

REGULAR ARTICLE

Excessive homework, inadequate sleep, physical inactivity and screen viewing time are major contributors to high paediatric obesity

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ABSTRACT

Aim: This study examined the relationships between energy balance-related behaviours (EBRBs) outside school hours and obesity in Chinese primary school students. We also explored the influence of gender on those relationships.

Methods: The study sample was a cross-sectional cohort of 5032 Chinese children who were enrolled in grades 1–6 in primary schools in five Chinese cities and whose mean ages ranged from seven years and three months to 11.9 years. The children's parents completed a survey on their child's height, weight and EBRBs outside school hours.

Results: The response rate was 97%, and the reported rates of overweight and obesity were 13.6% and 13.8%, respectively. The obesity rates were higher in boys and lower grade children. Most EBRBs varied between boys and girls and with increased grade levels. The amount of time spent on academic-related activities, screen viewing, outdoor activities and sleep was mostly associated with obesity on weekdays and varied by gender.

Conclusion: Rate of obesity was alarmingly high in the primary school Chinese children in this cohort, especially in younger children. Excessive time spent on academic-related activities outside school hours, inadequate sleep, physical inactivity and higher levels of screen viewing were major contributors to obesity in these Chinese children.

INTRODUCTION

Childhood obesity has been rising rapidly in China, following the trends in developed countries (1), and the increase is more dramatic in large urban regions (1,2). According to the Chinese National Surveys on Students Constitution and Health, the prevalence of obesity in children aged 7–19 increased from 0.2% in 1985 to 8.1% in 2010. The Survey reported that obesity levels were highest among children aged seven to nine years, at 15.7% for boys and 8% for girls, and lowest in the 16–18 age group, at 6.8% for boys and 2.25% for girls (2). While this increase has far exceeded those found in American and European children, the gender differences and high prevalence among the youngest children are particularly alarming and indicate a secular trend that could have serious health and economic implications for China in the near future (2).

Energy balance-related behaviours (EBRBs) refer to behaviours that influence energy intake and expenditure

(3), and the essence of obesity is dysregulation of EBRBs, leading to a positive energy balance. The links between obesity and EBRBs have been observed in preschool and primary school children (4). Because activities at school are highly regulated and focused on academic pursuits, the study of EBRBs outside school hours – before and after school and during weekends and school holidays – provides additional insights for combating childhood obesity. Participation in outdoor activities, especially moderate-to-vigorous physical activity (MVPA) has been positively associated with lower body mass index (BMI), while

Abbreviations

BMI, Body mass index; EBRBs, Energy balance-related behaviours; MVPA, Moderate-to-vigorous physical activity; WGOC, Working Group on Obesity in China; WHO, World Health Organization.

Key notes

- This study examined the relationships between energy balance-related behaviours outside school hours and obesity in Chinese primary school students.
- Rates of obesity were alarmingly high in the children in this cohort, especially in younger children, with some notable age and gender differences.
- Excessive time spent on academic-related activities outside school hours, inadequate sleep, physical inactivity and higher levels of screen viewing were major contributors to obesity levels.

increases in sedentary activities, such as sitting for lengthy periods of time, watching TV and playing computer games, have been associated with higher BMIs in children (4,5). Epidemiological studies have also showed a close association between sleep deficiency and increases in childhood obesity (5). However, it is not clear whether time spent on homework and other academic remedial activities outside school hours is associated with obesity in children.

From a young age, Chinese children are exposed to a fiery competitive system to prepare them for admission to universities (6). Children start school in China at the age of 6 or 7, and primary school students are expected to spend at least three hours a day on academic-related work, which includes homework assignments from their teachers and additional academic remedial and enrichment activities offered by external providers. This is in addition to a long school day that lasts eight to nine hours. These extra activities are paid tutoring programmes that enhance the children's academic achievement and aptitude. Little is known about the health effects of dedicating such a large amount of time to academic-related studies on obesity in children of this age group (3). An emerging body of research has related obesity with physical activity, sedentary behaviour and diet in Chinese children, similar to those conducted in developed countries (7,8). However, a few studies have examined the effects of EBRBs outside school hours on obesity by age and gender in Chinese children.

This study reports the findings of a multicity parent survey on children's engagement in a broad range of EBRBs outside school hours in Chinese primary school students. The aims of this study were to examine the rate of obesity, the levels and patterns of EBRBs outside school hours and the relationships between engaging in EBRBs and obesity in a large sample of Chinese primary school students. Understanding children's activities outside school hours can facilitate a balanced development that promotes children's health and well-being.

METHODS

Study sample and data collection procedure

The study was conducted from March 1 to March 15, 2012 and included primary school students in five large metropolitan cities in five geographical regions of China: Beijing in Northern China, Guangzhou in Southern China, Hefei in Central China, Shanghai in Eastern Coastal China and Xi'an in Western China. Four to five schools were selected from various areas of the city that were representative of the schools in the city. In each school, one classroom was randomly chosen from each of the six class grade levels to participate in the study. The parents of 5517 students were invited to complete a survey, and 5339 surveys were returned, providing a 97% response rate. Students who participated in sport teams or clubs were not asked not to complete the survey. The parents were informed that they could opt out of the study without any repercussions, and no financial incentive was provided for participating in the survey. The response rates were similar

for all class grade levels and cities. After excluding the surveys with incomplete data on gender, age, grade, height and weight, 5032 students – 91% of the initial sample – were included in the data analysis. The study protocol was approved by the Research Review Committee of Beijing Sport University.

Parents were asked to complete a survey on their children's participation in five categories of leisure and nonleisure activities outside school hours on weekdays and at weekends, including three of the most common outdoor activities in children (9). Parents talked to their children and estimated the number of hours that they spent on outdoor activities, homework assignments screen viewing – covering television and playing games on computers – remedial academic work to supplement and enrich their academic activities and sleep outside school hours on weekdays and at weekends. The students were not permitted to complete the surveys by themselves regardless of their ages. Parents were asked to report their child's current height and weight based on results from their most recent clinic visit or latest physical examination. Information was also requested on the students' age, gender, grade levels, average school grades – with A being the best grade and F the lowest – for all subject areas (excluding physical education) and physical education. They were also asked about their own education levels and the monthly family income in renminbi, which is the Chinese currency. The students brought the completed surveys back to school the following day. The surveys were screened for completeness and entered into a database for quality checking by six research staff. These staff re-entered 10% of the surveys to check for accuracy and the error rate was <0.0002%. Information on the children's attitudes towards outdoor activities, hygiene practices such as hand washing during outdoor activities and parent and peer support were also collected, but not included in this study.

Data analysis

The children's BMI, BMI Z-score and standard deviations of BMI for age were calculated with the free AnthroPlus software from the World Health Organization (WHO) and using WHO Child Growth Standards (10). The classification of obesity was based on the reference developed by the Working Group on Obesity in China (WGOC) (11). We also classified obesity using the WHO age-specific and sex-specific BMI cut-off points that were based on the WHO Child Growth Standards (12). We used the BMI Z-score as the continuous measure of obesity in this study, but performed the analyses on BMI as well. Associations between categorical variables were analysed with chi-square (χ^2) statistics, and associations between categorical and ordinal variables were analysed with Somer's d. Spearman's correlation was used to examine the relation between ordinal and continuous variables. The one-way F-test was used to test group differences or trends on continuous variables. Generalised estimation equations were used to estimate the independent associations between the BMI Z-score as the response variable and

EBRBs outside school hours as the explanatory variables. The city where the school data collection sites were based was included as a random term to control the clustering effect. The children's age, gender, grade levels, average school grades, average physical education grade, father's and mother's education levels and monthly family income were included as covariates. The analysis was repeated with stratification by gender to examine gender-specific relationships between obesity and EBRBs outside school hours. To produce a parsimonious model, only significant covariates were kept in the final model. SPSS Statistics version 22 (IBM Corp., New York, NY, USA) was used in data analysis, with significance set at $p = 0.05$ based on a two-sided test.

RESULTS

The study comprised 5032 students from six years and one month to 14.1 years, with a mean age of 9.70 and standard

deviation of 1.72. Grades 1–6 normally cover students up to the age of 12, but sometimes they contain a few older students who are behind with their education for some reason. Table 1 shows the student characteristics and associations with obesity status. In general, the students in the study came from educated families, as 50.1% of the fathers and 46.2% of the mothers had attended college or higher education. More than two-thirds of the families had a monthly income of <10 000 RMB, which was comparable to the 2012 national average family income of 13 000 RMB or 2100 US dollars per month. Students had a wide range of school grades in academic subject areas and physical education. Similar proportions of students from the five cities and across school grade levels were presented in the study sample (data not shown). Finally, higher levels of parent education and family income were associated with higher levels of obesity.

Table 2 shows the rate of overweight and obesity based on the Chinese WGO reference in the overall student

Table 1 Student characteristics (n = 5032) and unadjusted correlations[†] with obesity status

	n (%)	All students (%)	Normal weight (%)	Overweight (%)	Obese (%)
Student gender*					
Male	2556 (50.8%)	50.8	64.7	18.3	17.1
Female	2476 (49.2%)	49.2	81.0	9.1	9.9
Father's education level*					
n = 4936					
Postgraduate	578 (11.70%)	11.70	73.50	16.40	10.00
College/university	1943 (39.40%)	39.40	74.40	11.80	13.70
High school/trade school	1449 (29.40%)	29.40	72.00	14.40	13.70
Middle school or less	966 (19.60%)	19.60	70.70	14.50	14.80
Mother's education level*					
n = 4923					
Postgraduate	966 (19.60%)	8.10	74.10	15.80	10.10
College/university	398 (8.10%)	38.10	74.50	12.40	13.10
High school/trade school	1875 (38.10%)	30.30	72.00	14.10	13.90
Middle school or less	1493 (30.30%)	23.50	71.00	14.10	14.90
Family monthly income**					
n = 4908					
15 000 RMB or more	637 (13.00%)	13.00	72.70	13.00	14.30
10 000–14 999 RMB	541 (11.00%)	11.00	77.10	13.30	9.60
6000–9999 RMB	1133 (23.10%)	23.10	77.50	11.00	11.50
3000–5999 RMB	1820 (37.10%)	37.10	71.30	14.80	13.90
<3000 RMB	777 (15.80%)	15.80	66.80	15.40	17.80
Physical education grade**					
n = 4973					
A	45.80%	76.60	12.00	11.40	45.80
B	36.20%	71.70	14.50	13.80	36.20
C	11.00%	66.50	16.20	17.30	11.00
D and F	7.00%	62.30	16.90	20.90	7.00
Average school grade**					
n = 5020					
A	50.30%	75.40	12.30	12.40	50.30
B	31.60%	73.50	13.80	12.70	31.60
C	13.80%	64.40	18.00	17.60	13.80
D and F	4.30%	63.10	15.70	21.20	4.30

A = The best grade; Grade F = Poorest grade; RMB = Renminbi (Chinese currency).

* $p > 0.05$, ** $p > 0.001$, two-sided test.

[†]Somer's d.

Table 2 Rates of overweight and obesity in the overall student sample and broken down by gender

Study city	Obesity reference	All students			Boys			Girls		
		N	Overweight (%)	Obese (%)	N	Overweight (%)	Obese (%)	N	Overweight (%)	Obese (%)
Total sample	WGOC	5032	13.7	13.6	2558	18.3	17.1	2474	9.1	9.9
	WHO		17.8	13.8		23.2	19.0		12.2	8.4
Beijing	WGOC	1061	12.8	15.7	529	17.4	18.7	532	8.3	12.8
	WHO		16.9	15.6		21.9	20.6		11.8	10.7
Guangzhou	WGOC	1039	11.6	12.9	534	15.0	15.2	505	8.1	10.5
	WHO		14.8	13.7		19.5	17.0		9.9	10.1
Hefei	WGOC	933	14.7	10.8	456	18.9	13.8	477	10.7	8.0
	WHO		20.0	10.4		26.8	14.9		13.6	6.1
Shanghai	WGOC	927	13.4	15.2	482	18.3	21.0	445	8.1	9.0
	WHO		17.7	15.2		22.4	22.8		12.6	7.0
Xi'an	WGOC	1072	16.1	13.1	557	21.7	16.7	515	10.1	9.1
	WHO		19.8	13.6		25.9	19.2		13.2	7.6

WGOC = Working Group on Obesity in China; WHO = World Health Organization child growth charts.

sample and by the cities included in the data collection. Boys were more likely to be overweight ($\chi^2 = 115.48$, $df = 1$, $p < 0.001$) and obese ($\chi^2 = 80.43$, $df = 1$, $p < 0.001$) than girls, and the patterns were similar across all five cities. The highest prevalence was observed in Beijing and Shanghai, two of the largest and most developed cities in China. Obesity rates based on the WHO Child Growth Standards are also presented. The rate for overweight was higher in the WHO reference than the WGOC reference, but the levels were similar for obesity. There was a significant inverse relationship for the total sample and by gender between the level of obesity and the students' class grade level in school ($p < 0.001$ for trend) (Table 3). The inverse trend with age was particularly striking, with a difference of more than 10 percentage points between students in the first grade (19.6%) and the sixth grade (6.8%).

Chinese primary students dedicated more time to academic-related work outside school hours, namely homework and remedial academic work, and this reached almost three hours on weekdays and more than four hours on weekend days (Table S1). The time they spent on screen viewing and outdoor activities was rather limited on

weekdays, at approximately one hour per day. On weekdays, boys spent more time on homework, screen viewing and sleep than girls. Girls spent more time on remedial academic work on both weekdays and weekend days than boys. Boys also spent more time on outdoor play on weekend days. Finally, children in higher grades spent more time on academic-related activities and less time on nonacademic-related activities and sleep, especially on weekdays (Table S2). Overall, there was a limited amount of discretionary time, approximately two to three hours per day, left for children to engage in other essential daily routine activities, such as travelling to and from school, eating meals, going to the toilet and washing (data not shown). A higher class grade level was significantly correlated with more time spent on homework and remedial academic work on weekdays and weekend days. Higher grades were also significantly correlated with less time spent on screen viewing and outdoor activities on weekend days and less sleep on weekdays.

In general, weekday afterschool EBRBs were associated more closely with obesity status as shown in Table 4. Weekday homework, screen viewing and outdoor activities were positively associated with obesity status, while

Table 3 Unadjusted correlations between school grade level and obesity status[†]

Grade level	All students (n = 5032)**			Boys (n = 2558)**			Girls (n = 2474)**		
	n	Overweight (%)	Obese (%)	n	Overweight (%)	Obese (%)	n	Overweight (%)	Obese (%)
1st (mean age = 7.3)	764	10.9	19.6	378	14.0	22.0	386	7.8	17.4
2nd (mean age = 8.1)	846	14.8	17.5	434	19.4	23.0	412	10.0	11.7
3rd (mean age = 9.1)	755	12.2	15.9	393	15.0	19.1	362	9.1	12.4
4th (mean age = 10.0)	932	15.8	14.5	501	22.6	18.6	431	7.9	9.7
5th (mean age = 10.9)	981	15.7	8.1	471	21.4	11.7	510	10.4	4.7
6th (mean age = 11.9)	754	11.9	6.8	381	15.0	8.1	373	8.8	5.4

* $p > 0.05$, ** $p > 0.001$, two-sided test.

[†]Somer's d.

Table 4 Means, standard deviations (SD) of out of school EBRBs and their correlations[†] with obesity status

Hours spent on	Normal weight		Overweight		Obese		Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Homework on weekdays*	1.87	0.96	1.93	1.04	1.94	1.18	1.88	1.01
Homework on weekend days	2.37	1.47	2.38	1.46	2.25	1.47	2.35	1.47
Screen viewing on weekdays**	0.82	0.85	0.84	0.84	1.00	1.07	0.84	0.88
Screen viewing on weekend days*	1.77	1.34	1.79	1.37	1.92	1.46	1.79	1.36
Remedial academic work on weekdays	0.97	1.31	0.92	1.24	0.92	1.30	0.96	1.30
Remedial academic work on weekend days**‡	2.27	2.01	2.12	2.00	1.88	1.76	2.19	1.98
Outdoor activities on weekdays**	1.02	1.03	1.09	1.03	1.23	1.36	1.06	1.08
Outdoor activities on weekend days	2.16	1.51	2.08	1.44	2.28	1.77	2.16	1.54
Sleeping on weekdays*‡	8.83	1.60	8.75	1.67	8.69	2.04	8.80	1.67
Sleeping on weekend days	9.61	1.90	9.48	2.05	9.53	2.18	9.58	1.96

EBRB = Energy balance-related behaviour.

* $p > 0.05$, ** $p > 0.001$, two-sided test.

†Spearman's correlation.

‡Inversely correlated.

weekend day remedial academic work and weekday sleep were inversely associated ($p < 0.05$). Finally, obesity status was positively correlated with time spent on homework on weekdays, screen viewing on weekdays and weekend days and outdoor activities on weekdays. It was also inversely correlated with time spent on remedial academic work on weekend days and sleep on weekdays.

After controlling for significant covariates, the BMI Z-score in the model that combined all the students was significantly and positively associated with hours of homework and screen viewing, inversely associated with hours of sleeping on weekdays and marginally and negatively associated with hours of outdoor activities on weekend days (Table 5). In the boys' model, the BMI Z-score was

significantly and positively associated with hours spent on homework and negatively associated with hours of sleep on weekdays and was not related to EBRBs on weekend days. In the girls' model, the BMI Z-score was significantly and positively associated with hours of screen viewing on weekdays and was significantly and negatively associated with hours of outdoor activities on weekend days. The results were similar when we performed the analysis with BMI as the outcome variable (result not shown).

DISCUSSION

Findings from this survey study revealed that levels of overweight (13.7%) and obesity (13.6%) in primary school

Table 5 Results from generalised estimation equations analysis on the relationships between the children's body mass index Z-score and energy balanced-related behaviours outside school

	All students* [†]			Boys ^{‡,§}			Girls ^{¶,**}		
	B	SE	p<	B	SE	p<	B	SE	p<
Hour spent on weekdays on									
Homework	0.07	0.02	0.004	0.09	0.03	0.002	0.01	0.03	ns
Screen viewing	0.07	0.03	0.03	0.04	0.04	ns	0.09	0.05	0.05
Remedial academic work	-0.03	0.02	ns	-0.04	0.03	ns	-0.01	0.03	ns
Outdoor activities	0.02	0.02	ns	0.05	0.03	ns	-0.001	0.03	ns
Sleeping	-0.03	0.02	0.05	-0.05	0.02	0.02	-0.003	0.02	ns
Hours spent on weekend days on									
Homework	0.005	0.02	ns	0.01	0.02	ns	-0.01	0.02	ns
Screen viewing	0.021	0.02	ns	-0.01	0.03	ns	0.03	0.03	ns
Remedial academic work	0.003	0.01	ns	0.02	0.02	ns	-0.002	0.02	ns
Outdoor activities	-0.030	0.02	0.06	0.00	0.02	ns	-0.06	0.02	0.004
Sleeping	-0.004	0.01	ns	0.00	0.02	ns	-0.01	0.02	ns

B = Regression coefficient; SE = Standard error; p = Level of significance; ns = Not significant.

*Weekday model and [†]weekend day model both adjusted for intercept, gender and grade level.‡Weekday model and [§]weekend day model both adjusted for intercept, grade level and physical education grade.¶Weekday model and ^{**}weekend day model both adjusted for intercept, grade level and father's education level.

students living in large metropolitan cities were alarmingly high, continuing a secular trend that has emerged since the 2000s in Chinese children (2,13). It is particularly worrying to see the gender disparity in obesity that emerged in this study, with the rate in boys nearly doubling and disproportional obesity at lower grade levels. Higher levels of parental education and family income were associated with higher levels of obesity in this sample of urban Chinese children, and this was consistent with studies conducted in the United States and other Western countries. The associations disappeared in the multivariate analysis, except for in the models for just girls, where the father's education remained a significant covariate. However, class grades and gender remained as significant covariates, suggesting the important role they play in understanding the obesity epidemic in Chinese students. Finally, there was evidence that time spent on academic-related activities, screen viewing, outdoor activities and sleep was closely associated with obesity and that this varied by gender between weekdays and weekend days.

The rate of obesity in our study sample was consistent with recent studies based on the Chinese WGO reference that used height and weight measured directly by trained research staff (2,13). The prevalence of childhood obesity in China has doubled over the past 10 years according to a report published by the National Health and Family Planning Commission of the People's Republic of China in 2014 (14). It is not a surprise that the prevalence of childhood obesity has approached those observed in the United States and other developed countries in less than two decades, in the light of the alarming temporal increase in rate of obesity since the 1980s (8,13). For instance, Ma et al. reported that the obesity rates were 0.10%, 0.30%, 0.23% and 0.23% in 1985–1995, 1995–2000, 2000–2005 and 2005–2010, respectively, using data from the Chinese National Survey on Students Constitution and Health (15).

While some studies, including our study, have showed that time for academic-related activity and screen viewing increased with age, while sleep duration decreased with age (8,16), other studies have reported that older children and adolescents were more physically active and spent less on screen viewing (7). A study of 2163 Chinese children aged nine years to 17 years from 11 cities measured daily physical activity and sedentary behaviour using accelerometry (17). As the children got older, they had higher levels of moderate and vigorous physical activity (MVPA) and sedentary behaviour. However, levels of MVPA and sedentary behaviour were not correlated with children's obesity status in the study sample. The same was also observed in a sample of Australian girls (18). These findings suggest that other EBRBs influenced the energy balance and obesity in children as well.

Concern has been raised about the faster increase in obesity in lower-level primary school students (grades 1–3) than upper-level students (grades 4–6) that have been found in studies of Chinese children (8,19), and these were also found in our study. A similar trend has also been reported in other developing countries in recent years (20). Although

there is no clear explanation for this secular trend of obesity, Yang and Huffman speculated that the introduction of formula feeding, increased consumption of foods with high protein levels and added sugar, reduced access to physical activities and poor maternal prenatal diets might have contributed to the higher prevalence of obesity among younger children in developing countries (21).

However, it is still unclear why the prevalence of obesity in boys in our study was nearly twice as high as the girls who took part. This gender disparity has also been reported by others studies of Chinese children (8,19). As nutritious foods are in plentiful supply and food insecurity is not an issue in Chinese urban cities (1,13), one plausible explanation is that boys consumed a more energy-dense diet than girls and that led to a positive energy balance. However, food consumption or eating unhealthy foods has not been associated with a particular gender and cannot explain the differences in obesity in Chinese children reported in the current literature (7). This means that we are left with the other parameter in the energy balance equation, namely the energy expenditure. Although we could not quantify which gender was more sedentary based on the reported EBRBs, there were clear differences in EBRBs between boys and girls that suggested that boys were more sedentary on weekdays. Furthermore, the stratified analyses showed differential associations of EBRBs with obesity: the boys' obesity was influenced by more time spent on homework and less sleep on weekdays while the girls' obesity was associated with more screen viewing on weekdays and less outdoor activity on weekend days. While the increased sedentary time and decreased sleep in boys can be explained by a displacement effect due to increase time spent on academic-related work on weekdays, girls have been reported to prefer sedentary activities (17,22).

Higher pressure for academic excellence from society, schools and parents has been linked to increased time spent on homework and lack of sleep and may contribute to the limited time spent on screen viewing by Chinese students, as suggested by cross-cultural studies (8). Chinese students spend more time on homework and other academic-related work outside school hours and less time on screen viewing and sleep, compared to students of the same age from Western countries. However, less is known about the differences in physical activity and diet between Chinese and Western students. Although academic pressure has been related to childhood obesity in some developing countries (23), it has not become the focus of studies in China. Our findings showed that academic-related activities outside school hours displaced time for physical activity and sleep in primary school students (24). This should serve as a warning to parents, schools, policy makers and ultimately the Chinese education system to re-examine and modify the current practices and expectations of children in primary schools (7). It should be noted that the amount of time spent on homework, screen viewing and sleep based on the parental reports in this study was similar to those reported in large national surveys in China (8,22).

Childhood obesity prevention in China has generally focused on promoting physical activity and healthy eating (25). Recently studies have identified that sedentary behaviours, such as watching TV and playing on computers, high level of life stress and lack of sleep were independently associated with obesity in Western children (5,26). Findings from our study suggest that sedentary behaviour from an excessive amount of time spent on academic-related work and inadequate sleep, in addition to a lack of physical activity and excessive screen viewing, may be responsible for increased obesity in Chinese children (7). An examination of childhood obesity intervention studies in China revealed that focusing interventions on physical activity and unhealthy diets, commonly regarded as two primary contributors to the current obesity epidemic, produced marginally effective outcomes, suggesting additional factors may also play roles (25). Therefore, all EBRBs need to be considered in order to prevent childhood obesity and interventions should specifically target the relevant EBRBs to be effective for different genders and age groups.

We found a positive association between obesity status and outdoor activity time on weekdays, but not on weekend days, in the study sample. Because of the ongoing school-based national Sunshine Activity campaign, which has encouraged Chinese children to play outside in the sunshine since 2007, we assessed the time spent on outdoor activities rather than on MVPA in this study. However, it is not appropriate to equate the outdoor activities reported in this study with MVPA. The three most commonly reported outdoor activities in this study were as follows: (i) exercises and sport activities involving moderate and vigorous intensity, such as jumping with ropes, soccer, swimming, jogging and exercise stations; (ii) games and play activities involving light and moderate intensity, such as hide-and-seek and playing in the park; and (iii) outdoor leisure activities involving light intensity, such as leisurely strolls with friends and walking the dog. High-intensity exercises and sports activities were less common in our cohort. When we examined these three reported activities in the study sample, we found that overweight and obese students engaged more frequently in light- and moderate-intensity activities and less frequently in higher-intensity exercises and sport activities than normal weight students on weekdays (data not shown). Therefore, the positive correlation between obesity and outdoor activities on weekdays could be due to the measurement method used. However, this cannot be directly examined in this study.

There were several limitations to the study. First, because this study used a cross-sectional design, the findings relating to relationships between responses and explanatory variables should not be interpreted as causal. Future studies should examine the findings further using longitudinal study designs. Second, all of the data, including height and weight, were self-reported and subject to bias in self-reports and inaccurate recalls. Although parental reports of children's health information is regularly used in population-based health studies, the use of such data tends to

overestimate weight and that lead to overestimation of obesity rates in children (27). Therefore, study findings based on parent-reported height and weight should be interpreted with caution. Similarly, parental reports of the time that their children spend on various activities outside school hours on weekdays and weekend days are also subject to recall errors. Nonetheless, the obesity rates and how the school-aged children in this study used their time were similar to studies based on directly measured height and weight or observational studies from the same period. Third, because the study data were not collected from a nationally representative sample and did not include children from small cities or rural regions, the findings should not be overgeneralised. Fourth, the use of the Chinese WGO cut-off reference for obesity tends to overestimate obesity for boys aged 6–16 and underestimate obesity for girls aged 3–18 and that may have exacerbated the gender disparity (28). Finally, the study only focused on EBRBs outside school hours and did not collect data on diet and physical activity at school. Future studies need to examine EBRBs that occur both inside and outside school, including diet, to establish a full picture of the relationships between obesity and EBRBs in children.

CONCLUSION

The rate of obesity was high in Chinese primary school children, especially among boys and children in lower grades, and there were differential associations between obesity status and EBRBs in Chinese boys and girls outside school hours. Accordingly, obesity prevention programmes that only focus on physical activity, screen viewing and diet may not produce expected outcomes without addressing excessive time spent on academic-related activity and inadequate sleep in Chinese children (25). The design of interventions should also take into account the differences between EBRBs on weekdays and weekend days (17). Finally, there is a need to conduct cross-cultural studies of obesity and EBRBs that can help us to understand the underlying causes of the gender differences and the increased rates of obesity in younger children. These will enable us to develop culturally relevant lifestyle interventions for different population groups in China.

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CONFLICT OF INTEREST

The authors have no conflict of interests to disclose.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Table S1. Means, standard deviations (SD) of non-school EBRBs for all students and comparison by gender.

Table S2. Means (M), standard deviations (SD) of after-school EBRBs by grade level.