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The prevalence of myopia and the factors associated with it among university students in Nanjing

A cross-sectional study

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Abstract

Myopia, a common eye disease, is a global health burden that is increasing worldwide. Although the risk factors for myopia among children have been extensively investigated, those among university students have not. The aim of our study was to investigate the prevalence of myopia and the factors associated with it among university students in Nanjing.

Subjects were selected from among the university students using a stratified random sampling method. A total of 1200 first-year university students were invited to participate in the study. A self-reported questionnaire was used to collect data on the students' demographic information, history of parental myopia, and behavioral factors, such as having bad postures while reading or writing, performing eye exercises, taking breaks after 30 minutes of continuous reading, using computers or smartphones, sleep, near-work, and outdoor activity. Univariate analyses were performed to find the associations between myopia and the various parameters. Factors that were statistically significant in univariate analyses were selected as candidate variates for multivariate analysis.

The overall prevalence of myopia was 86.8%: 86.1% among males, and 88.0% among females ($\chi^2 = 0.68$, $P = .411$). Chi-squared tests showed that parental myopia, performing eye exercises, taking breaks after 30 minutes of continuous reading, and engaging in outdoor activity were significantly associated with myopia ($P < .001$, $P = .034$, $P < .001$, and $P = .002$, respectively). Having at least 1 parent with myopia was a risk factor for myopia (OR = 3.58, 95% CI = 1.96–6.54); whereas, taking breaks after 30 minutes of continuous reading and performing at least 2 hours of outdoor activity per day were protective against myopia in multivariate analysis (OR = 0.61, 95% CI = 0.41–0.93; and OR = 0.45, 95% CI = 0.2–0.99; respectively).

The prevalence of myopia among university students was 86.8%. Parental myopia was a risk factor for myopia. Taking breaks after 30 minutes of continuous reading, and engaging in at least 2 hours of outdoor activity were associated with less myopia. In addition, performing eye exercises was associated with less myopia on univariate analysis.

Abbreviations: 95% CI = 95% confidence interval, OR = odds ratio.

Keywords: eye exercises, myopia, outdoor activity, parental myopia, prevalence, university students

1. Introduction

Myopia, one of the most common eye diseases, has become a global public health issue worldwide. In the last 50 years, the prevalence of myopia in Asian countries, especially among the Chinese populations, has dramatically increased.[1] The increase in the prevalence of myopia has huge social, educational, and economic consequences to the society.[2] In a one-year study of school-based populations of children and adolescents, myopia was found to be present among 33.6% of first graders and 54% of seventh graders in China.[3] Myopia is present in 90% of Chinese teenagers and young adults.[4] According to another research, in Shanghai, myopia was present among 94.9% of undergraduate students and 96.9% of postgraduate students, and 19.5% of all myopic students had high myopia.[5] Myopia extensively exists in the student populations and affects not only their physical health, but also increases their risk of complications in the eye, including myopic retinopathy, myopic glaucoma, retinal detachments, and blindness.[6–8]

As the prevalence of myopia is increasing worldwide, studies have been conducted to document the possible factors associated with myopia. Although the mechanisms of development and progression of myopia remain uncertain, both genetic and environmental factors have been demonstrated to contribute to myopia. Family history of myopia is associated with the incidence of myopia among children.[9,10] Other studies show that environmental factors, such as a higher level of education, more near-work, and lesser outdoor activities, could be associated with myopia.[5,11–16] In addition, the use of computers and smartphones is omnipresent and extensive in daily life. The use of display screen equipment may be linked to the development or progression of myopia.[17] Populations with a higher level of

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education are reported to have higher proportions of myopia.[5,14] Near-work, particularly continuous reading without rests, has been shown to lead to myopia.[18,19] At the same time, some protective measures against myopia have also been investigated. Chinese eye excises have been shown to have a modest protective effect against myopia.[20] Furthermore, Rose et al showed that spending more time outdoors is associated with less myopia.[21]

Although the risk factors for myopia among children have been extensively investigated, those for university students have not been studied as extensively. According to the data published by the Ministry of Education of the People's Republic of China in 2017, there are about 27.53 million university or college students in China.[22] This large population is selected through the national college entrance examination based on academic excellence in senior-high school. The rates of myopia and high myopia have been increasing in this population, the reasons for which may include the increase in time spent on continuous near-work, the reduction in time spent outdoors, and the increase in academic pressure. Since they comprise the young elite population of the future society, more attention should be paid to their visual health. Hence, we performed this study to investigate the prevalence of myopia and to analyze the behavioral factors that may be associated with the development of myopia among the university students in Nanjing, a developing city located in the East of China.

2. Methods

2.1. Study population

This study was approved by the Human Ethics Committee of Hiroshima University (E-1346) and was carried out according to the tenets of the declaration of Helsinki. To calculate the sample size, the following formula was used: $n=(\mu_\alpha/\delta)^2 p(1-p)$. Previous studies showed that the prevalence of myopia among the Inner Mongolia Medical Students and the Shanghai undergraduate students were 70.5%[23] and 94.9%,[5] respectively. Based on this, we estimated that the prevalence of myopia in Nanjing would be 80.0%. This required 983 university students to be investigated. Considering the validated response rate, 1200 university students were invited to participate in the study in June 2017 in Nanjing. The stratified random sampling method was used to select the participants. The university has 13 colleges with about 10 classes in each college and approximately 30 students in each class. Using stratified random cluster sampling, 3 classes (clusters) from each college (stratification) were randomly selected. The purpose of the study was explained, a written informed consent was obtained from each participant, and a self-reported questionnaire survey was administered.

2.2. Questionnaire survey

Myopia was defined as the need to use spectacles or contact lens for distant vision.[14,24] The sensitivity and specificity of identifying myopia correctly by self-reporting is reported to be high: 0.76 and 0.74, respectively.[25] Subjects with hyperopia, amblyopia, eye diseases, and history of refractive correction surgery were excluded from the study. The definition of myopia was explained to the participants by trained optometrists and orthoptist. The questionnaires were completed by the participants during their self-study at night, as per the instruction of the optometrists.

2.3. Survey contents

The questionnaire included items to obtain data on the demographic information, history of parental myopia, and the behavioral factors of the participants. The demographic information collected included age, gender, and the major subject the participant was studying. To ensure the reliability of the questionnaire, the behavioral factors known to be related to myopia in previous studies were investigated.[10,18,21] The behavioral factors asked for included maintaining bad postures while reading or writing, having the habit of performing eye exercises, and taking breaks after 30 minutes of continuous reading. Additionally, the average durations of daily computer or smartphone use (including games, videos, and chatting), sleep, near-work (including studying, reading, and writing), and outdoor activity were obtained through the questionnaire.

2.4. Statistical analysis

Statistical analyses were conducted using the statistical package for social sciences (SPSS, version 21.0, IBM, Chicago). The correlations between myopia and the various parameters considered in this study were assessed using the chi-squared test. The specific associations of those parameters that correlated with myopia in the chi-squared test were confirmed using univariate analyses. Parameters that showed a univariate association with P value less than .05 were selected as candidate variates for multivariate analysis.[26] The odds ratio (OR) and 95% confidence intervals (CI) for the associated factors were calculated. Factors with OR less than 1 were regarded to be protective against myopia, whereas those with OR above 1 were considered to be risk factors for myopia. The continuous variables were represented as mean ± standard deviation, and the categorical variables were represented as percentages. A P value less than .05 was considered as statistically significant.

3. Results

A total of 1153 students were enrolled in the study. The response rate was 96.1%. Invalid questionnaires, and the questionnaires of participants with hyperopia, amblyopia, eye diseases, and history of refractive correction surgery were excluded, and 968 questionnaires were validated for analysis. The response rate based on the number of validated questionnaires was 80.7%, of which 66.1% (n = 631) were from male participants, and 33.9% (n = 324) were from female participants. The mean age of the students was 19.6 ± 0.9 years. According to the self-reported myopia status, the overall prevalence of myopia was 86.8% (95% CI = 84.6–88.9%). There was no statically significant difference in the prevalence of myopia between the male (86.1%) and female students (88.0%) (χ^2=0.68, P = .411).

Table 1 shows the prevalence of myopia among university students and its association with the factors studied. The proportions of myopia among students with one and 2 myopic parents were 94.2% and 89.5%, respectively. The prevalence of myopia among students whose parents were not myopic was 83.1%. The presence of myopia in one or both parents was strongly associated with the presence of myopia in the student ($P < .001$). The prevalence of myopia among students who had been performing eye exercises was 83.2%. This was significantly less than that among students who did not perform eye exercises (88.3%) (P = .034). The prevalence of myopia among students who took breaks after 30 minutes of continuous reading was 81.6%, which was less than that among students who did not

Table 1

The prevalence of myopia and its association with the factors studied.

Parameters	Number (n = 968)	Myopia (n)	Prevalence (%)	χ^2	*P*
Gender					
Male	631	543	86.1	0.677	.411
Female	324	285	88.0		
Parental myopia					
Neither	629	523	83.1	19.880	<.001
Either	260	245	94.2		
Both	57	51	89.5		
Has bad postures while reading or writing					
No	204	170	83.3	2.626	.105
Yes	762	668	87.7		
Has the habit of preforming eye exercises					
No	673	594	88.3	4.500	.034
Yes	292	243	83.2		
Takes breaks after 30 min of continuous reading					
No	617	555	90.0	13.766	<.001
Yes	347	283	81.6		
Uses Computers (h per day)					
No	201	171	85.1	8.880	.064
≤1	172	156	90.7		
1.01–2	221	196	88.7		
2.01–3	202	177	87.6		
>3	160	129	80.6		
Uses Smartphone (h per day)					
No	126	113	89.7	3.662	.454
≤1	124	108	87.1		
1.01–2	156	140	89.7		
2.01–3	204	176	86.3		
>3	350	296	84.6		
Sleep (h per day)					
≤7	477	423	88.7	3.097	.078
>7	481	408	84.8		
Near work (h per day)					
≤2	125	107	85.6	1.363	.851
2.01–4	242	206	85.1		
4.01–6	184	162	88.0		
6.01–8	180	159	88.3		
>8	228	198	86.8		
Outdoor activity (h per day)					
<1	711	629	88.5	12.405	.002
1–2	205	172	83.9		
>2	41	29	70.7		

The chi-squared tests were used to examine the differences between myopia and non-myopia group.

take breaks ($P < .001$). The prevalence of myopia among students who spent more than 2 hours daily on outdoor activities was 70.7%, whereas that among students who spent less than 2 hours a day outdoors was over 80% ($P = .002$). Parameters such as gender, having bad postures for reading or writing, the use of computers or smartphones, sleep, and near-work were not found to have significant associations with myopia.

Table 2 shows the association between myopia and the factors studied. Compared with having parents without myopia, having at least one parent with myopia was a risk factor for myopia (OR = 3.31, 95% CI = 1.89–5.81, $P < .001$). Having the habit of performing eye exercises and taking breaks after 30 minutes of continuous reading were associated with less myopia (OR = 0.66, 95% CI = 0.45–0.97, $P = .035$; and OR = 0.49, 95% CI = 0.34–0.72, $P < .001$, respectively). Performing over 2 hours of outdoor activity per day was also a protective factor (OR = 0.32, 95% CI = 0.16–0.64, $P = .001$).

The parameters that were significantly associated with myopia in univariate analyses were included for multiple logistic regression analysis. Table 3 shows that after adjustment for age and gender, there was no significant difference in the rates of myopia between students who performed and did not perform eye excises ($P = .278$). Having a myopic parent was a risk factor for myopia (OR = 3.58, 95% CI = 1.96–6.54, $P < .001$). The habits of taking breaks after 30 minutes of continuous reading, and performing more than 2 hours of outdoor activity per day were associated with less myopia (OR = 0.61, 95% CI = 0.41–0.93, $P = .02$; and OR = 0.45, 95% CI = 0.20–0.99, $P = .047$, respectively).

4. Discussion

In our study, we confirmed the association between myopia and the following factors among undergraduate students in Nanjing: parental myopia, performing eye exercises, taking breaks after 30 minutes of continuous reading, and performing more than 2 hours of outdoor activity per day.

Table 2

The association between myopia and the factors studied.

Parameters	OR	95% CI	*P*
Age	0.96	0.78–1.18	.689
Gender			
Male	Reference		
Female	1.18	0.79–1.77	.411
Parental myopia			
Neither	Reference		
Either	3.31	1.89–5.81	<.001
Both	1.72	0.72–4.12	.221
Has bad postures while reading or writing			
No	Reference		
Yes	1.42	0.93–2.18	.106
Has the habit of preforming eye exercises			
No	Reference		
Yes	0.66	0.45–0.97	.035
Takes breaks after 30 min of continuous reading			
No	Reference		
Yes	0.49	0.34–0.72	<.001
Uses Computers (hours per day)			
No	Reference		
≤1	1.71	0.90–3.26	.103
1.01–2	1.38	0.78–2.43	.272
2.01–3	1.24	0.70–2.20	.457
>3	0.73	0.42–1.27	.264
Uses Smartphone (h per day)			
No	Reference		
≤1	0.78	0.36–1.69	.524
1.01–2	1.01	0.47–2.18	.987
2.01–3	0.72	0.36–1.46	.363
>3	0.63	0.33–1.20	.160
Sleep (h per day)			
≤7	Reference		
>7	0.71	0.49–1.04	.079
Near work (h per day)			
≤2	Reference		
2.01–4	0.96	0.52–1.78	.903
4.01–6	1.24	0.63–2.42	.531
6.01–8	1.27	0.65–2.50	.483
>8	1.11	0.59–2.08	.745
Outdoor activity (h per day)			
<1	Reference		
1–2	0.68	0.44–1.05	.084
>2	0.32	0.16–0.64	.001

95% CI = 95% confidence interval, OR = odds ratio.

Univariate analyses were used to find the factors associated with myopia.

Table 3

Factors associated with myopia based on multiple logistic regression analysis.

Parameters	OR	95% CI	*P*
Age	1.05	0.85–1.31	.634
Gender			
Male	Reference		
Female	1.17	0.75–1.82	.483
Parental myopia			
Neither	Reference		
Either	3.58	1.96–6.54	<.001
Both	1.92	0.73–5.05	.185
Has the habit of preforming eye exercises			
No	Reference		
Yes	0.79	0.51–1.21	.278
Takes breaks after 30 min of continuous reading			
No	Reference		
Yes	0.61	0.41–0.93	.020
Outdoor activity (h per day)			
<1	Reference		
1–2	0.75	0.47–1.20	.232
>2	0.45	0.20–0.99	.047

95% CI = 95% confidence interval, OR = odds ratio.

Parameters showed a univariate association with outcome ($P < .05$) were selected as candidate variates for multivariate analysis.

The overall prevalence of myopia among the university students in Nanjing was 86.8%, and the prevalence of myopia was confirmed to be higher among them than among the general population. Undoubtedly, undergraduate students in universities and colleges constitute a population with a higher level of education than the general population. Populations with higher levels of education or school achievement have been found to be associated with myopia, which is thought to be because these populations spend more time on near-work jobs.[9] Similarly, in the cross-sectional study conducted by Sun et al on 5083 university students in Shanghai, a coastal developed city in China, the prevalence of myopia among undergraduates in Donghua University was found to be 94.9% and that among postgraduates was found to be 96.9%.[5] In a population-based study in Inner Mongolia, an underdeveloped inland city in North China, the prevalence of myopia among medical students was found to be 70.5% and 69.2% in the years 2011 and 2013, respectively.[23] These studies confirm the presence of a higher proportion of myopia among Chinese students in universities and colleges. There were smaller differences between the results of these studies, probably because populations in different geographic regions had different proportions of myopia.[27] A study performed by Guo et al, with 20,609 participants, showed that myopia was associated with both residing in regions with higher degrees of urbanization, and higher levels of education in young adults and adults.[14] Differences exist in the degrees of economic development between the different cities in China where the universities are located. When compared with the inland and underdeveloped cities, the proportions of myopia are higher in the coastal and developed cities in China.[28] Moreover, the proportion of myopia among students in Donghua University (94.9%), a key university in China, was higher than that in our study (86.8%) and those among the Inner Mongolia medical students (70.5% and 69.2%). In accordance with these findings, it has been indicated by You et al that children in key schools have a higher proportion of myopia and higher myopic refractive errors than children in non-key schools.[10] A cross-sectional study done in Singapore revealed that children with higher Intelligence Quotient scores were more likely to be myopic.[29] Several studies documented that persons with higher levels of education and academic achievements tend to have a higher proportion of myopia.[9,14]

Parental myopia was significantly associated with myopia in our study, which corresponded to several previous studies. A cross-sectional study on 11,138 medical students showed that students who had 1 or 2 parents with myopia had a higher risk of myopia when compared with those whose parents did not have myopia.[23] Another study by Wu et al, conducted on 4798 students aged between 16 and 18 years, showed that parental myopia is a risk factor for myopia (OR = 2.28, 95% CI = 1.80–2.801).[30] In the Singapore Cohort Study of the Risk Factors for Myopia (SCORM), the presence of myopic parents was found to be associated with an increased incidence of myopia among children.[31] These studies suggest that genetic factors strongly

influence myopia. However, the effect of lifestyle and habits cannot be neglected, especially since myopic parents could share the same environments as their children.

Performing eye exercises was associated with less myopia in the chi-squared test and the univariate analysis. However, multivariate analysis that adjusted for age and gender showed that the association was not statistically significant. This might be due to the removal of a confounding effect associated with performing eye exercises and myopia in multivariate analysis. A few studies have found different results between performing eye exercises and myopia.[20,23,32] Chinese eye exercises as an eye-care program for protecting against or preventing myopia was wide-spread, and children in schools were required to perform them. Massaging the acupoints around the eyes accelerates the blood circulation, improves metabolism, rests the eye muscles, and relieves eye fatigue.[33] In a study conducted on Chinese children between 6 and 17 years of age in a rural county, performing Chinese eye exercises was found to have a modest protective effect against myopia.[20] Wang et al conducted a study on the Inner Mongolia medical students that showed that students who did not perform eye exercises were at a higher risk of myopia than the students who did.[23] On the other hand, Kang et al conducted a study on 201 students, who were followed-up for more than 2 years, that indicated that although there was no significant association between performing eye exercises and myopia onset or myopia shift, students who followed the rules of performing eye exercises and performed them seriously had a slightly lower myopia shift than students who did not perform eye exercises.[32] The difficulty in finding an association might be due to the limited sample size and the absence of scientifically objective ways to measure the quality of eye exercises performed. Therefore, whether or not eye exercises are protective against a myopia shift remains controversial. Further studies that objectively evaluate eye exercises are required.

In our study, near-work was not found to have a significant association with myopia. A possible explanation could be that the participants in the present study comprised of a population selected based on academic excellence. Approximately 87% of them were performing near-work for more than 2 hours daily (Table 1). However, taking breaks after 30 minutes of continuous reading was associated with less myopia. This finding is consistent with the Australian study performed by IP et al that documented that reading continuously for more than 30 minutes independently increased the odds of myopia among children (OR = 1.5, 95% CI = 1.05–2.1).[18] Additionally, in a school-based study of 4814 students aged between 6 and 10 years, You et al reported that continuously performing near-work for more than 30 to 40 minutes without any eye rest was associated with a high risk of myopic shifts.[19] The convergence and accommodative lag of near-vision that is produced by prolonged close-work may contribute to the mechanisms by which myopia develops.[34] When the reading distances become closer, the accommodative lag increases, and the accommodative lag may reduce the hyperopic retinal defocus, thereby enhancing the progression of myopia.[35,36]

Recently, mainstream studies have demonstrated that engaging in outdoor activities is a key environmental determinant of myopia with a possible protective effect against the development of myopia.[21,37–40] An accepted explanation for this finding is that the light intensities in outdoor environments are higher than those in indoor environments, and light stimulates the retina to release dopamine, which suppresses eye growth.[41] This has been demonstrated in a prospective longitudinal observational study by Scott et al that indicated that greater daily light exposure is related to less axial eye growth among children between 10 and 15 years of age.[42] Moreover, the longitudinal study performed by Wu et al on children between 7 and 11 years of age documented that outdoor activities during class breaks in school was protective against the onset and progression of myopia.[37] The Sydney Myopia Study found that spending more time outdoors was associated with less myopia in children.[21] Sherwin et al reported that increasing the time spent outdoors by an additional hour per week reduced the risk of myopia by 2%, and that spending more time outdoors significantly reduced the progression of myopia.[40] Similarly, in the study by Onal et al, where medical students in Turkey aged between 18 and 26 years were followed-up for 1 year, outdoor activity during early childhood was documented to have a protective effect against myopia in multivariate analysis (OR = 0.44, 95% CI = 0.23–0.82).[38] These studies have documented that engaging in more outdoor activities during childhood has a protective effect against myopia, which corresponded with our results. Our study showed that spending more than 2 hours per day on outdoor activities was associated with less myopia in multivariate analysis (OR = 0.45, 95% CI = 0.20–0.99). This finding is consistent with the findings of a study conducted in North India which showed that among school children, performing outdoor activities for more than 2 hours a day was protective against myopia, and had an inverse relation to the development of myopia.[39]

The usage of display screen equipment, such as computers and smartphones, was not statistically associated with myopia in the present study. These results were similar to several previous studies. Mutti et al carried out a cross-sectional study in 366 children with mean age of 13.7 years in America, and evaluated the risk factors involved in the incidence of adolescent myopia.[9] They found no evidence suggesting that the use of computers affected the incidence of myopia. Similarly, an Australia study conducted by IP et al on 2353 12-year-old school children reported that there is no correlation between the use of computers and myopia.[18] However, a large population-based cohort study conducted on 17,217 Spanish university graduates with mean age of 38.5 ± 12.1 years showed that exposure to computers was associated with the development and progression of myopia.[17] Nevertheless, the fact to consider is that all the participants in that study were university graduates whose vocations tended to be related to jobs that required the use of display screen equipment.[17] In contrast to the middle-aged participants in Spain, the participants in the other studies mentioned above and in our study were adolescents or children whose main daily tasks included attending lectures and studying. In addition, when a PubMed search for the keywords "smartphone", "myopia", and "refractive error" was conducted in November 2018, we did not find any relevant studies. There were no references to support our finding. Admittedly, studies on the correlation between myopia and display screen equipment use are limited and remain controversial. Future studies are needed to confirm these findings.

There were some limitations in our study. First, the myopia status and behavioral factors were obtained using a self-reported questionnaire. Not clinically verifying myopia might have underestimated the prevalence of myopia, since students with very mild myopia might have had no visual problems for distant vision, would not have required refractive correction, and would have reported themselves as not myopic. Additionally, the behavioral data gathered using the self-reported questionnaire might have been subject to recall bias. However, since this study was conducted by trained optometrists and the subjects were

comprehensive undergraduate students, the quality and validity of the data would have been high. To reduce recall bias in future studies, behavioral parameters including sleep quality, outdoor activity, and duration of near-work could be measured objectively using wearable devices. Finally, as the sample size was small and only 1 university was selected for analysis, the sample might have been subject to selection bias. Further population-based studies among university students are needed.

According to the comprehensive implementation plans on prevention and control of myopia among children and adolescents published by the Ministry of Education of the People's Republic of China in August 2018,[43] due to the increase in the academic burden, the excessive use of the eyes, and the reduction in physical and outdoor activities performed, the age of onset of myopia is becoming lower. As it contributes to a serious public health problem among children and adolescents in China, there is an urgent need for measures that promote visual health and reduce myopia in the society. By identifying the factors associated with myopia, the findings of our study may be crucially significant with regard to visual health. In societies that emphasize the need for a degree or diploma, visual health should be promoted among students by ensuring the inclusion of proper behavioral patterns, such as taking breaks after continuous reading, spending more time spend on outdoor activities, and performing eye exercises, in to their daily lives. The success of any measure, including the acceptance of recommended behaviors for visual health, needs the individuals to be aware of the condition and the benefits of the recommended behaviors. Thus, the findings of our study can increase the awareness of visual health among the students, and thereby, contribute to the development of policies for healthy vision in the future.

5. Conclusion

In conclusion, our study assessed the prevalence of myopia and the associations between myopia and behavioral factors among university students in Nanjing. Parental myopia was a risk factor for myopia. Taking breaks after 30 minutes of continuous reading and performing at least 2 hours of outdoor activity were associated with less myopia. Performing eye exercises was associated with less myopia in univariate analysis, but not on multivariate analysis that adjusted for age and gender. There were no significant associations between myopia and having bad postures while reading or writing, using the computer, using smartphones, sleep, and near-work.

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