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• Original Article •

Lifestyle and myopia among primary school students in urban areas of Fujian following comprehensive prevention and control of myopia in children and adolescents implementation plan: a cross-sectional study

Lanqin Zhao (赵兰琴)^{1#}, Wei Xiao (肖薇)^{1#}, Mingwei Wang (王铭薇)^{1#}, Yahan Yang (杨雅涵)¹,
Duoru Lin (林铎儒)¹, Jianyu Pang (庞健宇)¹, Weiqing Qiu (丘蔚晴)¹, Yue Wu (吴悦)¹,
Yuchun He (何雨春)^{2,4}, Jianmin Hu (胡建民)^{3,4}, Haotian Lin (林浩添)¹

1. State Key Laboratory of Ophthalmology, Zhongshan Ophthalmic Center, Sun Yat-sen University, Guangdong Provincial Key Laboratory of Ophthalmology and Visual Science, Guangzhou 510060, China
2. School of Medical Technology and Engineering, Fujian Medical University, Fuzhou 350122, China
3. The Second Affiliated Hospital of Fujian Medical University, Fujian Medical University, Quanzhou 362000, China
4. The Research Center for Juvenile Myopia Prevention and Control of Fujian Province, Fuzhou 350122, China

HIGHLIGHTS

- There is considerable scope for improving the lifestyle of primary school students in urban areas of Fujian, and lifestyle is strongly associated with myopia onset.
- Adopting AUC to quantify predictive performance of lifestyle factors and demonstrate the association between lifestyle and myopia onset.
- Targeted interventions: Prioritize students with myopic parents (especially biparental myopia) for early screening and structured outdoor programs.
- School policy reforms: Advocate for extended outdoor recess and mandatory daily outdoor time (≥ 2 hours) to align with national guidelines.
- Conducting longitudinal studies with wearable devices to objectively and precisely measure lifestyle factors to assess the effect of lifestyle on myopia development and progression.

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Co-first authors

Corresponding author: Haotian Lin, E-mail: linht5@mail.sysu.edu.cn.



Full Text

Abstract: **Objective:** To investigate the lifestyle and myopia among primary school students in urban areas of Fujian with the context of myopia prevention and control measures, aiming to provide scientific evidence for identifying high-risk myopia population and formulating effective intervention strategies. **Methods:** A cross-sectional study was conducted from October to November 2023, enrolling 811 fourth-grade students from three primary schools in three cities across Fujian. Personal information and lifestyle-related pattern were collected using customized questionnaire. Participants underwent comprehensive ophthalmic assessments including distance visual acuity tests and refractive examinations. Logistic regression analysis was used to assess the impact of lifestyle on the onset of myopia. **Results:** The prevalence of myopia among fourth-grade students in urban primary schools in Fujian was 46.4%. Only 25.8% students engaged in outdoor activities for more than 2 hours daily, while 63.3% participated in outdoor activities during class breaks. Multivariate Logistic regression analysis revealed that outdoor activities during class breaks (OR= 0.646 [95% confidence interval(CI): 0.473-0.881], $P=0.006$) and daily time spent outdoors (2-3 hours, OR=0.682 [95%CI: 0.466-0.993], $P=0.047$; more than 3 hours, OR=0.403 [95%CI: 0.192-0.796], $P=0.01$) were independent protective factors against myopia. Lifestyle significantly enhanced the predictive performance for myopia ($P=0.01$). Additionally, parental myopia (one parent with myopia, OR=2.247 [95%CI: 1.612- 3.145], $P<0.001$; both parents with myopia, OR=4.824 [95%CI: 3.262-7.204], $P<0.001$) emerged as a key risk factor for myopia. **Conclusions:** There is considerable scope for improving the lifestyle of primary school students in urban areas of Fujian. Lifestyle is strongly associated with myopia onset, highlighting the need for schools and families to actively encourage students to engage in more outdoor activities and take breaks outdoors to prevent and control myopia. Students with parents, especially both parents, having myopia should be considered as a key target group for myopia prevention efforts.

Keywords: myopia prevention and control; lifestyle; myopia; primary school students

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INTRODUCTION

Myopia has become a significant global public health issue. In 2016, Holden projected that the global prevalence of myopia would reach around 50% by 2050.^[1] In 2018, the World Health Organization reported that about 600 million people in China, nearly half the population, had myopia, with the highest rate of myopia among adolescents worldwide. A nationwide survey in 2018 revealed that the overall myopia rate among Chinese children and adolescents was 53.6%.^[2] Myopia in this population has been highly prevalent and occurred earlier and progressed rapidly. It not only impacts their academic performance and daily lives but also poses challenges to the sustainable development of the country. Therefore, it has been both crucial and urgent to

take myopia prevention and control measures.

Previous studies have indicated that lifestyle-related factors, including time outdoor, outdoor activities during class recess, near work, and sleep duration, may influence the onset and progression of myopia in children and adolescents.^[3-14] In August 2018, the Ministry of Education and other seven national departments jointly released the "Comprehensive Prevention and Control of Myopia in Children and Adolescents Implementation Plan (PLAN)", outlining key measures for myopia prevention and control in the new era. These measures required that schools and families take action regarding students' lifestyle. Specifically, schools should limit daily written homework for students in grades 3-6 to no more than 60 minutes, ensure that primary and secondary school students engage in more than one hour of physical

activities each school day, and organize and encourage students to go outdoors or look into the distance during class breaks. Families, on the other hand, should ensure that children spend more than 60 minutes a day outside in natural light, limit non-educational electronic device use to under 1 hour per day, and guarantee 10 hours of sleep daily for primary school students.^[15] The epidemiology data displayed that the overall myopia rate among children and adolescents in China was 52.7% in 2020,^[2] 52.6% in 2021, and 51.9% in 2022, reflecting a downward trend and positive outcomes in myopia prevention and control efforts.^[16] However, challenges remain. Fujian Province exhibited a significantly higher myopia rate. In 2020, the overall myopia rate among children and adolescents in Fujian was 66.7%, with 68.2% in urban areas and 51.1% among primary school students.^[28] Fujian has prioritized myopia prevention and control in recent years. However, after years of intervention, the lifestyle patterns of urban students remain poorly understood, and their impact on myopia lacks systematic research. This cross-sectional study investigates lifestyle and myopia among urban primary school students in Fujian, aiming to explore current lifestyles of students in the context of myopia prevention and control and their influence on myopia. The findings will provide scientific evidence for identifying key target populations and formulate effective prevention measures.

MATERIALS AND METHODS

Participants

From October to November 2023, a questionnaire survey and myopia screening were conducted on fourth-grade students from three primary schools in the cities of Quanzhou, Sanming, and Ningde in Fujian Province using a random sampling method. All eye examinations were performed by trained professionals. A total of 811 students were included in the study, comprising 435 boys (53.6%) and 376 girls (46.4%), with an average age of 9.70 ± 0.54 years. The study adhered to the relevant principles outlined in the Declaration of Helsinki and was approved by the Ethics Committee of Sun Yat-sen University Zhongshan Ophthalmic Center (Approval No.: 04161326). Informed consent was obtained from both the students and their guardians prior to the survey and vision test.

Vision examination

Vision examinations were conducted in accordance with the "Guidelines for Screening of Refractive Errors in Primary and Secondary School Students" (WS/T 663-2020).^[17] The examinations included uncorrected and corrected distance visual acuity tests, autorefractive evaluation, and identification of major eye diseases. The distance visual acuity test was carried out at a distance of 5 meters with Chinese standard logarithmic visual acuity E chart. Subsequently, non-cycloplegic autorefractive evaluation was performed to measure spherical and cylindrical diopters using a handheld vision screening device (SL-100, New Horizon). Each eye was measured three times, with the average taken and recorded to 2 decimal places. A student was defined as having screening myopia if their uncorrected distance visual acuity was <5.0 and the effective spherical equivalent (calculated as sphere + cylinder / 2) was $\leq -0.5D$ in at least one eye.^[18] Additionally, students wearing orthokeratology lenses were directly classified as having myopia without undergoing autorefractive evaluation.

Questionnaire survey

Based on the prevention and control measures outlined in the PLAN and references related to myopia risk factors,^[3-14] a questionnaire was designed. The questionnaire consisted of personal basic information, including sex, age, paternal myopia, and maternal myopia; as well as lifestyle factors such as place of activity during class recess, average daily time spent on outdoor activities on weekdays, average daily time spent on outdoor activities during weekends and holidays, average daily screen time, average daily study time after school, and daily sleep duration. Before the vision examination, the questionnaire was completed online by students with the assistance of their parents using the "Sojump" platform. The average daily time spent on outdoor activities was calculated using the formula: (average daily time spent outdoor activity on weekdays * 5 + average daily time spent outdoor activities during holidays and weekends * 2) / 7.

Quality control

This survey is part of the "China Urban Eye Health Index Project" led by Zhongshan Ophthalmic Center, Sun Yat-sen University. Prior to the survey, ophthalmology

graduate students who had received standardized training from the center explained the objectives and significance of the study, as well as provided instructions for filling out the questionnaire. The questionnaire was administered via the "Sojump" platform. During the completion process, students and their parents were guided as needed. After the questionnaire was filled out, vision examinations were performed by professional ophthalmologists from the center. All results were promptly uploaded to an electronic information platform after the examination to ensure the authenticity and accuracy of the data.

Statistical analysis

Data analysis was conducted using the statistical software R 4.1.1 (R Foundation for Statistical Computing, Vienna, Austria). Students who completed both the questionnaire and vision tests were included in the analysis. The characteristics of the students were described as follows: mean \pm standard deviation (Mean \pm SD) for continuous variables, after normality was confirmed with Kolmogorov-Smirnov test; and frequency (percentage) for categorical variables. Differences between myopic and non-myopic student groups were compared using t-tests for continuous variables and chi-square tests for categorical variables.

The impact of lifestyle on myopia was assessed with logistic regression. First, univariate logistic regression analyses were performed to evaluate the associations of each lifestyle-related factor with myopia. Myopia status was considered the dependent variable, while individual lifestyle-related factors served as independent variables, with adjustment for the confounding factors of sex, age, and parental myopia. Then, all lifestyle-related factors with $P < 0.2$ were selected as independent variables, again with adjustment for sex, age, and parental myopia, to assess the impact of lifestyle on myopia using multivariate logistic regression. Odds ratios (OR) and their 95% confidence intervals (CI) were reported.

Moreover, the predictive ability of lifestyle factors on myopia was evaluated. Logistic regression was employed to establish myopia prediction models using basic information (sex, age, and parental myopia) and a combination of both basic information and lifestyle factors, separately. The ROC (Receiver Operating Characteristic) curves, areas under the curve (AUCs) along with 95% Delong confidence intervals were

utilized to demonstrate the performance of two models. Paired DeLong tests were performed to compare the two AUCs. All statistical tests were two-tailed, and P values < 0.05 were considered statistically significant.

RESULTS

Demographic characteristics and lifestyle

The study included 811 fourth-grade primary school students from Fujian Province who completed both vision examinations and questionnaires. The overall prevalence of myopia was 46.4% (376/811). Among the myopic students, 39.1% had one parent with myopia and 34.3% had both parents affected. Conversely, among non-myopic students, the proportions were 33.8% and 13.3% respectively. The difference in parental myopia between the two groups were statistically significant ($P < 0.001$).

All students spent more than one hour daily on outdoor activities. Specifically, 74.2% of students spent for 1 to 2 hours, and 25.8% spent over 2 hours (including 5.9% for over 3 hours). A higher proportion of non-myopic students engaged in outdoor activities for over 2 hours compared to myopic students (31.0% vs. 19.7%, $P < 0.001$). Similarly, more non-myopic students participated in activities outside the classroom during recess compared to myopic students (69.4% vs. 56.1%, $P < 0.001$).

Regarding screen time, 32.4% of students had an average daily screen time of 1-2 hours, while 9.5% had over 2 hours of screen time. In terms of study time after school, 34.6% of students had an average of 2-3 hours, and 11.5% had over 3 hours of study time. Additionally, 35.9% of students reported average daily sleep duration of less than 8 hours. There were no significant differences in these three factors between the two groups (Table 1).

The impact of lifestyle on myopia

Univariate logistic regression analysis was conducted to assess the relationship between individual lifestyle factors and myopia, with adjustment for sex, age and parental myopia. The results indicated that average daily time spent on outdoor activities and recess outside classroom were significantly associated with myopia. Conversely, daily screen time, study time after school, and sleep duration exhibited no significant association with myopia (Table 2).

Table 1 Demographic characteristics and lifestyle of the primary school students in Fujian

Variable	Total N = 811 Mean±SD/ n(%)	Myopia N = 376 Mean±SD/ n(%)	Non-myopia N = 435 Mean±SD/ n(%)	P
Age, year	9.70±0.54	9.73±0.48	9.67±0.58	0.08
Sex				
girls	376(46.4)	178(47.3)	198(45.5)	0.65
boys	435(53.6)	198(52.7)	237(54.5)	
Parental myopia				<0.001
None	330(40.7)	100(26.6)	230(52.9)	
One	294(36.3)	147(39.1)	147(33.8)	
Both	187(23.1)	129(34.3)	58(13.3)	
Class recess				<0.001
Inside classroom	298(36.7)	165(43.9)	133(30.6)	
Outside classroom	513(63.3)	211(56.1)	302(69.4)	
Time outdoor, h/d				<0.001
1-2 h	602(74.2)	302(80.3)	300(69)	
2-3 h	161(19.9)	62(16.5)	99(22.8)	
>3 h	48(5.9)	12(3.2)	36(8.3)	
Screen time, h/d				0.27
<1 h	471(58.1)	224(59.6)	247(56.8)	
1-2 h	263(32.4)	123(32.7)	140(32.2)	
>2 h	77(9.5)	29(7.7)	48(11)	
Study time after school, h/d				0.68
<2 h	437(53.9)	208(55.3)	229(52.6)	
2-3 h	281(34.6)	128(34)	153(35.2)	
>3 h	93(11.5)	40(10.6)	53(12.2)	
Sleep duration, h/d				0.94
<8 h	291(35.9)	137(36.5)	154(35.4)	
8-9 h	441(54.4)	202(53.7)	239(54.9)	
>9 h	79(9.7)	37(9.8)	42(9.7)	

Lifestyle-related factors with P -values <0.2 in the univariate logistic regression analyses were further analyzed using multivariate logistic regression. These factors included average daily time spent on outdoor activities, recess outside classroom, and screen time. After adjusting for sex, age and parental myopia, the results demonstrated that engaging in outdoor activity during class recess (OR = 0.646 [95% CI: 0.473-0.881], $P = 0.006$) and average daily time spent outdoors (2-3 hours: OR = 0.682 [95% CI: 0.466-0.993], $P = 0.047$; over 3 hours: OR = 0.403 [95% CI: 0.192-0.796],

$P = 0.01$) were independent protective factors against the development of myopia. Additionally, parental myopia emerged as a significant risk factor. Compared to students with neither parent having myopia, students with myopic parents were much more likely myopic (either myopic parent: OR = 2.247 [95% CI: 1.612–3.145], $P < 0.001$); both myopic parents: (OR = 4.824 [95% CI: 3.262–7.204], $P < 0.001$) (Table 3).

Lifestyle improved myopia prediction capacity

Myopia prediction models were developed using

Table 2 Association between myopia and each factor of lifestyle among primary school students using univariate logistic regression

Lifestyle	OR [95%CI]	P value
Class recess		
Inside classroom	1	
Outside classroom	0.614[0.451, 0.835]	0.002
Time outdoor, h/d		
1-2 h	1	
2-3 h	0.643[0.441, 0.932]	0.02
>3 h	0.379[0.182, 0.739]	0.006
Screen time, h/d		
<1 h	1	
1-2 h	0.99[0.721, 1.363]	0.96
>2 h	0.683[0.399, 1.152]	0.16
Study time after school, h/d		
<2 h	1	
2-3 h	0.935[0.682, 1.283]	0.68
>3 h	0.831[0.513, 1.338]	0.45
Sleep duration, h/d		
<8 h	1.023[0.747, 1.400]	0.89
8-9 h	1	
>9 h	1.151[0.690, 1.915]	0.59

Logistic regression adjusted for sex, age and parental myopia. OR, Odds Ratio; CI, confidence interval; h, hour.

Table 3 Association between myopia and lifestyle among primary school students using multivariate logistic regression

Variable	OR [95%CI]	P value
Age, year	1.314[0.995, 1.740]	0.06
Sex		
girls	1	
boys	0.966[0.714, 1.308]	0.82
Parental myopia		
Neither	1	
One	2.247[1.612, 3.145]	<0.001
Both	4.824[3.262, 7.204]	<0.001
Class recess		
Inside classroom		
Outside classroom	0.646[0.473, 0.881]	0.006
Time outdoor, h/d		
1-2 h	1	
2-3 h	0.682[0.466, 0.993]	0.047
>3 h	0.403[0.192, 0.796]	0.01
Screen time, h/d		
<1 h	1	
1-2 h	1.022[0.741, 1.409]	0.90
>2 h	0.739[0.427, 1.258]	0.27

OR, Odds Ratio; CI, confidence interval; h, hour.

logistic regression with basic information (sex, age, and parental myopia) only and a combination of basic information with lifestyle factors (time spent outdoor activities, recess outside classroom, and screen time), respectively. The ROC curves and corresponding AUCs for the two models are presented in Figure 1. The model based solely on basic information yielded an AUC of 0.678 [95% CI: 0.641-0.715], whereas the model that included both basic information and lifestyle factors achieved an AUC of 0.701 [95% CI: 0.665-0.737]. The addition of lifestyle factors significantly enhanced the model's predictive performance for myopia ($P = 0.01$).

DISCUSSION

The study revealed that all participating students engaged in more than 1 hour of outdoor activities daily, highlighting the positive impact of the PLAN. However, only 25.8% of students participated in more than 2 hours of outdoor activities. Furthermore, 63.3% of students took part in activities outside classroom during class breaks. These findings suggest considerable potential for optimizing lifestyle habits to aid in myopia prevention and control among urban primary school students in Fujian. The results of this study demonstrated that time spent outdoors and engaging in outdoor activities during class breaks are protective factors against myopia, which is consistent with previous research findings. Lifestyle factors significantly enhanced the predictive capacity for myopia, underscoring their substantial impact on its development. Schools and families must actively encourage students and implement effective measures to promote increased time spent on outdoor activities and encourage recess outside the classroom. Adopting a healthy lifestyle is essential for students to prevent and control myopia. Recently, some primary schools in Fujian have taken the initiative to reform their practices. For instance, Jinguang Primary School in Quanzhou City has decided to extend the length of short breaks from the original 10 minutes to 15 minutes starting from fall semester of 2024. Additionally, the school provides students with a variety of outdoor activities, such as games, sports, puzzles, and leisure activities, to ensure adequate relaxation for their eyes and bodies. To achieve myopia prevention and control objectives, more schools need to innovate and change their approaches with the support of educational bureaus in the future.

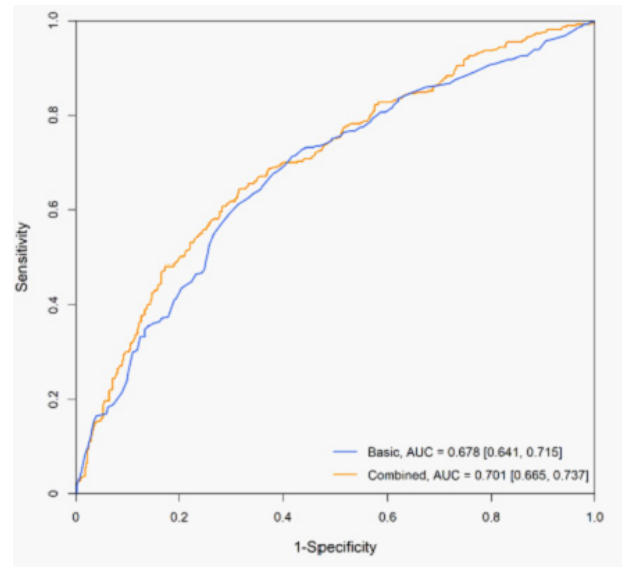


Figure 1 ROC curve plot of myopia prediction using lifestyle

In addition, our results indicated that students whose parents were nearsighted exhibited a significantly higher risk of developing myopia. Compared to students whose parents were not myopic, students with one myopic parent had a 2.2-fold risk of myopia, while the risk rose to 4.8 times for students whose both parents were myopic. Therefore, students with nearsighted parents, especially those had two myopic parents, should be considered a key target population for myopia prevention efforts.

Screen time, study time after school, and sleep duration were not significantly associated with myopia in this study. This was a cross-sectional observational study, and the reasons for this findings may be that parents paid more attention to the lifestyle of their nearsighted children, thereby promoting better behavior, or these factors may indeed be unrelated to myopia. The associations between these factors and myopia have been contentious in previous research. Studies have found that myopia was not related to total screen time;^[19] it was not associated with total time spent on near work but was linked to continuous near work duration and working distance;^[20] and myopia was not correlated with sleep duration but was associated with sleeping late and sleep quality.^[21-22] Furthermore, the lifestyle data were collected through self-reports, which are subjective and may be subject to recall bias. For this reason, although incorporating lifestyle factors significantly enhanced the

predictive capacity for myopia, the improvement was relatively small. To assess the effectiveness of lifestyle-based strategies in myopia prevention and control, future studies should employ longitudinal research design and use wearable electronic devices to objectively, precisely, and quantitatively measure various aspects of lifestyle. A limited number of studies have begun to explore these methods and have offered crucial methodological insights.^[23-27] For example, measuring near work using D-hours (diopter-hours), collecting data on continuous screen time, and intervals of screen use. Investigating the effects of lifestyle-related factors on myopia development and progression is essential for achieving cost-effective myopia mitigation.

In conclusion, our study demonstrated suboptimal lifestyle patterns among urban primary school students in Fujian. The time spent on outdoor activities and recess outdoor were significantly associated with myopia. Multifaceted interventions should prioritize: school-family partnerships to implement structured outdoor activity programs (at least two hours of outdoor activities, as advocated by the PLAN); protocols for transitioning from classroom to outdoors during class recesses; and targeted surveillance for high-risk students, particularly those with biparental myopia.

Correction notice

None

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Author Contributions

(I) Conception and design: Lanqin Zhao, Wei Xiao, Yahan Yang, Haotian Lin

(II) Administrative support: Duoru Lin, Jianyu Pang

(III) Provision of study materials or patients: Wei Xiao, Jianyu Pang, Yuchun He, Jianmin Hu

(IV) Collection and assembly of data: Wei Xiao, Jianyu Pang, Weiqin Qiu, Yue Wu

(V) Data analysis and interpretation: Lanqin Zhao, Wei Xiao, Yahan Yang

(VI) Manuscript writing: All authors

(VII) Final approval of manuscript: All authors

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Conflict of Interests

None of the authors has any conflicts of interest to disclose. All authors have declared in the completed the ICMJE uniform disclosure form.

Patient consent for publication

None

Ethical Statement

This study was approved by the Ethics Committee of Sun Yat-sen University Zhongshan Ophthalmic Center (04161326). Written informed consent was obtained from both the students and their guardians.

Provenance and Peer Review

This article was a standard submission to our journal. The article has undergone peer review with our anonymous review system.

Data Sharing Statement

None

Open Access Statement

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