Theory Clin. Pract. Pediatr., 2017, 1(1), 11−17
DOI: 10.25082/TCPP.2017.01.004

RESEARCH ARTICLE

Sleep Less, myopia more

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Abstract: The data through 15,316 Chinese school students aged 6 to 18 years from 19 randomized schools inside Beijing city including the cycloplegic refractor and also the possible genetic, environmental as well as behavioural habit risk factors were examined to explore the key risk aspects for myopia. Univariate along with multiple logistic regression analysis were carried out, and receiver operator characteristic (ROC) curves generated.The results showed that myopia was associated with short sleeping time (lowest time span) versus long sleeping time (highest time span) (odds ratio=3.37; 95%CI 3.07-3.70). Controlling for the same factors, children with shorter sleeping time had significantly more myopic refractions (-1.69D for children with the shortest sleeping time compared with -1.29D for children with the longest sleeping time per day). Analysis of the areas under the ROC curves showed five variables with predictive values better than chance: age, sleeping time, reading or writing distance, hours of studying, and parent's myopia.The findings indicated that Sleeping time may be an independent risk factor of myopia, and this relationship may not be explained merely by increased hours of studying or hours of watching TV. An interesting observation is that sleeping time may be an important risk factor for myopia compared with other near work factors. The complexity of the relationship between sleeping time and myopia need additional studies to clarify any cause-effect relationship.

Keywords: Sleeping time, Myopia, Social Medicine, Children

The prevalence of myopia of Chinese school-aged students has been one of the highest[1–3] in the world according to the Report of Student Physical Health Monitoring by Ministry of Education of China in 2010, and which in Beijing city (31.10% of primary school students, 62.12% of middle school students, 77.88% of high school students) is higher than the average of whole country and shows an upward trend. Considering myopias high prevalence, being able to slow or stop myopia progression and ultimately prevent the occurrence of myopia is important especially in China.

An extensive literature on the possible environmental, behavioural habit and genetic risk factors for myopia exists, but the strength of many 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, illumination condition, and behavioural risk factors such as reading distance, hours of sports, hours of watching TV or using computer, sleeping time, as well as parental myopia, a possible indicator of genetic susceptibility.[4] Studies focusing on reducing the progression of myopia have had limited success. Trials using progressive addition lenses,[5] bifocals,[6] and rigid gas permeable contact lenses[7] found small, statistically significant reduction in myopic progression when compared to relevant control groups. As a main measurement for preventing and controlling myopia of school students in China, Eye Exercises (a method of massage for eye) has been carried out for near 30 years in school, but that doesn't make the prevalence of myopia lower.

In this article we use mass data of school-age students about potential risk factors of myopia from primary and middle schools in Beijing city to explore the prior or sensitive factors and evaluate the association with myopia.

Received: March 3, 2017 **Accepted:** April 4, 2017 **Published:** May 8, 2017

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Citation: Xu XX, Wang DF, Xiao GX, *et al.* Sleep Less, myopia more. *Theory Clin Pract Pediatr*, 2017, **1**(1): 12—18

Funding: This research was supported by a grant from The National Education Science eleven five project, China (No. ELA-070228)

1 Materials and methods

1.1 Subjects

The sample of this study came from a multistage stratified random sampling, in which 18 districts in Beijing were divided into three strata of developed region, developing region and undeveloped region according to the economic indicator of GDP; six schools of 3 primary schools and 3 middle schools were randomly selected from each stratum; and a total of 900 students from each school were randomly drawn in 2008. Parents and students were provided an explanation of the study, and the parents gave their consents for their children's participation in the study if the study protocol was approved by Beijing Municipal Commission of Education. Finally, 15316 school-aged students (response rate is 94.5%) from grade 1 in primary school to grade 3 in high school located in different districts in Beijing were invited to participate in the survey (primary school students:5643 (36.8%), middle school students:4378 (28.6%), and 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%)).

1.2 Questionnaire survey

A questionnaire designed to evaluate the genetic, environmental and behavioral risk factors risk factors of myopia ,which included several parts, the first part: general characteristic (gender, age, parent's education, parent's profession, family income, etc); the second part: near work questions (reading or writing distance, studying time per day, hours of watching TV and using computer per day, distance to TV and computer per day, etc); the third part: sports, sleeping and nutrition questions (hours of sports per day, sleeping time per day , quantity of sweet foods, fruit, vegetable and high protein foods, etc); the forth part: parent's myopia. By the reliability and validity test about the questionnaire, the Crosspatch's alpha,the Guttman split half correlation coefficient and the Scale reliability coefficient are 0.71,0.654, 0.704, respectively.

1.3 Measurements

Myopia was defined as at least -0.75D of myopia in both the horizontal and vertical meridians on cycloplegic auto refraction. An auto keratorefractometer (model RM A7000, Topcon, Ltd, Japan) was used to obtain the average of five consecutive refraction readings (all readings <0.25D apart) and average of two corneal curvature readings in the flatter and steeper meridians was calculated.[8,9] Parents provided information through a survey on parental myopia,parental education level and the number of hours per day of watching TV or using computer a child performed and the children provided information of years of birth, gender, the distance of reading or writing, hours of sports (not include outdoor leisure activities), and hours of sleeping.

1.4 Data analysis

Refraction was analyzed as (spherical equivalent [SE]: sphere + half negativecylinder power). Myopia was defined as SE at least -0.75D. Data (SE) from the right and left eye were similar (Pearson correlation coefficient=0.88), and thus the left eye results were presented. To count the univariate odds ratio(OR) and multivariate OR after adjusting other variables for myopia by logistic regression models with refraction as the dependent variable and sleeping time, age, gender, parental myopia, parental education, reading or writing distance, hours of sports, hours of watching TV or using computers the explanatory variables.To count the adjusted mean refraction in different sleeping time span by multiple linear regression models after adjusting other risk factors. The linear trend tests were performed by assigning consecutive integers to each sleeping time span. The areas under the ROC curves (AUC) was used to compare the specificity and sensitivity to myopia among the main risk factors include age, hours of sleeping, father's education, parent's myopia and reading distance.Data analysis was conducted using the commercially available software (Stata, Ver.10.0; Stata, College Station, TX).[10]

2 Results

2.1 Characteristics of the subjects

The mean refractive error was -1.45 D (SD 2.50; range -14.78 to 14.37), and the prevalence rate of myopia was 8178/15316 (53.40%; 95% confidence interval (CI), 52.60%-54.19%).The median number of hours of watching TV or use computer and hours of studying was 1 to 2 hours and 7 to 9 hours per day, respectively.

There were 278 (4.95%) and 1141 (25.16%)childrenin the highest sleeping time span whose hours of studying greater than 10 hours per day compared with the lowest sleeping time span (P<0.001; Table1).The spearman correlation coefficient of sleeping time and hours of studying per day was -0.26(P<0.001).Children with sleeping time in the highest span were more likely to spend hours of watching TV or use computer more than 2h (33.32%) compared with children with sleeping time in the lowest sleeping time span (18.08%;P<0.001).

Table 1. Hours of studying per day of Chinese children by sleeping time span

		Hours of Studying per Day				
Sleeping time	n	6 Hours or Less	6 to 8 Hours	8 to 10 Hours	10 Hours or	P
7Hoursor less	4535	679 (14.97%)	1512 (33.34%)	1203 (26.53%)	1141(25.16%	<0.001
About 8 hours	4809	929 (19.32%)	2046 (42.55%)	1189 (24.72%)	645 (13.41%)	
9Hoursor more	5618	1692(30.12%)	2819 (50.18%)	829 (14.76%)	278 (4.95%)	

2.2 Risk factors associated with myopia

In univariate analyses, myopia was associated with older age (17 or more years) compared with younger age (6 to 9 years; odds ratio [OR]=11.24; 95% CI 9.99-12.63; Table 2), but not associated with female versus male (OR=1.33; 95% CI 1.25-1.42), and marginally associated with maternal tertiary education versus primary education (OR=1.71; 95%CI 1.40-2.10). Myopia was associated with two versus no myopia parents (OR=1.88; 95%CI 1.69-2.10), and myopia was not associated with the hours of sports, and hours of watching TV or using computer per day in the highest level versus in the lowest level (OR=1.17, 0.86; 95%CI 1.07-1.27, 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, 3.06; 95%CI 2.21-2.84, 2.72-3.44), and associated with hours of sleep more than 9 hours versus less than 7 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 of watching TV or using 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 computer per day, and the association with hours of studying was marginally significant (OR=1.43; 95%CI 1.25-1.64 for more than 10h vs. less than 6h) in multivariate analyses.

2.3 Unadjusted and adjusted refraction changes by sleeping time

The prevalence rates of myopia in children with the lowest sleeping time span were 68.45%, 56.08% in the second highest sleeping time span, 34.80% in the highest sleeping time span. Myopia associated with sleeping time more than 9h vs. less than 7h (OR=3.37; 95%CI 3.07-3.70) after controlling for age, gender, parental myopia, father's education, reading or writing distance, hours of sports per day, hours of watching TV or using computer per day, hours of studying per day (Table 2).Myopia was also associated with unit increases in sleeping time (OR=1.95; 95%CI 1.86-2.04;P<0.001), after controlling for the same factors. Similar significant univariate (OR=2.05; 95%CI 1.96-2.13;P<0.001) and multivariate (OR=1.94; 95%CI 1.85-2.04;P<0.001) associations between myopia and sleeping time were found. The relationship between sleeping time and myopia remained significantly positive within each strata of hours of watching TV or using computer per day. There was no interaction between hours of studying or hours of sports per day and sleeping time. Moreover, there was no interaction between father's education or parental myopia and sleeping time.The multivariate adjusted mean refractive error for children with sleeping time in the highest span was -1.69 D compared with -1.29 D for children with sleeping time in the lowest span (P<0.001; Table 3). For every point increase in sleeping time, there is a 0.09 D shift in refraction toward less myopia values (P<0.001; Table 3).

The areas under the ROC curves (AUC) associated with univariate logistic predictive models are presented in Table 4. The variable of age has the largest AUC (0.72), and sleeping time, reading distance, and hours of studying are the next closest variables (0.65, 0.57, 0.57). The remainder activities had AUCs between 0.50 and 0.55.[11,12]

The R^2, or coefficient of multiple determinations, that estimate the proportion of variance in refraction explained in several models.[13] Explanatory variables were added to a baseline model (model 1) in a stepwise fashion, whereby the explanatory variables that explained the greatest variance in refraction were added first. The baseline model include age, gender, and parental myopia (R^2=0.155). Model 2 included the addition of sleeping time, the explanatory variable that explained the greatest variance in refractive error, in addition to the base model (R^2=0.157). Model 2 was statistically significant improvement in the explanation of variables for refractive error compared with the base model, model 1 (partial F test: P<0.001). Model 3 included reading or writing distance in addition to all the explanatory variables in model 2 (R^2=0.161), and model 4 included father's education in addition to all the explanatory variables in model 3 (R^2=0.164). Model 5 included studying time per day in addition to all the explanatory variables in model 4 (R^2=0.165), and model 6 included hours of watching

Table 2. Risk factors associated with myopia

	n	Univariate OR for Myopia (95%CI)	P	Multivariate OR for Myopia (95%CI)	P
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 education level					
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(1.342.14)	(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					
2 Hours or more	6400	1 (referent)			
1 to 2 Hours	5680	0.83(0.77 0.89)	<0.001	0.94(0.86 1.02)	0.453
1 Hour or less	2974	0.86(0.79 0.94)	<0.001	0.88(0.790.97)	0.473
Hours of studying per day					
10 Hours or more	3365	1 (referent)		1 (referent)	
8 to10 Hours	6457	1.30(1.20 1.42)	<0.001	1.14(1.04 1.26)	0.015
6 to 8 Hours	3265	2.37(2.15 2.62)	(trend)	1.39(1.241.56)	<0.001
6 Hours or less	2085	3.06(2.72 3.44)		1.43(1.251.64)	(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(3.073.70)	<0.001

TV or using computer per day in addition to all the explanatory variables in model 5 (R^2=0.166), and model 7 included hours of sports per day in addition to the explanatory variables in model 6 (R^2=0.166). The R^2 values for model 3 were significantly higher than those in model 2, and the R^2 values were also higher for model 4 than model 3, model 5 than model 4, model 6 than model 5 (all partial F test: $P<0.001$), but the R^2 values for model 7 were similar to those in model 6 (partial F test: P=0.976).[14–16]

3 Discussion

As an important risk factor for myopia, sleeping time was often ignored in some prior studies,[17–26] maybe the sleeping time is enough for school-aged children in some countries, but which is not enough yet in China. Our data suggest that the mean hours of sleep is 9 hours per day for primary school students, 8 hours per day for middle school students, and 7 hours per day for high school students in Beijing city. Chinese children aged 6 to 18

Table 3. Unadjusted and Adjusted Mean Refraction by Sleeping Time

Sleeping Time	n	Refractive Error (D)			
		Unadjusted Mean (SD)	95%CI	Adjusted Mean (SD)	95%CI
9 Hours or more	5061	-0.76(1.82)	-0.81, -0.71	-1.29(0.03)	-1.36, -1.23
About 8 hours	4423	-1.57(3.23)	-1.67, -1.48	-1.49(0.02)	-1.54, -1.45
7 Hours or less	4208	-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 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	0.52	0.01	0.51- 0.53
Hours of studying	0.57	0.01	0.56- 0.58
Hours of TV	0.5	0.01	0.49- 0.51

years with less sleeping time in Beijing city were more likely to be myopia, after controlling for age, gender, parental myopia, father's education, reading or writing distance, hours of sports per day, hours of watching TV or using computer per day, and hours of studying per day. Our data suggest that sleeping time has an association with myopia independent of near work in Chinese school-aged students, though the mechanism underlying the sleeping time-myopia relationship is not well understood. An interesting observation is that myopia (SE at least -0.75 D) is not significantly associated with hours of watching TV or using computer, hours of studying, hours of sports per day after controlling for other confounders, including sleeping time, however, remains associated with number of parent with myopia, reading or writing distance after controlling other factors, including sleeping time. The number of hours of sports(not include any outdoor leisure activities) was not a significant factor in the logistic models. Myopia was not associated with hours of sports less than 30 minutes versus greater 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 computer per day, hours of studying per day, and sleeping time per day (OR=0.97; 95%CI 0.88-1.08).This is similar to the results of Parssinen and Lyyra,[27] but is contrast with the results of Lisa and Loraine,[28] who evaluated factors associated with myopic progression in a survey from Orinda Longitudinal Study of Myopia subjects from 1989 to 2001. They assessed parental history of myopia, near work factors, and sports per week (include outdoor activities) to predict the future myopia and concluded that greater weekly participation in sports was associated with reduced odds of having myopia. Prior studies suggest that several hours of sports or outdoor activities per day are required for myopia protection, but only the hours of sports(without hours of outdoor activities) was collected in our study because it is difficult to record the hours of outdoor activities of the large number of participations. Likewise, there is no body of literature addressing the relation between sleeping time and myopia. A possible explanation about the effect of sleeping for myopia could be to relieve ciliary muscle to be tired and prevents or alleviates the myopic progression. Confounding effects must also be considered. Myopia has been associated with other characteristic such as IQ[29–31] and personality.[32,33] Perhaps increased sleeping time can be a surrogate for more extroverted personality from psychological characteristics.There have been a few previously published reports of ambient lighting during sleep and the association of myopia, and concluded that night-time light exposure during infancy is not a major risk factor for myopia development in most population groups.[34]Maybe hours of sleep, ambient lighting during sleep, and quality of sleep should be considered all together to analysis the association between sleep and myopia. In assessing these results, it is possible that using a questionnaire asking the number of hours of the sleeping time per day may present difficulties. The questionnaire may not be the most appropriate information to target the amount of near work or other activities actually completely. The results may also be affected by deleting the missing data during data analysis, though the sample size is large. In conclusion, sleeping time per day may be associated with myopia, independent of near work factors in school-aged children. Sleeping time contributes to a greater variance in refraction compared with near work. Enough sleeping time will benefit to myopia

for school-aged children.

Acknowledgement

We sincerely thank all the participants of the study and colleagues including Song YuZhen,Zhao Hong, Wang JiZhou,et al. for their participants and kind support. The authors are also grateful to staff of every Primary and Middle School Students Health Care Centers affiliated to the District Education Committee in Beijing for their support and technical assistance.

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