The Relationship between Sleep Duration, Body Mass Index, Physical Education Classes, Age and High Blood Pressure in Children and Adolescents: A Cross-sectional Study

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Abstract

Background In order to study the high blood pressure of children and adolescents and its influencing factors, it provides evidence-based evidence for the high blood pressure prevention of primary and secondary school students.

Methods This study is a cross-sectional survey, which uses stratified cluster sampling method to select students from 7 schools to participate in questionnaire survey and physical examination. The correlation between single factor and high blood pressure was analyzed by chi-square test, and multivariate logistic regression analysis was used for multivariate analysis.

Results A total of 1,814 subjects, including 512 primary school students (28.22%), 499 junior high school students (27.51%), 563 senior high school (31.04%), and 240 vocational high school (13.23%). There were 1000 males (55.13%) and 814 females (44.70%). The average age was 13.64±2.65 years. The detection rate of high blood pressure was 9.76%. Multivariate logistic regression analysis showed that the age groups were 10~ and 14~ (OR=20.870, 95%CI=2.372-183.666; OR=10.049, 95%CI=1.306-77.353) , sleep duration < 7h (OR=4.136, 95%CI=4.136), and physical education class times ≤2 times per week (OR=5.073, 95%CI=2.497-10.306), which were risk factors for high blood pressure in children and adolescents. Normal weight and overweight group were protective factors compared to the obesity group (OR=0.094, 95%CI=0.061-0.146; OR=0.225, 95%CI=0.134-0.378).

Conclusion The age groups of 14~ and 16~ years old, physical education classes ≤ 2 times per week, and sleep duration <7h were risk factors for primary and secondary school students, and BMI of Normal weight and overweight group were protective factors compared to the obesity group students.

Background

Hypertension is one of the major public health problems. From 2002 to 2012, the prevalence of hypertension among Chinese residents increased from 18.8% to 25.2% [1]. According to the Chinese Hypertension Survey (CHS) survey from 1993 to 2011, hypertension in Chinese children increased by 0.16 percent per year on average [2]. Study have shown that there is a trajectory of hypertension, and adult hypertension is closely related to hypertension in children and adolescents [3], and 10-year-old child with a high blood pressure has a 50% chance of developing hypertension at 20 years old [4]. In 2014, the physique investigation of Chinese students found that the prevalence of high blood pressure in children and adolescents was as high as 6.4% [5]. Therefore, monitoring the high blood pressure of children and adolescents is very important for adult hypertension. The purpose of this study is to investigate the current status and influencing factors of high blood pressure in primary and middle school students, so as to provide evidence-based basis for the prevention and control of hypertension in primary and secondary school students.

Methods

Study population

The data for this study came from the results of 2017 monitoring of common diseases and health risk factors for students in a district health department of Chongqing, China. In this survey, a total of 7 schools were selected by stratified cluster sampling method, including grades 4–6 in primary school, and junior middle school, senior high school and vocational high school. These three types of schools are all grades 1–3. Each school randomly selected 1 to 3 classes, each class surveyed at least 80 students, and each school surveyed at least 240 students. The survey collected a total of 1816 primary and secondary school students.

Investigative process

This research used two methods, questionnaire survey and physical examination. And the research process consists of three parts. The first part is to investigate the basic characteristics of the study population, including the student's identity code, school, gender, nationality, date of birth, medical history and so on. The second part is the investigation of students' health risk factors. The questionnaire of students' health status and influencing factors compiled by the Chinese government, which is adopted to monitor some health risk factors that affect students' common diseases. The first part and the second part of the work were completed by the staff of the Centers for Disease Control and Prevention (CDC), who had been trained before the questionnaire. The third part is the monitoring of students' common diseases, which is jointly completed by the Health Care Center of Primary and Secondary Schools in the district and the university hospital, including height, weight, blood pressure (BP) and other demographic indicators.

Quality control

The investigation has taken strict quality control measures. Firstly, the researchers conducted unified training and assessment of the questionnaire survey workers and only the staff who successfully passed the assessment can participate in the questionnaire survey. And to avoid any inducement and suggestion of the survey results of the respondents. Secondly, the investigators are composed of medical professional, including doctors and public health workers, and the monitoring equipment must comply with national standards. Thirdly, the questionnaire contents and data entry results were reviewed by professional researchers. Finally, The supervision department carried out on-site supervision and sampling review in real time, supervised the questionnaire survey and the measurement of demographic indicators.

Determination criterion

Body mass index (BMI) = weight (kg) / height (m^2). Overweight and obesity were screened according to *Screening for Overweight and Obesity among School-age Children and Adolescents (WS/T 586–2018)* [6].

Overweight is defined as BMI greater than or equal to the overweight threshold for the corresponding gender and age group, and smaller than the obesity threshold. Those who have a BMI greater than or equal to the corresponding gender and age group “obesity” boundary points are obesity. Normal-high blood pressure and high blood pressure were screened according to *Reference of Screening for Elevated Blood Pressure among Children and Adolescents Aged 7–18 years (WS/T 610—2018) [7*]. Among children aged 7 to 17, according to the classification of blood pressure by age, weight and height, the normal blood pressure was defined as the systolic blood pressure (SBP) and diastolic blood pressure (DBP) < 90th percentile. The high-normal blood pressure was defined as SBP and/or DBP between the ≥ 90th percentile and the <95th percentile. The high blood pressure was defined as SBP and/or DBP ≥ 95th percentile. The blood pressure threshold of students aged 18 years and above should refer to the adult standard. Normal blood pressure was defined as SBP < 120 mm Hg and DBP < 80 mm Hg. The high-normal blood pressure was defined as SBP ≥120 mm Hg and < 139 mm Hg and/or DPB ≥80 mm Hg and < 89 mm Hg. The high blood pressure was defined as SBP ≥140 mm Hg and/or DPB ≥90 mm Hg. The definition of adequate sleep: ≥10h/d for students aged 7–12, ≥9h/d for students aged 13–15, ≥8h/d for students aged 16–18 [8], and ≥7h/d for adults over 18 years old [9].

Statistical Process

Data entry and analysis were performed with EpiData3.1 and SPSS22.0 respectively. The descriptive data are expressed as frequency and percentage (n,%), and the measurement data are expressed as mean and standard deviation (Mean± SD). Kolmogorov-smirnov test and F test were used respectively for normality test and homogeneity of variance test of samples. The rank-sum test (Kruskal-wallis H test) was used for the difference analysis of measurement data of continuous non-normal distribution. Single-factor correlation analysis was performed by chi-square test. Spearson correlation test was used for continuous non-normal distribution data. Multivariate analysis was performed using disordered multivariate Logistic regression.

Results

The Table 1 shows the basic characteristics of the study population. A total of 1,816 students were surveyed in this study, of which the effective sample was 1,814 and the effective rate was 99.89%. Of all the 1,814 subjects, 512 were primary school students (28.22%), 499 were junior high school students (27.51%), 563 were senior high school (31.04%), and 240 were vocational high school (13.23%). And there were 1000 males and 814 females, accounting for 55.13% and 44.70% respectively. All subjects were 7 to 20 years old and the average age was 13.64±2.65 years. According to blood pressure screening criteria, 177 primary and middle school students with high blood pressure were found in this study, accounting for 9.76%, and the normal blood pressure was 1,500, accounting for 82.69%, the high-normal blood pressure was 137, accounting for 7.55%. From primary

school to vocational high school, the detection rate of high blood pressure gradually increased, among which the detection rate of high blood pressure of vocational high school students was the highest (17.08%), and the primary school students was the lowest (7.23%). All of the differences in distribution characteristics were statistically significant.

Table1 The Basic Characteristics of Study Population

Variables	Total (n=1814)	Primary school (n=512, 28.22%)	Junior high school (n=499, 27.51%)	Senior high school (n=563, 31.04%)	Vocational high school (n=240, 13.23%)	*P*
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	<0.001*
Age	13.64±2.65	10.24±0.99	14.68±1.58	14.41±1.56	16.95±0.76	<0.001*
Height	156.71±12.34	142.86±8.44	162.65±9.66	160.36±8.16	165.37±7.80	<0.001*
Weight	50.99±14.52	38.23±8.923	55.35±14.49	54.26±11.441	61.46±12.65	<0.001*
SBP	111.73±9.96	108.95±7.34	111.24±9.84	111.9±10.45	118.27±10.88	<0.001*
DBP	61.55±8.46	59.12±6.43	62.56±9.80	60.76±8.05	66.45±7.87	<0.001*
BMI	20.43±3.92	18.56±3.11	20.78±4.41	20.99±3.50	22.37±3.75	0.001*
Gender						
Male	1000 (55.13%)	231(45.12%)	354(70.94%)	274(48.67%)	141(58.75%)	<0.001#
Female	814 (44.70%)	281(54.88%)	145(29.06%)	289(51.33%)	99(41.25%)	
Blood pressure						
Normal BP	1500(82.69%)	438(85.55%)	435(87.17%)	467(82.95%)	160(66.67)	<0.001#
High-normal BP	137(7.55%)	37(7.23%)	25(5.01%)	36(6.39%)	39(16.25%)	
High blood BP	177(9.76%)	37(7.23%)	39(7.82%)	60(10.66%)	41 (17.08%)	

*: Significant difference by Kruskal-Wallis H test #: Significant difference by Chi-square (X^2) test

Table 2 presents the correlation between SBP, DBP and height, weight, age, BMI, and sleep duration, respectively. The results showed that the diastolic blood pressure and systolic blood pressure of primary and secondary school students were positively correlated with age, height, weight and BMI, but there is a negative correlation relationship between sleep duration and diastolic or systolic blood pressure. And all these differences were statistically significant (P<0.05).

Table 2 Spearman Correlation Analysis of BP with Anthropometric indicators and Sleep Duration

Variables	SBP		DBP	
	r	P	r	*P*
Age	0.385	0.001**	0.361	0.001**
Height	0.407	0.001**	0.380	0.001**
Weight	0.511	0.001**	0.447	0.001**
BMI	0.433	0.001**	0.364	0.001**
Sleep Duration	-0.231	0.001**	-0.227	0.001**

**: significant difference using Spearman correlation analysis

The table 3 shows the correlation analysis results of blood pressure with different gender, different age groups and different BMI categories. In this study, 286 primary and secondary school students had a BMI of overweight, and the detection rate of overweight was 15.77%. The BMI of obese students was only 196, and the detection rate of obesity was 10.80%. However, obesity group had the highest detection rate of high blood pressure (28.57% for obesity group), followed by overweight (12.59% for overweight group), and the normal weight group had the lowest detection rate of high blood pressure (6.38%), and the difference in BMI distribution was statistically significant by Chi-square test. The detection rate of male students was higher than female students (55.13% for boys and 44.87% for girls), but there was no significant difference between the two groups. Among

all age groups, the detection rate of high blood pressure in the 16~ age group and the 14~ age group was significantly higher than that in other age groups, and the difference was also statistically significant.

Table 3 Correlation Analysis of BP with BMI, Gender and Age

Variables	Normal BP (n=1500)		High-normal BP (n=137)		High blood BP (n=177)		Total (n=1814)		X^2	*p*
BMI categories										
Normal	1164	87.39%	83	6.23%	85	6.38%	1332	73.43%	119.888	<0.001#
Overweight	221	77.27%	29	10.14%	36	12.59%	286	15.77%		
Obesity	115	58.67%	25	12.76%	56	28.57%	196	10.80%		
Gender										
Male	813	81.30%	78	7.80%	109	10.90%	1000	55.13%	3.683	0.159
Female	687	84.40%	59	7.25%	68	8.35%	814	44.87%		
Age groups (years)										
≤9	119	86.23%	13	9.42%	6	4.35%	138	7.61%	154.422	<0.001#
10~	287	85.93%	21	6.29%	26	7.78%	334	18.41%		
12~	323	93.35%	9	2.60%	14	4.05%	346	19.07%		
14~	346	79.54%	32	7.36%	57	13.10%	435	23.98%		
16~	394	78.02%	38	7.52%	73	14.46%	505	27.84%		
≥18	31	55.36%	24	42.86%	1	1.79%	56	3.09%		

#: Significant difference using Chi-square (X^2) test

Table 4 shows the relationship between students' blood pressure and their sleep duration and physical exercise. In terms of exercise, most of students spent 1-3 days a week doing moderate or high intensity exercises, accounting for 53.97% and 49.95% of the total students respectively, and the two groups also had highest detection rates of high blood pressure, the detection rate of high blood pressure in moderate intensity exercise

was 12.16%, and that in high intensity exercise was 11.71%. The detection rate of high blood pressure in students who did not participate in moderate or high intensity exercise was next, 9.51% and 9.91%, respectively. However, students who exercise 4-6 days of moderate or high-intensity exercise every week have the lowest rate of hypertension, the high blood pressure detection rates for moderate or high-intensity exercise for 4-6 days per week were 5.14% and 3.40%. Among all the students who joined in the study, students who attended physical education classes ≤2 times a week were the most, accounting for 45.76% of all students, and those who attended physical education classes ≥4 times a week was lowest, accounted for 20.07%. And the detection rate of high blood pressure of students who attended physical education classes ≤2 times a week was higher than that of students who attended physical education classes 3 times and ≥4 times a week（15.30% > 5.59% > 4.84%). The lower the sleep time, the higher the detection rate of high blood pressure. Students who slept less than 7 hours per day had the highest detection rate of blood pressure, accounting for 15.95%, while students who slept 10 hours or more per day had the lowest detection rate, accounting for only 4.05%. Moreover, from the results of the study, most students do not have enough sleep duration, accounting for 73.10% of all subjects, and only 26.90% of students with adequate sleep. Moreover, the high blood pressure detection rate of students with insufficient sleep was 11.39%, which was higher than that of students with adequate sleep, and the proportion of students with adequate sleep was 5.33%.

Table 4 The Correlation Analysis of BP with Lifestyle Habits

Variables	Normal BP (n=1500)		High-normal BP(n=137)		High blood BP(n=177)		Total (n=1814)		X^2	*p*
Days of moderate intensity exercise per week										
No exercise	227	79.93%	30	10.56%	27	9.51%	284	15.66%	23.727	0.001#
1-3 days	795	81.21%	65	6.64%	119	12.16%	979	53.97%		
4-6 days	343	88.17%	26	6.68%	20	5.14%	389	21.44%		
7 days	135	83.33%	16	9.88%	11	6.79%	162	8.93%		
Days of high intensity exercise per week										
No exercise	473	80.85%	54	9.23%	58	9.91%	585	32.25%	20.448	0.002#
1-3 days	734	81.83%	58	6.47%	105	11.71%	897	49.45%		
4-6 days	237	89.43%	19	7.17%	9	3.40%	265	14.61%		
7 days	56	83.58%	6	8.96%	5	7.46%	67	3.69%		
Number of physical education classes per week										
≤2 times	611	73.61%	92	11.08%	127	15.30%	830	45.76%	90.713	<0.001#
3 times	567	91.45%	23	3.71%	130	4.84%	620	34.18%		
≥4 times	322	88.46%	22	6.04%	20	5.49%	364	20.07%		
Sleep duration categories										
7h	250	71.23%	45	12.82%	56	15.95%	351	19.35%	52.092	<0.001#
7h~	370	81.68%	32	7.06%	51	11.26%	453	24.97%		
8h~	369	85.22%	27	6.24%	37	8.55%	433	23.87%		
9h~	245	87.19%	15	5.34%	21	7.47%	281	15.49%		
≥10h	266	89.86%	18	6.08%	12	4.05%	296	16.32%		
Sleep duration enough or not										
NO	1068	80.54%	107	8.07%	151	11.39%	1326	73.10%	17.917	<0.001#
Yes	432	88.52%	30	6.15%	26	5.33%	488	26.90%		

#: Significant difference using Chi-square (X2) test

Moderate intensity exercise: Moderate intensity exercise are those that require moderate strength and sweat, including table tennis, badminton, dancing, gymnastics, but not walking.

High intensity exercise: High-intensity exercise refers to sports that require a lot of effort and can be completed with a lot of sweat, including running, fast climbing, basketball, football, swimming, heavy loads, and so on.

Table 5 presents the health risk factors of high blood pressure through by univariate and multivariate logistic regression analysis. In this study, through correlation analysis ,and univariate logistic regression analysis by adjust gender, it was found that BMI categories, number of P.E. classes per week, sleep duration and whether sleep is enough were related to high blood pressure. In the multiple regression analysis of adjusting gender, the age group of 10~ and 14~ is a risk factor for high blood pressure in children and adolescents, and students aged 10~ have a higher risk of high blood pressure than students aged 14~ (OR=20.870, CI: 2.372-183.666; OR=10.049, CI: 1.306-77.353). Compared with students who attended physical education class 3 times or more than 4 times a week, students who attended physical education class less than 2 times a week had a higher risk of high blood pressure (OR=5.073 , 95%CI=2.497-10.306). Students with a BMI that is overweight are more likely to have higher blood pressure than normal students (OR=0.025 > OR=0.094). Moreover, compared with other sleep duration groups, sleep duration <7 hours is an risk factor for high blood pressure in children and adolescents (OR=4.136, 95%CI=1.779-9.617).

Table 5 Univariate and Multivariate Logistic Regression Analysis of Factors Affecting High Blood Pressure

Variables		High Blood Pressure		
		Sig	OR	95% CI
Univariate logistic regression (adjust by gender)				
Age groups (years)	≤9	0.668	1.603	0.186-13.822
	10~	0.303	2.909	0.381-22.202
	12~	0.768	1.364	0.174-10.73
	14~	0.110	5.149	0.689-38.473
	16~	0.090	5.690	0.765-42.345
	≥18	.	.	.
BMI categories	**Normal**	**0.000**	**0.153**	**0.104-0.226**
	Overweight	**0.000**	**0.338**	**0.210-0.544**
	Obesity	.	.	.
Days of moderate intensity exercise per week	No exercise	0.311	1.461	0.702-3.041
	1-3 days	0.065	1.833	0.962-3.492
	4-6 days	0.396	0.719	0.335-1.541
	7 days	.	.	.
Days of high intensity exercise per week	No exercise	0.449	1.447	0.556-3.767
	1-3 days	0.290	1.661	0.650-4.246
	4-6 days	0.159	0.443	0.143-1.374
	7 days	.	.	.
Number of physical education classes per week	**≤2 times**	**0.000**	**3.300**	**2.019-5.393**
	3 times	0.604	0.857	0.479-1.535
	≥4 times	.	.	.
Sleep duration groups	**7h**	**0.000**	**4.874**	**2.550-9.313**
	7h~	**0.001**	**2.979**	**1.556-5.702**
	8h~	**0.026**	**2.144**	**1.096-4.197**
	9h~	0.086	1.895	0.913-3.935
	≥10h	.	.	.
Sleeping duration enough or not	**NO**	**0.000**	**2.367**	**1.538-3.644**

	Yes	.	.	.
Multiple logistic regression analysis adjust by gender (the forward stepwise)				
Age group (years)	≤9	0.061	9.001	0.900-89.994
	10~	**0.006**	**20.870**	**2.372-183.666**
	12~	0.113	5.684	0.664-48.667
	14~	**0.027**	**10.049**	**1.306-77.353**
	16~	0.074	6.380	0.837-48.631
	≥18	.	.	.
Number of physical education classes per week	**≤2 times**	**0.000**	**5.073**	**2.497-10.306**
	3 times	0.762	0.910	0.493-1.678
	≥4 times	.	.	.
BMI categories	**Normal**	**0.000**	**0.094**	**0.061-0.146**
	Overweight	**0.000**	**0.225**	**0.134-0.378**
	Obesity	.	.	.
Sleep duration categories	**7h**	**0.001**	**4.136**	**1.779-9.617**
	7h~	0.066	2.204	0.95-5.111
	8h~	0.152	1.825	0.801-4.161
	9h~	0.118	1.849	0.855-4.00,
	≥10h	.	.	.

Discussion

Hypertension is an important risk factor for cardiovascular diseases, and childhood hypertension is closely related to adult hypertension. Study have shown that the prevalence of hypertension in children and adolescents is within 3.4% ~23.7% [10]. The prevalence of hypertension in Chinese school-age children in 2010 was 14.5% [2], and the prevalence of hypertension among primary and secondary school students in Chongqing in 2013 was as high as 16.1% [11]. High blood pressure is a prerequisite for hypertension. When a blood pressure is detected ≥P95th, it needs to be measured 3 times or more on different dates. If the blood pressure is ≥P95th every time, it can be determined as hypertension [7]. From 1993 to 2011, the prevalence of high blood pressure among children and adolescents in China increased from 10% to 12.9% [3]. Therefore, the high blood pressure of children and adolescents such as primary and secondary school students deserves social attention. In this study, the detection rate of high blood

pressure was 9.76%, lower than study in Suzhou during the same period (23.45%) [12], and higher than the national detection rate of high blood pressure in 2014 (6.4%) [5].

In this study, 1814 primary and secondary school students were investigated, and it was found that the detection rate of high blood pressure in males was higher than that in females. From primary school to high school, the detection rate of high blood pressure gradually increased. The detection rate of high blood pressure in vocational high school students was the highest, while that in primary school students was the lowest. Univariate correlation analysis found that factors related to high blood pressure in primary and secondary school students included BMI categories, age groups, days of moderate or high intensity exercise per week, number of physical education class per week, sleep duration and whether the sleep duration was sufficient. Students in the obesity group had higher rates of high blood pressure than the overweight and normal weight groups. The blood pressure of students in 14~ and 16~ age groups was significantly higher than that in other age groups. Students who did moderate or high intensity physical exercise 1-3 days a week and did not participate in physical activity had higher detection rates than students who did moderate or high intensity physical exercise 4-6 or 7 days a week. Compared with students who received physical education classes 3 or more times a week, students who received physical education classes ≤ 2 times a week had higher detection rates. And the less sleep duration, the higher the detection rate of high blood pressure. The high blood pressure detection rate of the students with sleep duration <7h and insufficient sleep was significantly higher than that of the students with other sleep duration groups and those with sufficient sleep.

After univariate and multivariate logistic regression analysis by adjusted gender, it was found that both the10~ and 14~ age groups were risk factors for high blood pressure of primary and secondary school students. And the risk of high blood pressure was higher in the 10~ age group than in the 14 ~ age group (20.870>10.049). The 10~ age group is the initiation period of puberty development, and children begin to enter puberty. Studies have shown that due to the regulation of the neuroendocrine system during this period, the contractile function and vascular resistance of the heart can not adapt to the sudden changes in the body, so that blood pressure rises [13]. And students in the 14~ age group began to enter the second to third year junior high school. In addition to the changes in blood pressure caused by growth and development, it is also possible that the mental stress caused by increased academic burden will increase blood pressure [14]. Therefore, this paper suggests that we should focus on the blood pressure status of students age 10~and 14~ years old groups.

This study found that in the number of physical education classes per week, most students attended physical education classes ≤2 times per week, accounting for 45.76%, and the detection rate of these students was the highest. After multivariate regression analysis, it was found that there was a higher risk of high blood pressure in physical education classes with the number of times per week ≤2 than in physical education classes with 3 or more times per week (OR=5.073). Therefore, the insufficient number of physical education classes is a risk factor for blood pressure in primary and middle school students. The Chinese government stipulates that the number of physical education classes for primary and secondary school students is 5 times a week, and not less than 20-30 minutes each time [15]. so that

most of the students in this survey did not reach the standard. Several studies have shown that physical activity is a contributing factor to high blood pressure in children and adolescents [14]. With a 15 minutes increase in moderate or high intensity exercise, the risk of blood pressure will decrease by 0.65 times [16] and the SBP will decrease by 0.5 mmHg [17]. Therefore, it is recommended that all primary and secondary schools should guarantee the weekly physical education time and encourage students to participate in outdoor activity and physical education classes.

Studies have shown that children's BMI is a predictive factor in adult BMI [18] and an important basis for the diagnosis of overweight and obesity. Burke V. found that BMI also is a predictor of SBP. In this study found that 26.57% of the subjects were overweight and obesity, and 19.09% of overweight and obesity students have high blood pressure. High blood pressure detection rate: obesity group > overweight group> normal weight group. The univariate correlation analysis found that BMI is related to both SBP and DBP. Regression analysis found that compared with the obesity group, the overweight and normal weight group were the protective factors for the high blood pressure of primary and secondary school students, and the OR value was lower when the BMI was normal. This result is consistent with several studies. Researchers found that being overweight and obesity remained a risk factor for hypertension after adjusting for gender and age [19-20]. The WGOC also recommends BMI as a sensitive factor in predicting blood pressure. Juonala M.'s [18] studies have shown that decreasing BMI, overweight and obesity can reduce the risk of cardiovascular disease. Therefore, it is recommended that students in primary and secondary schools should actively control their BMI values, control their weight, and reduce obesity, thereby reducing the risk of high blood pressure.

Several studies have linked sleep duration to high blood pressure [21-22]. There are many studies on adult sleep duration and hypertension, and there are few studies on children and adolescents. In recent years, researchers have begun to pay attention to the relationship between sleep and hypertension in children and adolescents. Studies have shown a significant correlation between sleep and cardiovascular disease in children and adolescents [23-24], and increased sleep duration can decrease blood pressure [25]. Guo et al. found in their sleep study on children aged 5-18 that for every 1h increase in sleep time, SBP and DBP decreased by 1.04mmHg and 0.55mmHg, respectively [26]. In this study, Most of students sleep 7 and 8 hours a day, accounting for 48.84%. However, the detection rate of high blood pressure in the students who slept for < 7h per day was higher than that in the students who slept for other duration groups. Multivariate analysis showed that sleep duration <7h was a risk factor for high blood pressure in primary and middle school students, which was consistent with the results of Kuciene R.'s study [23] . The study also found that students with insufficient sleep time accounted for the highest proportion of all students (73.10%), and the high blood pressure detection rate was higher than those with adequate sleep (11.39%). The sleep adequacy ratio is only 26.9%, which is lower than the 33.78% sleep duration pass rate of Chinese students in 2010 [8]. The results of the study indicate that the sleep duration of primary and secondary school students in the area needs to be improved. They should ensure adequate sleep by reasonable arrangement of work and rest, and the sleep time should not be lower than 7h.

The limitation of this study is that the sample size is not large enough. The study population only selected one district of Chongqing, but did not expand to the entire city. Moreover, the number of students in each grade from primary school and high school is not enough. In order to popularize the results of this study, more sample sizes are needed to better prove the results of this study.

Conclusion

In this study, it was found that age, body mass index, weekly physical education classes and sleep were associated with high blood pressure in children and adolescents. The age groups of 14~ and 16~ years old, physical education classes ≤ 2 times per week, and sleep duration <7h were risk factors for primary and secondary school students, and BMI of Normal weight and overweight group were protective factors compared to the obesity group students.

Abbreviations

CHS: Chinese Hypertension Survey; **BMI:** Body Mass Index; **CDC:** Centers for Disease Control and Prevention; **BP:**Blood Pressure; **SBP:** Systolic Blood Pressure; **DBP:** Diastolic Blood Pressure;

Declarations

Ethics approval and consent to participate

The survey received written consent from the student guardian and the local ethics committee ruled that no formal ethics approval was required in this particular case.

Consent for publication

Not applicable.

Availability of data and materials

All data generated or analysed during this study are included in this published article [and its supplementary information files].

Competing interests

The authors declare that they have no competing interests.

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Author Contributions

Collected data, L.J and X.H.; Writing original draft preparation, C.L.; Writing checks, L.G.; C.H. guided the statistical analysis. Both authors collaborated on interpreting the results and writing the paper. And all authors have read and approved the manuscript.

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