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The prevalence of myopia and eye health behaviors among 3 to 18 years: a cross-sectional survey study

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forKindergartenandPrimarySchoolStudentsinGrades1-3-ParentVersion(EHBAS-P)andtheEyeHealthBehavior AssessmentScaleforPrimarySchoolStudentsinGrades4–6andMiddleSchoolStudents-StudentVersion(EHBAS-S) online.Dataonsocio-demographicfactors(gender,grades,region)andmyopiaratewerecollected.

Results Atotalof3500participantswereinvited,and3240usablequestionnaireswerecollected(responserate, 92.57%).Theoverallprevalenceofself-reportedmyopiaamongchildrenandadolescentsaged3–18yearsinHubei Provincewas34.35%.Riskofmyopiawashigherinfemalesthaninmales(OR = 1.27, $P = 0.007$),inruralthaninurban areas (OR = 1.88, $P < 0.001$), and in children with myopic parents than with non-myopic parents (OR = 3.21, $P < 0.001$). Furthermore, of the 3240 participants, only 18.1% ($n = 587$) had good eye health behavior levels, 46.1% ($n = 1494$) had moderate eye health behavior levels, and the rest had poor levels, and there was a signi□cantly higher risk of myopia for poor compared to good eye health behavior levels (OR = 1.74, $P < 0.001$). The regression analysis showed that the level of eye health behaviors varied signi□cantly with many of the demographic variables particularly with grades group, gender and whether myopia.

Conclusion The prevalence of self-reported myopia is at a high level among individuals between the ages of 3 and 18 in Hubei province, China, with notable di□erences between urban and rural populations. The level of eye health behaviors among children and adolescents is suboptimal. A particular focus on fostering the development of positive eye-use habits among younger children should be reinforced in the future.

Introduction

Myopia is one of the most common eye diseases globally, with a prevalence of 10–30% in the adult population in many countries and 80–90% in young adults in some parts of East and Southeast Asia [1]. e prevalence is estimated to increase to 4.76 billion individuals (49.8% of the global population) for myopia and almost 1 billion individuals (9.8% of the global population) for high myopia by 2050 [2]. China has one of the highest global prevalence of myopia. According to survey data from the National Administration of Disease Control and Prevention, the overall myopia prevalence among Chinese children and adolescents reached 51.9% in 2022, with rates of 36.7% in primary schools, 71.4% in junior high schools, and 81.2% in senior high schools [3]. Moreover, a nationwide cost-of-illness study illustrated that the total economic burden associated with myopia in the whole country was estimated as 173.6 billion CNY (26.3 billion US$) in China [4].

Eye health behaviors were con rmed to show protective e ects on the prevention or alleviation of myopia by numerous studies, and eye health behaviors were mainly composed of increased outdoor activity, regular physical exercise, reduced intensive near-work, healthy eating habits, and su cient sleep time [5–8]. It was found in a 23-year longitudinal study that limited outdoor activity in

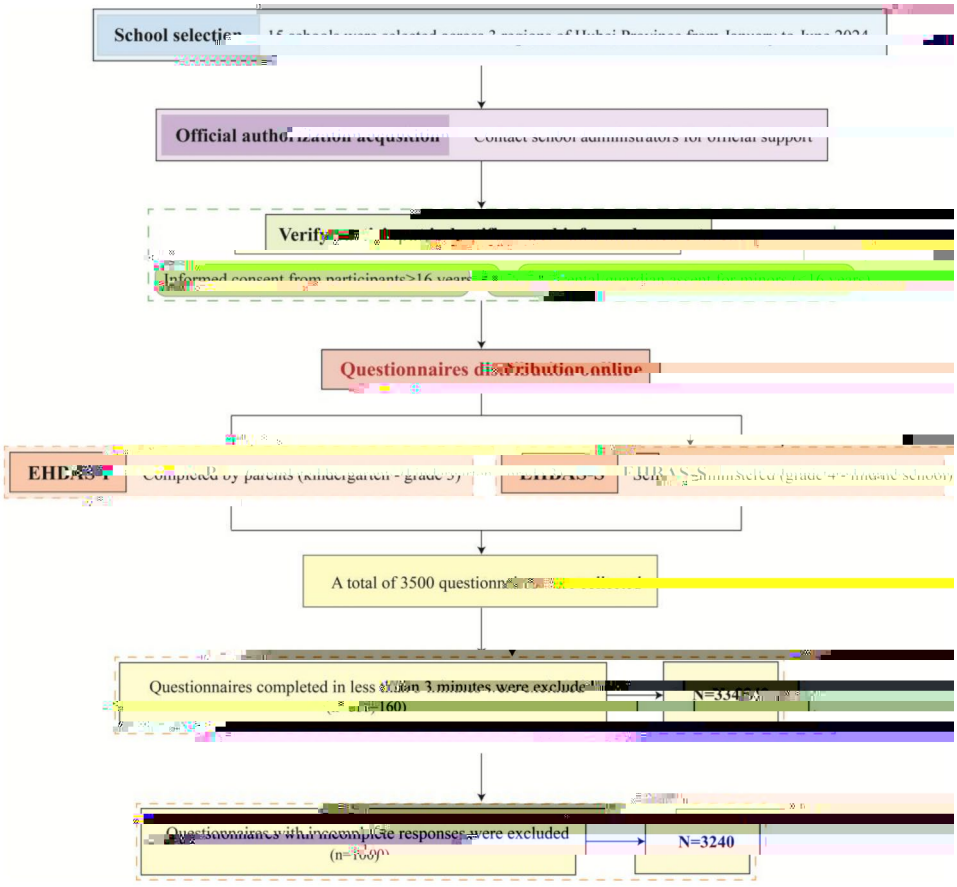

Fig. 1 Flowchart of study profile

primary grades 4–6, 875 (27.01%) in junior high schools, and 398 (12.28%) in senior high schools.

Prevalence of myopia

The overall prevalence of myopia was 34.35% (1113/3240). Females had a significantly higher prevalence of myopia at 38.50% than males (30.10%, $\chi^2 = 25.21$, $P < 0.001$). The prevalence of myopia was 33.00% in urban and 38.30% in rural areas, with significant differences between the two regions ($\chi^2 = 7.80$, $P = 0.005$). In addition, the average age of myopic children (12.74 ± 2.84) was significantly higher than that of non-myopic children (9.13 ± 3.63) (Z=-25.797, $P < 0.001$). And the prevalence of myopia was different in different grades, 3.9% in kindergarten, 17.50% in grades 1–3 of primary school, 39.30% in grades 4–6 of primary school, 55.20% in junior high schools, and 63.30% in senior high schools. The results showed that the prevalence of myopia increased significantly with increasing grades ($\chi^2 = 672.06$, $P < 0.001$), and there was a notable increase in the prevalence of myopia in primary school grades 4–6 and junior high school (Table 1; Fig. 2).

The study also showed the relationship between the prevalence of myopia and whether parents were myopic, sleep time per day, time spent on electronics per day, and eye health behavior levels. The prevalence of myopia in children with parental myopia was 37.40%, while the prevalence of myopia in children with no parental myopia was 31.1%, and the difference was statistically significant ($\chi^2 = 14.18$, $P < 0.001$). The prevalence of myopia was 59.40%, 28.40% and 15.50% for less than 8 h, 8–9 h and more than 10 h of sleep per day, respectively. Shorter sleep duration significantly increased the prevalence of myopia ($\chi^2 = 315.17$, $P < 0.001$). Furthermore, the prevalence of myopia increased significantly with increased time spent using electronics per day ($\chi^2 = 79.86$, $P < 0.001$). We also found that the prevalence of myopia was higher in children with poorer eye health behavior level ($\chi^2 = 92.78$, $P < 0.001$), with the prevalence of myopia in children with poor being 43.60%, moderate being 32.50%, and good being 21.00% (Table 1; Fig. 2).

Urban and rural distribution

Table 1; Fig. 3 showed the distribution between urban and rural children's gender, age, grades, whether they

were myopic, whether their parents were myopic, sleep time, time spent using electronics, and eye health behavior levels. e distribution of rural and urban children in this study was not signi cantly di erent in terms of gender, age and grade ($P = 0.134$, $P =$

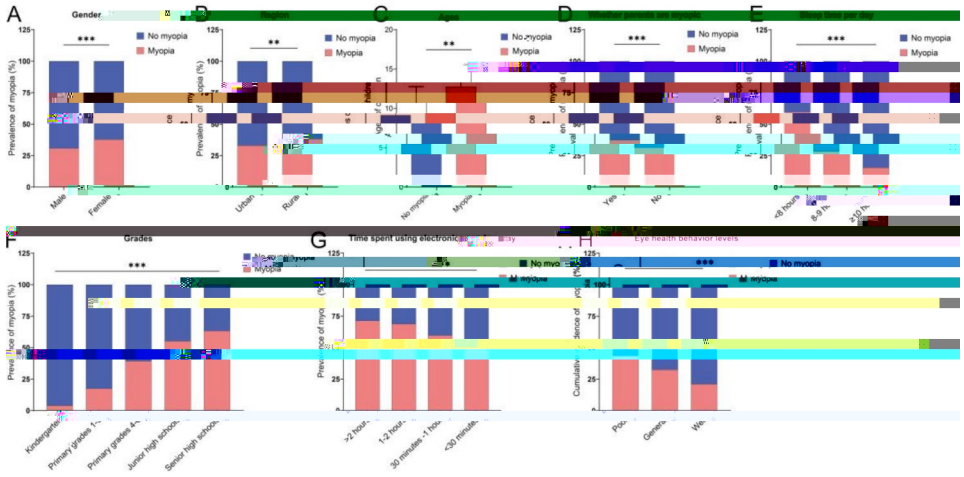

Fig. 2 Subject demographic characteristics
* Indicates $P<0.05$, ** Indicates $P<0.01$, *** Indicates $P<0.001$, statistically signi□cant di□erence

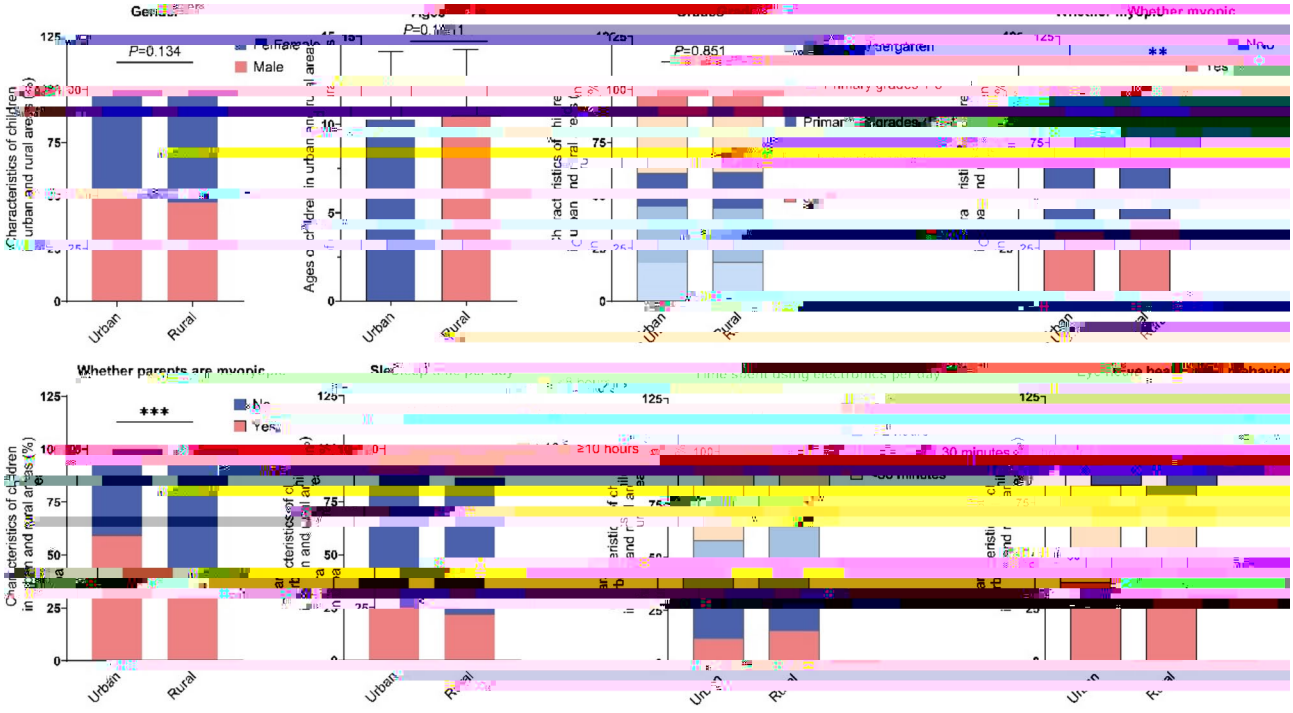

Fig. 3 Basic characteristics of children in urban and rural areas
* Indicates $P<0.05$, ** Indicates $P<0.01$, *** Indicates $P<0.001$, statistically signi□cant di□erence

of myopia prevalence. e risk of myopia was higher in females than in males (OR = 1.27, $P=0.007$), in rural than in urban areas (OR = 1.88, $P<0.001$), and in children with myopic parents than with non-myopic parents (OR = 3.21, $P<0.001$). In addition, children who slept less than 8 h per day had a signi cantly higher risk of myopia than those who slept more than 10 h (OR = 3.21, $P=0.001$), poor eye health behavior level higher than good ones (OR = 1.74, $P<0.001$). However, in the multi factorial regression analysis, we did not nd a signi cant association between the time spent using electronic devices per day and the risk of myopia (Table 2; Fig. 4).

Analysis of factors associated with eye health behaviors

We investigated the factors in uencing the eye health behavior levels. e univariate results showed that there were di erences in eye health behavior levels between children and adolescents of di erent grades ($\chi^2=180.49$, $P<0.001$), gender ($\chi^2=27.65$, $P<0.001$), regions ($\chi^2=12.90$, $P<0.001$), whether myopia

Table 2 Regression analysis of factors associated with myopia

	Univariate logistic regression		Multivariable logistic regression	
	OR (95%CI)	***P* value**	**OR (95%CI)**	***P* value**
Grades		< 0.001*		< 0.001*
Kindergarten	Reference		Reference	
Primary grades 1–3	5.25 (3.34, 8.25)	< 0.001*	4.86 (3.06, 7.71)	< 0.001*
Primary grades 4–6	15.94 (10.14, 25.06)	< 0.001*	19.74 (12.38, 31.49)	< 0.001*
Junior high schools	30.38 (19.61, 47.05)	< 0.001*	33.97 (21.47, 53.76)	< 0.001*
Senior high schools	42.55 (26.75, 67.68)	< 0.001*	61.99 (36.88, 104.19)	< 0.001*
Gender		< 0.001*		0.007*
Male	Reference		Reference	
Female	1.45 (1.26, 1.68)	< 0.001*	1.27 (1.07, 1.51)	0.007*
Region		0.005*		< 0.001*
Urban	Reference		Reference	
Rural	1.26 (1.07, 1.49)	0.005*	1.88 (1.54, 2.31)	< 0.001*
Whether parents are myopic		< 0.001*		< 0.001*
No	Reference		Reference	
Yes	1.32 (1.14, 1.53)	< 0.001*	3.21 (2.64, 3.92)	< 0.001*
Sleep time per day		< 0.001*		< 0.001*
≥ 10 h	Reference		Reference	
8–9 h	2.63 (1.63, 2.89)	< 0.001*	1.24 (0.89, 1.72)	0.204
< 8 h	7.89 (5.89, 10.81)	< 0.001*	1.83 (1.27, 2.64)	0.001*
Time spent using electronics per day		< 0.001*		0.649
< 30 min	Reference		Reference	
30 min–1 h	1.13 (0.94, 1.36)	0.189	1.10 (0.88, 1.36)	0.410
1–2 h	1.68 (1.37, 2.07)	< 0.001*	0.98 (0.76, 1.27)	0.879
> 2 h	2.55 (2.03, 3.21)	< 0.001*	0.91 (0.67, 1.23)	0.530
Eye health behavior levels		< 0.001*		0.001*
Good	Reference		Reference	
Moderate	1.81 (1.45, 2.27)	< 0.001*	1.52 (1.17, 1.99)	0.002*
Poor	2.91 (2.31, 3.67)	< 0.001*	1.74 (1.31, 2.32)	< 0.001*

*Indicates $P < 0.05$, statistically signi□cant di□erence; OR = odds ratios

($\chi^2 = 92.78$, $P < 0.001$) and whether parents are myopic ($\chi^2 = 61.78$, $P < 0.001$). e regression result showed that males had better levels of eye health behavior than females(OR = 0.64, P<0.001), children and adolescents who were already myopic and those with myopic parents had poorer eye health behavior level; children and adolescent who are in junior high school, senior high school and primary school of grade 1 to 3 had a higher risk of poor eye health behavior level, which was 3.53, 2.42 and 1.48 times higher than that of kindergarten children, respectively, while there were no statistical association between region and eye health behavior levels (Fig. 5).

Discussion

e study revealed that the overall prevalence of myopia among children and adolescents aged 3–18 years in Hubei Province was 34.35%, which is notably higher than that reported in Western countries such as Europe and Australia [24–26]. Existing literature has consistently linked the high prevalence of myopia in China to factors including elevated educational stress, limited outdoor time provided by schools, and genetic predispositions [1, 25]. A cross-sectional survey of primary school students aged 6–12 years in Tianjin, China, showed that the overall prevalence of myopia was 52.92% [27]. In northeastern Sichuan, the prevalence of myopia in primary and secondary school students aged 5–19 years was 65.61% [16]. Myopia rates also varied greatly from city to city in China, which may be related to di erent economic conditions, educational pressures, and the popularity of electronic devices in di erent cities, but ere commonly higher than abroad. Furthermore, in alignment with prior investigations [16], our study observed a positive correlation between myopia prevalence and grades, with the higher the grade level, the higher the myopia rate. We also found a notable increase in the prevalence of myopia at the primary and junior high schools, which may be related to accelerated growth and development and increased pressure on education [28].

In accordance with prevailing research ndings [16, 29–31], our study identi ed a higher prevalence of myopia among females compared to males, with females exhibiting a greater risk of myopia (OR = 1.27). is disparity has been attributed to potentially reduced

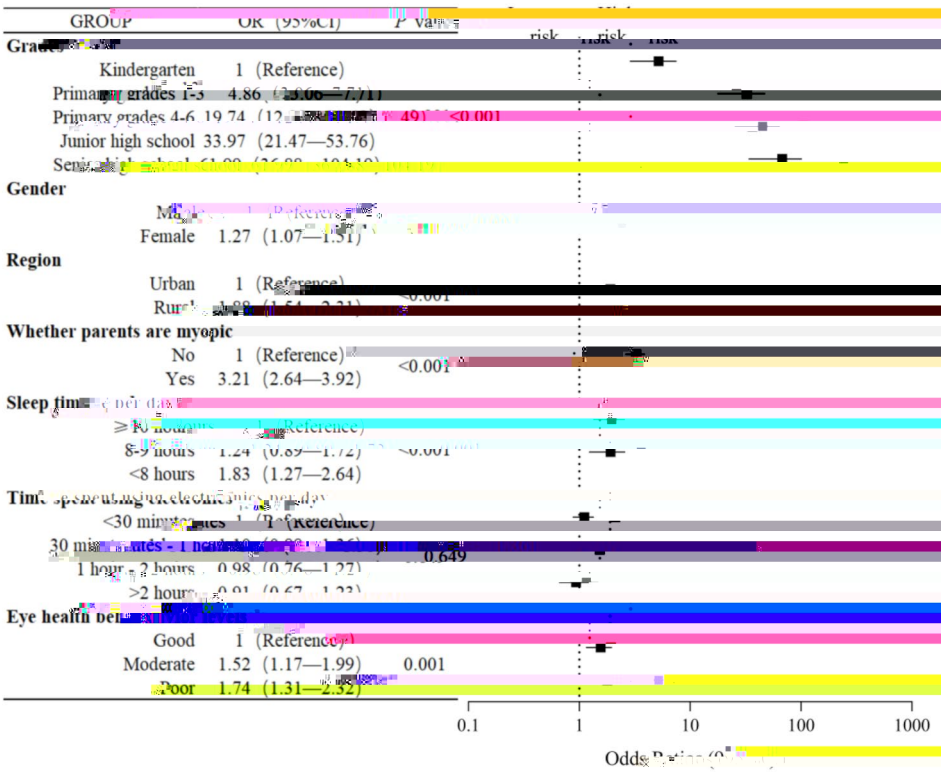

Fig. 4 Associations between potential factors and myopia in multivariate analysis

engagement in outdoor activities, prolonged periods of reading, and near work among females [32]. is is con- rmed by our research nding that females have poorer levels of eye health behavior than males. Additionally, the observed trend has been linked to variations in sex hormone levels and the accelerated growth and development experienced by females during adolescence [33]. Consequently, among the initiatives aimed at preventing and controlling myopia, priority attention could be given to female students to encourage them to reduce near-work hours and participate more in outdoor activities.

Based on our investigation ndings, o spring of myopic parents exhibit a heightened prevalence of myopia. Previous studies have established a clear association between parental myopia and the occurrence of myopia in children. A cohort study involving preschoolers across diverse nations revealed that parental myopia signi cantly elevates the likelihood of myopia in their o - spring [34]. In a study conducted in the Feng Hua District of Zhejiang Province, it was determined that the risk of myopia in students with two myopic parents or one myopic parent was 1.61 and 1.29 times greater, respectively, compared to those with non-myopic parents [31]. ese investigations collectively underscore the substantial role of genetic factors in the development of myopia. Consequently, children with myopic parents are given necessitate early and targeted interventions and their refractive progression is monitored.

e study results revealed that children with myopia exhibited inferior eye health behaviors compared to those without myopia, with the risk of myopia being signi cantly correlated with levels of eye health behaviors. e etiology and advancement of myopia are in uenced by a blend of genetic and environmental factors [1], with outdoor activity duration and near work predominantly shaping the environmental aspect [35–37]. Outdoor pursuits exert a protective in uence against myopia, as evidenced by a two-year prospective study indicating that heightened outdoor activity diminishes myopia incidence [36]. is protective e ect is likely attributed to the augmented release of retinal dopamine prompted by intense natural light exposure. Furthermore, near work stands as a closely intertwined factor in myopia development [23]. Prolonged near work can induce accommodative lag, leading to hyperopic retinal defocus and triggering ocular growth aimed at correcting the focus, thereby fostering axial elongation [35]. Studies have demonstrated that individuals who engage in tasks beyond 30 centimeters and take breaks every 30 min exhibit notably decelerated myopia progression [38]. erefore, schools and parents need to pay attention to children cultivating good eye behavior, reducing the hours of near work and increasing

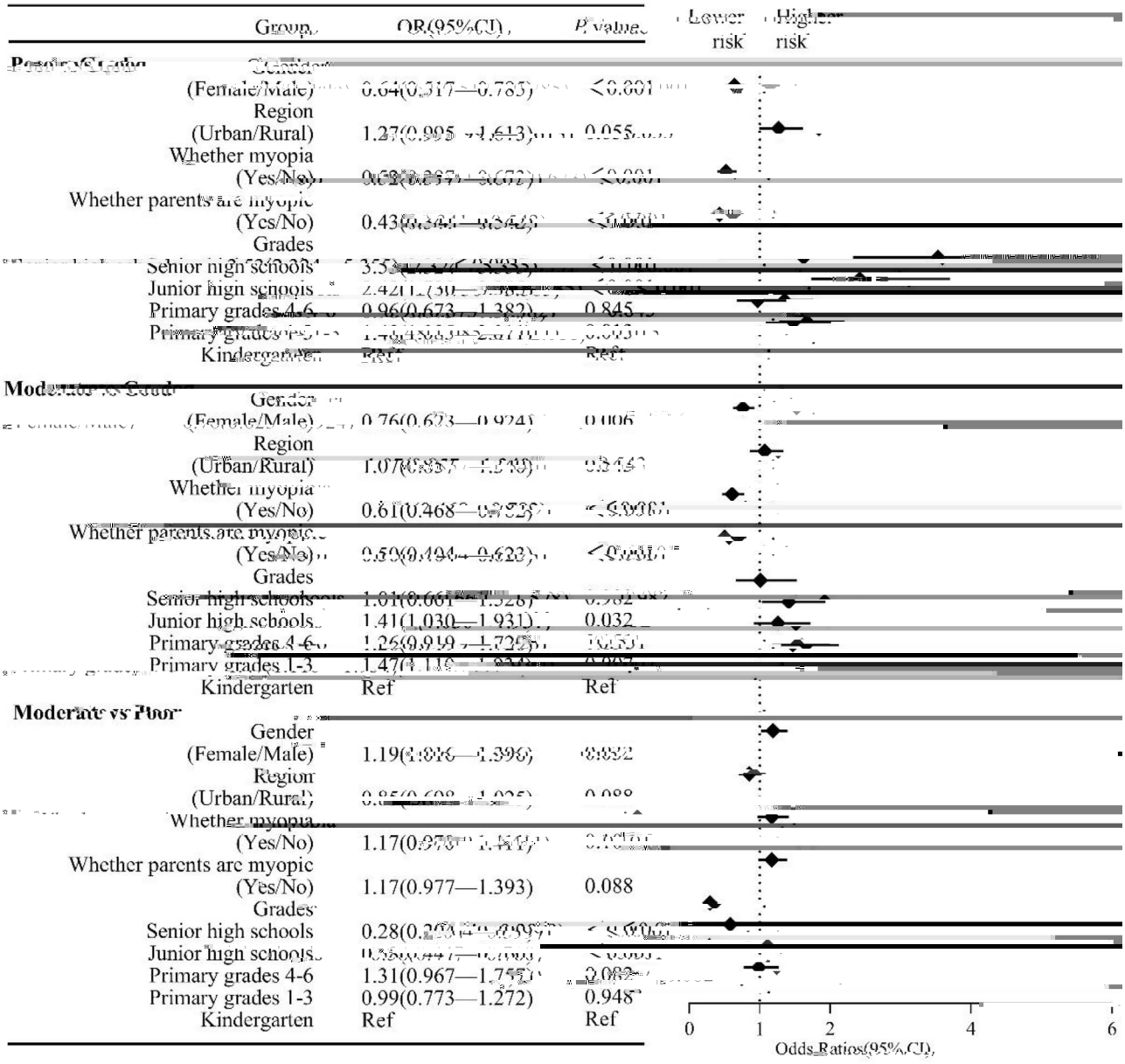

Fig. 5 Associations between potential factors and eye health behaviors in multivariate analysis

the hours of outdoor activities to slow down the progression of myopia.

e study revealed that individuals who slept less than 8 h per day had a 3.21 times higher risk of myopia compared to those who slept more than 10 h, highlighting adequate sleep duration as a protective factor against myopia. Nonetheless, conclusive evidence regarding the association between sleep duration and myopia remains elusive. Jee et al. [39] observed a 41% reduction in myopia incidence among subjects sleeping over 9 h in contrast to those with less than 5 h of sleep. Scholars have posited that shorter sleep durations may downregulate dopamine D2 receptors in the ventral striatum, potentially dampening ocular dopamine pathway activation and fostering myopia progression [40, 41]. Conversely, a meta-analysis indicated no signi cant link between sleep duration and myopia prevalence [42]. Further investigations are warranted to elucidate the intricate relationship between sleep duration and myopia development.

With the advancement of electronic technology, electronic devices are increasingly utilized for both in-class and after-class learning. Smartphones and electronic entertainment are becoming more pervasive in students' lives. Our study identi ed a higher prevalence of myopia among individuals who spent extended periods using electronic devices daily, although no signi cant

correlation was found in adjusted multi-factorial regression analyses. Similar to our ndings, Peng et al. [43] and Huang et al. [31] did not observe a signi cant link between daily electronic device usage and myopia incidence in their respective cross-sectional studies. Conversely, Harrington et al. [44] reported a signi cant association between myopia prevalence and over 3 h of daily screen time in children. In addition, increased screen time often leads to more near-work activities and reduced outdoor engagement, potentially heightening the risk of myopia [45]. erefore, further research is still needed on the e ect of the duration of electronic device use on the development and progression of myopia and its relationship with the reduction of outdoor activities.

Our research also revealed a signi cantly higher prevalence of myopia in rural regions compared to urban areas, with rural children facing a 1.88 times greater risk of myopia than their urban counterparts, diverging from certain prior studies. A rural-urban investigation on myopia in Anhui province demonstrated a lower myopia prevalence among rural children (63.7%) in contrast to urban children (68.1%) [43]. Tu et al. [46] similarly observed higher myopia rates among primary school students in the provincial capital city (32.35%) compared to urban (23.03%) and rural areas (14.82%), attributing this trend to reduced outdoor activities and heightened near-work intensity in the provincial capital city. However, the prevalence of myopia has accelerated signi - cantly in rural areas in recent years. A study of Chinese children and adolescents aged 7 to 18 years from 2010 to 2019 found that myopia detection rates in rural children have risen rapidly, which is thought to be related to their increased exposure to electronic devices, shorter outdoor time, and relatively weak health education in rural children compared to urban children [47]. To delve into the urban-rural disparities, we conducted a detailed analysis of myopia-related factors among urban and rural children. Our ndings indicated that urban children exhibited a higher prevalence of parental myopia and poorer eye health behavior, while rural children spent more time daily on electronic devices than their urban counterparts. Increased use of electronic devices can reduce outdoor activity time, leading to increased risk of myopia. In addi-