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Parental myopia, near work, hours of sleep and myopia in Chinese children

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ABSTRACT

Background/Aims: Juvenile myopia is a serious problem in China, the prevalence of which stays at a high level and shows an upward trend. The target of this study was to explore the factors associated with myopia in Chinese children. Methods: A cross-sectional analysis in a random sample survey was conducted in Beijing in 2008. The data collected from 15,316 Chinese school students aged 6 to 18 years, randomly selected from 19 schools were evaluated, including non-cycloplegic refraction and possible genetic, environmental and behavioral factors, to explore the key risk factors for myopia. Univariate and multiple logistic regression analyses were performed to compare the OR values, and receiver operator characteristic (ROC) curves were generated to compare the differences among the areas under the ROC curves using the method of multiple comparison with the best. Results: Myopia was associated with shorter sleep times versus longer sleep times (adjusted OR = 3.37; 95%CI 3.07 - 3.70), and the multivariate OR for two compared with no parents with myopic was 2.83 (95%CI 2.47 - 3.24) and 1.95 (95%CI 1.69 - 2.24) for reading or writing distances less than 33 cm compared to distances greater than 33 cm. Controlling for other factors, children that slept for shorter periods of time had significantly more myopic refractions (−1.69D *vs* −1.29D for children with longer sleeping time per day). Analysis of the areas under the ROC curves showed five variables with predictable values better than chance: age, sleeping time, reading or writing distance, hours of studying, and parental myopia. Conclusion: It was not surprising, as proved by other studies, that parental myopia, reading or writing distances, time spent on studying or other activities by using eyes were dominant risk factors associated with juvenile myopia. Our findings indicated that hours of sleeping were also closely related to juvenile myopia, in which the underlying mechanism should be explored in the future study.

KEYWORDS

Parental Myopia; Near Work; Hours of Sleep; Myopia

1. INTRODUCTION

Juvenile myopia is a very common condition and a significant public health problem in China. The prevalence of myopia for Chinese school-aged students is one of the highest in the world [1-3], and is higher in the city of Beijing (46.87% for primary school students, 71.02% for junior high school students, and 84.79% for senior high school students) than the national average and has shown an upward trend [4]. Because of myopia's high prevalence in China, it is especially important in China to be able to slow or stop myopia progression and ultimately prevent its occurrence.

Many studies have reported the possible environmental, behavioral and genetic risk factors for myopia [5 6], but the strength of these associations is often weak, and some prior results are often contradictory. Commonly investigated risk factors include environmental risk factors such as parental education, family income, and illu-

mination condition, and behavioral risk factors such as reading distance, time outdoors and physical activity [7 8], hours spent watching TV or using a computer, and length of time sleeping, as well as parental myopia, a possible indicator of genetic susceptibility [9]. Studies focusing on reducing the progression of myopia have had limited success. Trials using progressive addition lenses [10], bifocals [11], and rigid gas permeable contact lenses [12] found a small statistically significant reduction in myopic progression when compared to relevant control groups. We hypothesized that the lack of sleep would be also associated with myopia in Chinese children.

In this study, we used mass data from school-age students from primary and middle schools in Beijing to explore primary potential risk factors of myopia and evaluate their association with myopia.

2. METHODS

2.1. Study Design and Participants

The study protocol was approved by the Beijing Municipal Commission of Education and the Ethics Committee of School of Social Development and Public Policy, Beijing Normal University. The samples came from a multi-stage, stratified random sampling, in which 18 districts in Beijing were divided into three strata of developed, developing and undeveloped regions according to the economic indicator of the GDP; six schools, consisting of three primary schools and three middle schools, were randomly selected from each stratum, and a total of 900 students from each school were randomly selected in 2008. A thorough explanation of the study was provided to the selected students and their parents, and the parents gave their written consent for their child's participation in the study.

Finally, 15,316 students aged 7 to 18 years (mean = 12.1 ± 3.3 years) from grade 1 in primary school to grade 3 in senior high school located in different districts in Beijing (a response rate of 94.5%) were invited to participate in this survey (primary school students: 5643 (36.8%), junior high school students: 4378 (28.6%), and senior high school students: 5295 (34.6%); male students: 7434 (48.5%) and female students: 7882 (51.5%); urban areas: 6230 (40.7%) and suburban areas: 9086 (59.3%).

2.2. Measures

A questionnaire was designed to evaluate the genetic, environmental and behavioral risk factors of myopia, which included the following parts: 1) general characteristics: gender, age, parent's education level, parent's profession, family income, etc. 2) questions about near work: reading or writing distance, studying time per day last month, hours spent watching TV and using a computer per day last month, etc. 3) questions about sports, sleeping and nutrition: hours of sports per day, sleeping time per day last month, quantity of sweet foods, fruits, vegetables and high protein foods, etc. The data of parental myopia were collected by the value of the vision examination lately. The interview was carried out by the ophthalmologists from Primary and Middle School Students Health Care Centers affiliated to the District Education Committee in Beijing and the quality of the interview was controlled by disease control officers in each district center. After the interview, the children underwent an auto refractometry carried out by a senior experienced optometrist. We used an auto refractor (Topcon RM-A7000; Topcon Co., Tokyo, Japan) and did not apply cycloplegia.

2.3. Statistical Analysis

Refraction was analyzed as spherical equivalent [SE]: sphere + half negative cylinder power. Myopia was defined as an SE of at least −0.75D. Data (SE) from the right and left eyes were similar (Pearson correlation coefficient = 0.88), therefore the results from the left eyes are presented. The prevalence rate of myopia and mean refraction were described by different levels of factors and comparisons between groups of factors were tested by one-way ANOVA. The multivariate OR were calculated and their 95% confidence intervals (95%CI) were described by multivariate binary regression analysis after adjusting for other variables for myopia, with refraction as the dependent variable, and sleeping time, age, gender, parental myopia, parental education, reading or writing distance, hours of sports, and hours of watching TV or using a computer as the explanatory variables. To calculate the adjusted mean refraction for different lengths of sleep time by multiple linear regression models, the other risk factors were adjusted first. The linear trend tests were performed by assigning consecutive integers to each sleeping time-span. The areas under the ROC curves (AUC) were used to compare the specificity and sensitivity to myopia among the main risk factors including age, hours of sleep per day, father's education, parents' myopia and reading or writing distance. All P-values were 2-sided and considered statistically significant when less than 0.05. Data analysis was conducted using commercially available software (Stata, Ver.10.0; Stata, College Station, TX).

3. RESULTS

The mean refractive error was −1.45D (SD 2.50; range −14.78 to 10.37), and the prevalence rate of myopia was 53.40% (8178/15316; 95%CI 52.60% - 54.19%). The median number spent hours of watching TV or using a computer and hours spent studying were 1 to 2 hours and

7 to 9 hours per day, respectively. There were 2819 (50.18%) children who slept more than 9 hours and studied 6 to 8 hours per day and 1512 (33.34%) children who studied 6 to 8 hours but slept more than 9 hours per day (P < 0.001). The spearman correlation coefficient for hours spent sleeping and studying per day was 0.26 and P value less than 0.001 by trend test on the likelihood of co-variation of sleep hours with study time.

Table 1 gives the frequencies of risk factors and the mean refraction for myopia from school-aged students in Beijing. The prevalence rate of myopia was 67.31% (mean diopter: −1.97, SD: 0.06) in students older than 17 years, and that was 14.55% (mean diopter: 0.08, SD: 0.02) in students aged from 6 to 9 years. A higher prevalence of myopia and a higher refraction error for Beijing students was observed in subjects with the following characteristics: female, tertiary education, two parents with myopia, longer time spent watching TV or using a computer. The difference among each strata of factors were significant by one-way ANOVA. The prevalence rate of myopia was 68.45% in children who slept less than 7 hours, but which was 34.80% in children who slept more than 9 hours. The multivariate adjusted mean refractive errors for children who slept more than 9 hours was −1.69D (95%CI −1.77 - −1.62) compared with −1.29D (95%CI −1.36 - −1.23) for children who slept less than 7 hours (P < 0.001). For every point increase in sleeping time, there was a 0.09D shift in refraction toward less myopia values (P < 0.001; **Table 2**).

In the univariate analyses, myopia was more associated with older age (17 years or older) compared with younger age (6 to 9 years; odds ratio [OR] = 10.87; 95%CI 9.65 - 12.24; **Table 3**), but not associated with female versus male (OR = 1.33; 95%CI 1.25 - 1.42). Myopia

Table 1. Profile of myopia in school-aged students in Beijing.

	N	Myopia	Prevalence rate	Mean D	SD	F*
Age (y)						
6 to 9	3107	452	14.55%	0.08	0.02	131.57
10 to 13	4120	1660	40.29%	−0.88	0.03	
14 to 16	4547	2720	59.82%	−1.80	0.03	
17 or more	3542	2384	67.31%	−1.97	0.06	
Gender						
Male	7434	3518	47.32%	−1.04	0.03	64.55
Female	7882	4326	54.88%	−1.33	0.02	
Number of parent with myopia						
0	9893	4647	46.97%	−1.83	0.62	84.39
1	3883	2234	57.53%	−1.19	0.02	
2	1540	963	62.53%	−4.26	0.97	
Father's completed level of education						
Primary education	425	177	41.65%	−0.86	0.09	29.04
Secondary education	3969	1792	45.15%	−0.86	0.04	
Polytechnic education	4004	2044	51.05%	−1.18	0.03	
Tertiary education	6644	3683	55.43%	−1.41	0.03	
Reading or writing distance						
Greater than 33 cm	1374	481	35.01%	−0.54	0.15	78.58
About 33 cm	7280	3505	48.15%	−1.06	0.02	
Less than 33 cm	6556	3818	58.24%	−1.46	0.03	
Hours of sports per day						
30 min or less	3708	1947	52.51%	−1.19	0.04	8.19
30 min to 1 hour	6990	3657	52.32%	−1.27	0.03	
1 hour or more	4448	2172	48.83%	−1.07	0.03	
Hours of watching TV per day						
1 hour or less	6471	3472	53.65%	−1.29	0.03	9.4
1 to 2 hours	5741	2827	49.24%	−1.14	0.03	
2 hours or more	3009	1502	49.92%	−1.06	0.05	
Hours of studying per day						
6 hours or less	2085	1406	67.43%	−0.71	0.03	113.79
6 to 8 hours	3265	2013	61.65%	−0.99	0.03	
8 to10 hours	6457	3013	46.66%	−1.64	0.04	
10 hours or more	3365	1349	40.09%	−1.89	0.05	

Note: *Comparisons between groups of factors were tested by One-Way ANOVA.

Table 2. Unadjusted and adjusted mean refraction by sleeping time.

Sleeping time	N	Prevalence rate	Refractive error (D)			
			Unadjusted mean (SD)	95%CI	Adjusted mean (SD)	95%CI
9 hours or more	5675	34.08%	−0.76 (1.82)	−0.81, −0.71	−1.29 (0.03)	−1.36, −1.23
About 8 hours	4859	55.55%	−1.57 (3.23)	−1.67, −1.48	−1.49 (0.02)	−1.54, −1.45
7 hours or less	4567	68.03%	−2.28 (2.27)	−2.35, −2.21	−1.69 (0.04)	−1.77, −1.62
P (trend)			<0.001		<0.001	
Regression model results						
Regression coefficient			−0.71		−0.09	
P (regression)			<0.001		<0.001	

Table 3. Risk factors associations of myopia.

	N	Univariate OR for myopia (95%CI)	P value	Multivariate OR for myopia (95%CI)	P value
Age (y)					
6 to 9	3107	1 (referent)		1 (referent)	
10 to 13	4120	3.60 (3.21, 4.02)	<0.001	4.05 (3.59, 4.58)	<0.001
14 to 16	4547	7.84 (7.01, 8.77)	(trend)	7.87 (6.89, 8.98)	(trend)
17 or more	3542	10.87 (9.65, 12.24)		11.27 (9.74,13.05)	
Gender					
Male	7434	1 (referent)			
Female	7882	1.33 (1.25, 1.42)	<0.001	1.27 (1.18, 1.36)	
Number of parent with myopia					
0	9893	1 (referent)			
1	3883	1.53 (1.42, 1.65)	<0.001	1.91 (1.75, 2.10)	<0.001
2	1540	1.88 (1.69, 2.10)	(trend)	2.83 (2.47, 3.24)	(trend)
Father's completed level of education					
Primary education	425	1 (referent)			
Secondary education	3969	1.16 (0.94, 1.43)	0.17	1.27 (1.00, 1.60)	0.044
Polytechnic education	4004	1.43 (1.16, 1.76)	<0.001	1.54 (1.22, 1.94)	<0.001
Tertiary education	6644	1.71 (1.40, 2.10)	(trend)	1.70 (1.34, 2.14)	(trend)
Reading or writing distance					
Greater than 33cm	1374	1 (referent)			
About 33cm	7280	1.67 (1.48, 1.89)	<0.001	1.39 (1.21, 1.60)	<0.001
Less than 33cm	6556	2.51 (2.21, 2.84)	(trend)	1.95 (1.69, 2.24)	(trend)
Hours of sports per day					
30 min or less	4448	1 (referent)		1 (referent)	
30 min to 1 hour	6990	1.15 (1.06, 1.24)		1.05 (0.96, 1.15)	0.181
1 hour or more	3708	1.17 (1.07, 1.27)		0.97 (0.88, 1.08)	0.753
Hours of watching TV per day					
1 hour or less	6400	1 (referent)			
1 to 2 hours	5680	0.96 (0.87, 1.05)	0.38	1.04 (0.94, 1.15)	0.39
2 hours or more	2974	1.15 (1.06, 1.26)	0.001	1.11 (1.00, 1.23)	0.04
Hours of studying per day					
6 hours or less	3365	1 (referent)		1 (referent)	
6 to 8 hours	6457	1.30 (1.20, 1.42)	<0.001	1.14 (1.04, 1.26)	0.015
8 to10 hours	3265	2.37 (2.15, 2.62)	(trend)	1.39 (1.24, 1.56)	<0.001
10 hours or more	2085	3.06 (2.72, 3.44)		1.43 (1.25, 1.64)	(trend)
Hours of sleep per day					
9 hours or more	5675	1 (referent)			
About 8 hours	4859	2.39 (2.21, 2.59)	<0.001	2.12 (1.94, 2.31)	<0.001
7 hours or less	4567	4.07 (3.74, 4.43)	(trend)	3.37 (3.07, 3.70)	<0.001

was associated with two versus no parents with myopia (OR = 1.88; 95%CI 1.69 - 2.10), but myopia was not associated with the hours per day of sports, and hours per day spent watching TV or using a computer in the highest level versus in the lowest level (OR = 1.17, 95%CI 1.07 - 1.27; OR = 0.86, 95%CI 0.79 - 0.94, respectively). Myopia was associated with reading or writing distance and hours of studying per day in the highest level versus in the lowest level (OR = 2.51, 95%CI 2.21 - 2.84; OR = 3.06, 95%CI 2.72 - 3.44, respectively), and associated with hours of sleep less than 7 hours versus more than 9 hours (OR = 4.07; 95%CI 3.74 - 4.43). A final multivariate model was constructed with myopia as the outcome variable and age, gender, parental myopia, father's education, reading or writing distance, hours of sports per day, hours spent watching TV or using a computer per day, hours of studying per day, and hours of sleep as explanatory variables. Myopia did not remain associated with gender, hours of sports per day, hours of watching TV or using a computer per day, and the association with hours of studying was marginally significant (OR = 1.43; 95%CI 1.25 - 1.64 for studying more than 10 hours vs. studying less than 6 hours) in multivariate analyses, but was associated with 7 hours of sleep per day vs. more than 9 hours (OR = 3.37; 95%CI 3.07 - 3.70). Myopia was also associated with reading or writing distance more than 33 cm versus less than 33 cm (OR = 1.95; 95%CI 1.69 - 2.24; $P < 0.001$) after controlling for the same factors. Similar significant associations between myopia and hours of sleeping in the univariate analyses (OR = 2.05; 95%CI 1.96 - 2.13; $P < 0.001$) and in the multivariate analyses (OR = 1.94; 95%CI 1.85 - 2.04; $P < 0.001$) were found. The relationship between time asleep and myopia remained significantly positive within each stratum of hours spent watching TV or using a computer per day.

The areas under the ROC curves (AUC) associated with the univariate logistic predictive models are presented in **Table 4**. The age variable had the largest AUC (0.72), and sleeping time, reading distance, and hours of studying are the next closest variables (0.65, 0.57, and 0.57). The remaining activities had AUCs between 0.50 and 0.55 (**Figure 1**) [13,14].

Table 4. AUC Associated with variables of risk factors for myopia.

Variable	AUC	SE	95%CI
Age	0.72	0.01	0.71 - 0.73
Parent's myopia	0.56	0.01	0.55 - 0.56
Father's education	0.55	0.01	0.54 - 0.55
Reading distance	0.57	0.01	0.56 - 0.58
Hours of sleeping	0.65	0.01	0.64 - 0.66
Hours of sports/outdoor activity	0.52	0.01	0.51 - 0.53
Hours of studying	0.57	0.01	0.56 - 0.58
Hours of TV	0.50	0.01	0.49 - 0.51

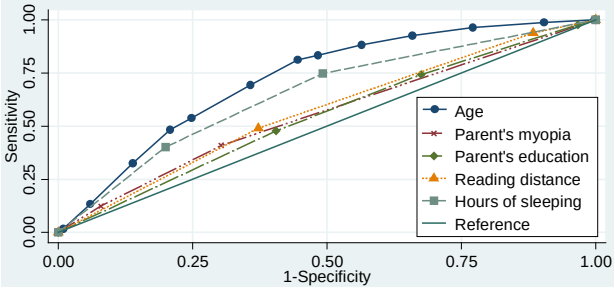

Figure 1. ROC curves associated with age, parent's myopia, father's education, reading distance, and hours of sleeping.

4. DISCUSSION

In this study, parental myopia, doing work at close distances, and hours of sleep were significantly associated with myopia, where the number of hours spent sleeping and parental myopia were shown to be more important. We also found no evidence to suggest that the amount of time spent studying and watching TV or using a computer is a major factor for myopia. As a potential risk factor for myopia, sleeping time was often ignored in several previous studies about factors associated with myopia [10,15-17]. Our data suggest that the mean hours of sleep are 9 hours per day for primary school students, 8 hours per day for junior high school students, and 7 hours per day for senior high school students in Beijing. Chinese children aged 6 to 18 years in Beijing that sleep for less time were more likely to have myopia, even after controlling for age, gender, parental myopia, father's education, reading or writing distance, and hours spent playing sports, watching TV or using a computer per day, and studying per day. Our data suggest that the amount of time spent sleeping had an association with myopia independent of the amount of time spent studying in Chinese school-aged students. However, the mechanism underlying the sleeping time-myopia relationship was not well understood. An interesting observation was that myopia (SE at least −0.75D) was not significantly associated with the number of hours spent watching TV or using a computer, studying, or playing sports per day after controlling for other factors; however, myopia remains associated with the number of parents with myopia and reading or writing distance after controlling the same factors.

Several previous studies reported the impact of family history on the development of myopia. Defining myopia as SE less than −0.75D, Mutti *et al.* [16] reported an OR of 6.4, and Jones *et al.* [5] reported an OR of 5.40 for children with two myopic parents compared to children without myopic parents, which is higher than our adjusted OR of 2.83, but the value of OR in our study was similar to Saw *et al.* [18] who reported an OR of 3.1 in young Singaporean men. The wide range of ORs from

these studies may be due to sample variation, recruitment schemes, recall bias, definition of myopia, and various risk factors within the different populations. However, all of these studies suggested that the myopic status of parents is an important risk factor.

The number of hours of sports was not a significant factor in the logistic models. Myopia was not associated with hours spent playing sports less than 30 minutes versus more than 1 hour per day after controlling for age, gender, parental myopia, father's education, reading or writing distance, hours of watching TV or using a computer per day, hours of studying per day, and sleeping time per day (OR = 0.97; 95%CI 0.88 - 1.08). This result was similar to Parssinen and Lyyra's [19].

Likewise, there is no body of literature addressing the relationship between the amount of sleep and myopia. A possible explanation of the effect of sleep on myopia could be to relieve or rest the ciliary muscle and prevent or alleviate the myopic progression. Confounding effects should also be considered. Myopia has been associated with other individual characteristics such as IQ [20,21] and personality [22,23]. Perhaps an increase in the amount of time spent sleeping is a surrogate for more extroverted personalities from psychological characteristics. There were a few previously published reports of the association between ambient lighting during sleep and myopia. These studies concluded that nighttime light exposure during infancy was not a major risk factor for myopia development in most populations [24]. Perhaps the number of hours of sleep, ambient lighting during sleep, and the quality of sleep should be considered all together to further analyze the association between sleep and myopia.

There are several limitations in this study: 1) similar to any retrospective epidemiologic study, our analysis may be subject to recall bias; 2) the questionnaire may not be the most appropriate way to obtain details about the amount of time spent on near work or other activities associated with myopia completely; 3) the results have also been affected by deleting any missing data during the data analysis steps despite the large sample size.

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CONTRIBUTORS

Yanhong gong and Xiuhua Guo contributed to data processing. Yanhong Gong, Xiulan Zhang, and Gexing Xiao conducted the data analysis and, with Donghua Tian, interpreted the data and drafted the article. All authors contributed to the study conception/design, critically revised the article and reviewed the final draft of the article.

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ETHICS APPROVAL

Beijing Municipal Commission of Education and the Ethics Committee of School of Social Development and Public Policy, Beijing Normal University.

DATA SHARING STATEMENT

Extra data is available by emailing yhgong2316@sina.com, Data Center, School of Social Development and Public Policy, Beijing Normal University.

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