quartile	1532(48.8)	319(20.8)	1213(79.2)		
3rd quartile	971(30.9)	185(19.1)	786(80.9)		
4th quartile	142(4.5)	29(20.4)	113(79.6)		
Physical activity(hours/day)				137.646	<0.001
0 hour	815(26.0)	85(10.4)	730(89.6)		
<1 hour	1311(41.8)	224(17.1)	1087(82.9)		
1–2 hours	671(21.4)	204(30.4)	467(69.6)		
2–4 hours	280(8.9)	87(31.1)	193(68.9)		
>4 hours	61(1.9)	25(41.0)	36(59.0)		
Sleep duration(hours/day)				91.122	<0.001
<7 hours	336(10.7)	39(11.6)	297(88.4)		
7–8 hours	1357(43.2)	202(14.9)	1155(85.1)		
8–9 hours	1078(34.4)	261(24.2)	817(75.8)		
9–10 hours	330(10.5)	111(33.6)	219(66.4)		
>10 hours	37(1.2)	12(32.4)	25(67.6)		

Notes: [a] 1st quartile was the poorest and 4th quartile was the richest.

Table 2 The Correlation Matrix Between SE, Sleep Duration, Physical Activity and BMI (N=3138)

Variables	1	2	3	4
1.SE[b]	1.000			
2.Sleep duration	0.205*	1.000		
3.Physical activity	0.230*	0.375*	1.000	
4.BMI[c]	−0.172*	−0.181*	−0.177*	1.000

Notes: [b] SE= spherical equivalent; [c] BMI=body mass index; * *P*-value<0.001;

as myopia (SE ≤-0.5D). The mean time of sleep duration for the respondents with and without myopia had significant difference (χ^2=91.122, *P*<0.001). And the mean physical activity time was also had significant difference ((χ^2=137.646, *P*<0.001) among myopia and non-myopia student group. With regard to the BMI, the myopia students had higher level of BMI (*Z*=7.256, *P*<0.001).

Correlation Between Variables

The correlation matrix between SE, sleep duration, physical activity and BMI is provided in Table 2. Sleep duration (*r*=0.205, *P*<0.001), physical activity (*r*=0.230, *P*<0.001), and BMI (*r*=−0.172, *P*<0.001) were all related to myopia. Within it, sleep duration and physical activity were positively related to SE, and MBI was negatively related to SE. It is worth noting that with the decrease of SE, the degree of myopia increases.

Mediating Effect Analysis

Figures 1–3 showed the mediation pathway model among the total participant, boys and girls respectively. Path coefficients showed that all relationships in the model were significantly correlated. After including the mediators of

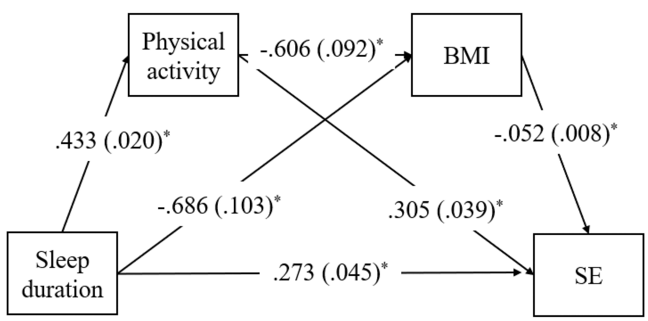

Figure 1 The mediation pathway model between SE and sleep duration through physical activities and BMI (total participant).
Note: * *P*-value<0.001.

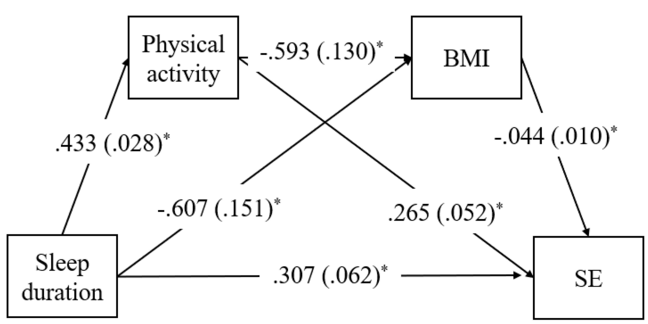

Figure 2 The mediation pathway model between SE and sleep duration through physical activities and BMI among the boys.
Note: * P-value<0.001.

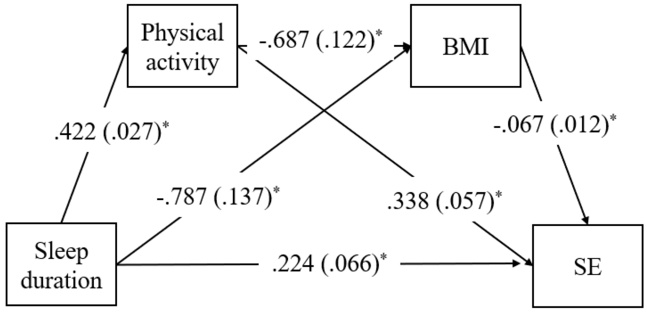

Figure 3 The mediation pathway model between SE and sleep duration through physical activities and BMI among the girls.
Note: * P-value<0.001.

the physical activity and BMI, the direct effect of sleep duration on myopia was still significant. Therefore, regardless of gender, the association between sleep duration and myopia was achieved partly through these two mediators.

The total effect, direct effect and indirect effects are described in Table 3.[35] The total standardized effect value of sleep duration on myopia was 0.454. Above all, the direct effect value was 0.273, with the mediating direct effect of sleep duration on myopia was 60.13%. The indirect effect value was 0.181, with the mediating indirect effect of sleep duration on myopia was 39.87%. Specifically, the standardized effect value of sleep duration on myopia through physical activity was 0.132, with the mediating effect of 29.07%. The standardized effect value of sleep duration on myopia through BMI was 0.035, with the mediating effect of 7.72%. The standardized effect value of sleep duration on myopia through physical activity and BMI was 0.014, with the mediating effect of 3.08%.

In terms of gender, the mediating direct effect of sleep duration on myopia of boys was 66.96%, which is much higher that of girls' 50.91%. The mediating indirect effect of sleep duration on myopia among girls is 49.09%, above all, the mediating indirect effect of sleep duration on myopia through physical activity and BMI are 32.65% and 12.10% respectively, both of which are significantly higher than that of boys.

Table 3 The Effects of Sleep Duration on SE with Physical Activities and BMI as Mediators (N=3138)

Model pathways	b	Posterior SD	95% CI	Mediating effect
Total effect sleep duration→SE [a]	0.454*	0.041	(0.374,0.534)	100%
Total effect sleep duration→SE [b]	0.460*	0.058	(0.351,0.577)	100%
Total effect sleep duration→SE [c]	0.438*	0.060	(0.317,0.553)	100%
Direct effect sleep duration→SE [a]	0.273*	0.045	(0.184,0.356)	60.13%
Direct effect sleep duration→SE [b]	0.308*	0.062	(0.193,0.433)	66.96%
Direct effect sleep duration→SE [c]	0.223*	0.066	(0.090,0.352)	50.91%
Total indirect effect sleep duration→SE [a]	0.181*	0.019	(0.147,0.223)	39.87%
Total indirect effect sleep duration→SE [b]	0.152*	0.024	(0.106,0.200)	33.04%
Total indirect effect sleep duration→SE [c]	0.215*	0.029	(0.156,0.271)	49.09%
Sleep duration→physical activities→SE [a]	0.132*	0.018	(0.102,0.172)	29.07%
Sleep duration→physical activities→SE [b]	0.115*	0.024	(0.071,0.164)	25.0%
Sleep duration→physical activities→SE [c]	0.143*	0.026	(0.092,0.195)	32.65%
Sleep duration→BMI→SE [a]	0.035*	0.008	(0.023,0.053)	7.72%
Sleep duration→BMI→SE [b]	0.026*	0.009	(0.012,0.048)	5.65%
Sleep duration→BMI→SE [c]	0.053*	0.013	(0.030,0.081)	12.10%
Sleep duration→physical activities→BMI→SE [a]	0.014*	0.003	(0.008,0.021)	3.08%
Sleep duration→physical activities→BMI→SE [b]	0.011*	0.004	(0.006,0.020)	2.39%
Sleep duration→physical activities→BMI→SE [c]	0.019*	0.005	(0.011,0.032)	4.34%

Notes: * *P*-value<0.001; [a] total participant; [b] boys; [c] girls.
Abbreviation: BMI, body mass index;

The test of path coefficients of different gender models is expressed by CR values.[36] The results showed that there are significant differences in the CR of sleep duration on myopia in children and adolescents of different genders (*CR*>1.96, $P < 0.05$).

Discussion

Our study indicated an 80.1% prevalence of myopia among primary and secondary school students in QingDao, China, significantly higher than the 2020 national average of 52.7%, as announced by the National Health Commission of the People's Republic of China.[37] This discrepancy may be attributed to QingDao's location within the developed eastern coastal region, typically associated with a high educational level.[38] Furthermore, our data revealed a higher prevalence of myopia in girls (81.9%) compared to boys (78.4%), consistent with previous studies,[39] suggesting gender-based differences in growth, development, and behavioral habits. The high prevalence of myopia among students in Qingdao necessitates attention from the relevant authorities for the prevention and treatment of myopia in this demographic.[40] However, the results of this study showed that there was no significant correlation between economic status and myopia, which may be related to the fact that the visual acuity in this study was a screening visual acuity result, and the population was limited to Qingdao, China, so the overall myopia rate and economic differences were not significant. Therefore, potential differences due to varying survey locations, subjects, and methods must be considered when interpreting these results.

Our study found that sleep duration was positively associated with myopia directly, and also indirectly, through physical activity and BMI. At present, the relationship between sleep duration and myopia is still controversial, and the results of previous studies are not consistent. Among them, some of the results[12–15] show that there is a significant positive correlation between myopia and sleep time among primary and secondary school students. It is believed that the importance of sleep in potentially contributing to myopia, either through late-night artificial light exposure due to prolonged reading and screen time or due to circadian rhythm disorders resulting from inadequate sleep.[41] In addition, most studies[16,17] have shown that there is no significant correlation between myopia and sleep. As the mechanism of sleep's impact on myopia remains unclear, future comprehensive studies, especially longitudinal ones, are recommended.

In addition, outdoor activity, as an effective protective factor for myopia, has been confirmed to be significantly correlated with sleep quality, and BMI is also considered to be significantly correlated with outdoor activity, sleep and myopia.[25–27] In addition, insufficient outdoor activities and overweight/obesity have become major public health problems affecting the physical and mental health of children and adolescents.[42] And, due to the different physical and mental development characteristics and lifestyles of children and adolescents of different genders, there are also significant differences in the development trajectory of physical and mental health.[43] It is of great significance to clarify the pathway relationship between sleep, outdoor activities, BMI and myopia in children and adolescents of different genders, so as to provide theoretical basis for individualized protection of children and adolescents' physical and mental health. Therefore, this study assumed outdoor activities and BMI as mediating factors from sleep to myopia, and explored the multi-path relationship between sleep, outdoor activities, BMI and myopia.

Our study results indicate that outdoor physical activities mediate 29.07% of the relationship between sleep duration and myopia, consistent with previous research findings. Regular outdoor physical activities in children and adolescents not only significantly improve sleep but have also been proven to have a substantial effect in improving pseudo myopia and preventing the further progression of myopia.[44,45] Interestingly, however, when analyzed by gender, the mediating role of outdoor physical activities between sleep duration and myopia was significant for both, but the effect size differed between boys and girls. For boys, the mediating effect of sleep duration on myopia through outdoor activities was 25.0%, while for girls, it was 32.65%, significantly higher than boys. This suggests that the direct impact of sleep duration on myopia is smaller in girls compared to boys, with a greater indirect impact through outdoor physical activity. Studies[46] showed that boys are more inclined towards outdoor physical activities than girls, who have a higher rate of poor visual habits. This phenomenon could lead to a lower sensitivity to outdoor activities in boys with myopia compared to girls.[47] Therefore, compared to boys, special attention should be given to the outdoor activity time of girls and its impact on the development and progression of myopia.

Similarly, our study results show that the mediating role of BMI in the relationship between sleep duration and myopia differs significantly between boys and girls. For boys, BMI only mediates 5.65% of the relationship between sleep duration and myopia, whereas, for girls, it has a higher mediation effect of 12.10%. The present research on the relationship between BMI and myopia is inconsistent. Some Chinese studies[48,49] have shown that there were significant differences in the vision of primary school students with different BMI levels, and the rate of poor vision in overweight and obese students was higher than that of normal weight and low weight students, but there was no significant difference in secondary school and junior school. But some other studies[50] also showed that it was impossible to find any relationship between BMI and myopia. Regarding the mechanism of BMI's effect on myopia, it may be related to the physical development caused by nutrition during childhood and adolescence, which affects the physiological structure of the eye, causing excessive growth of the eye axis, resulting in changes in the lens diopter that cannot compensate for the continuous growth of the eye axis, and causing poor vision.[51] This difference may primarily be due to changes in hormone levels during puberty. Girls enter puberty earlier than boys, with more significant fluctuations in height, weight, and consequently, BMI, making them more sensitive to the effects of myopia. This suggests that gender differences in myopia rates during puberty could be significant, highlighting a key period for myopia prevention and control in children and adolescents.[52] Special attention should be given to the impact of BMI changes on myopia in girls compared to boys.

Interestingly, we also observed a partial mediation in the sleep duration-myopia relationship through the chain mediation of physical activity and BMI, accounting for 3.08% of the total effect, and the difference between boys and girls was not significantly among them. Despite this seemingly small effect, our results underscore the importance of this mediation. Considering the significant correlation between outdoor physical activity and BMI, it's evident that these factors could mediate the relationship between sleep duration and myopia. Hence, for the vision health of children and adolescents, attention should be given to students with sleep deprivation, lack of outdoor physical activity, and overweight or obesity. The findings of this study suggest that myopia prevention and control efforts should be further implemented with refined management. Based on the varying growth, behavioral, and psychological characteristics of students of different genders at various stages, targeted interventions at key points should be conducted. It is important to recognize that myopia is not only a medical issue but also a social and educational concern. By establishing an eye health management system based on the participation of individuals, families, schools, and medical institutions, students' eye-using behavior can be improved, and vision health can be promoted.

Our study, the first to explore the gender difference of the association between sleep duration and myopia among primary and secondary school students comprehensively, provides valuable insights for early detection and prevention of myopia. However, many limitations need to be acknowledged also in this study. Initially, the study's cross-sectional nature means the causality in the relationships among sleep duration, physical activity, BMI, and myopia is not established. Future research should employ longitudinal and experimental methods for more definitive conclusions. Moreover, the myopia prevalence in our study might be overstated as refractive errors were assessed without cycloplegia. Typically, non-cycloplegic refraction methods could mask potential associations; therefore, the correlation we observed might be more significant than reported.[12] Additionally, our reliance on self-reported data for sleep and physical activity measurements has its constraints. Future studies could benefit from employing sleep tracking devices or biological assessment techniques. Lastly, our findings are specific to primary and secondary school students in Qingdao, China. The applicability to other demographics requires further exploration in subsequent studies.

Conclusion

In conclusion, our study found that there are significant differences in the impact of sleep duration on myopia in children and adolescents of different genders. Compared with boys, girls' sleep time has a greater indirect effect on myopia through outdoor activities and BMI. In this regard, while paying attention to the sleep duration of children and adolescents, special attention should also be paid to the indirect impact of girls' physical activity and BMI on myopia, and targeted measures should be formulated according to children of different genders to effectively protect the eye health of children and adolescents.

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Disclosure

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