Sleep and Obesity in Preschool Children

Fan Jiang, MD, PhD, Shankuan Zhu, PhD, Chonghuai Yan, MD, PhD, Xingming Jin, MD, Hari Bandla, MD, and Xiaoming Shen, MD, PhD

Objective To examine the relationship between sleep and obesity in children 3 to 4 years old in Shanghai, China.

Study design A total of 1311 Chinese children from 10 kindergarten classes in Shanghai, aged 3 to 4 years, who were participating in the kindergarten entrance health examination in 2000, were included in the study. Body weight and height were measured, and a questionnaire was given to the children's parents about sleep and physical and social characteristics of the children and their family. The main outcome measure was obesity, defined as body mass index (kg/m^2) ≥95th percentile for the children.

Results Compared with children reporting ≥11 hours of sleep per night, the odds ratio for childhood obesity was 4.76 (95% CI, 1.28-17.69) for children with <9 hours of sleep, and 3.42 (95% CI, 1.12-10.46) for children with 9.0 to 9.4 hours of sleep, after adjustment for age, sex, and other risk factors. Children with caregivers who slept less, who had mothers with higher education, or who co-slept with caregivers had less nighttime sleep than other children.

Conclusion Short sleep duration is positively associated with obesity in preschool children, and short nighttime sleep duration is significantly related to bedtime and co-sleeping with caregivers. *(J Pediatr 2009;154:814-8)*

There has been an increase in the prevalence of obesity in preschool children,[1] in both developing and developed countries.[2,3] Obesity related comorbidities have been associated with sleep disordered breathing, metabolic syndrome, and a pre-diabetic state.[4] In the treatment of obesity, much attention has focused on decreasing food intake and increasing physical activity, but these efforts are often only moderately effective on a short-term basis.[5] There is a need, therefore, to identify other approaches that might also affect the treatment and prevention of obesity.

The relationship between sleep duration and body mass index (BMI) in different age groups suggests one such alternative treatment approach.[6-12] A U-shaped relationship between sleep duration and BMI was observed in subjects with a mean age >50 years.[6,7] However, Gangswisch et al found that subjects 32 to 49 years old who slept <7 hours had a higher BMI than subjects who slept 7 hours, but sleeping >7 hours was not consistently associated with either an increased or decreased likelihood of obesity.[8] A study of young adults 27 years old found a linear trend toward lower BMI in those with longer sleep duration.[9] In school-age children, several studies have consistently reported that short sleep duration was an independent risk factor for obesity.[10-12] However, there are few studies on the relationship between short sleep duration and obesity in preschool children. We hypothesized that sleep duration <9 hours would be associated with increased risk of obesity in preschool children. Because many children in the age group 3 to 4 years old still nap routinely during the day and approximately 5% experience night-waking, we also evaluated other sleep variables. We also studied the effects of environmental factors, such as caregivers' sleep duration, bedtime, co-sleeping, and socioeconomic factors, on the amount of children's sleep, because this is not well documented.

METHODS

Subjects in this study participated in the Shanghai Preschool Children Sleep Study conducted in 2000. The study was designed to investigate the pattern of children's sleep in Shanghai, China. Five districts were selected from the 19 districts that encompass

BMI	Body mass index	OR	Odds ratio

From the Department of Child Development and Behavior, Shanghai Children's Medical Center, affiliated with Shanghai Jiao Tong University School of Medicine, Shanghai, China (F.J., X.J.); Injury Research Center, Medical College of Wisconsin, Milwaukee, WI, and Zhejiang University School of Medicine, Zhejiang, China (S.Z.); Shanghai Institute for Pediatric Research, Xinhua Hospital affiliated with Shanghai Jiaotong University School of Medicine, Shanghai, China (C.Y., X.S.); and Department of Pediatrics, University of Nebraska Medical Center, Omaha, NE (H.B.).

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Reprint requests: Xiaoming Shen, MD, PhD, Shanghai Institute for Pediatric Research, Xinhua Hospital, Shanghai Jiaotong University School of Medicine, 1665 Kongjiang Rd, Shanghai, 200092 China. E-mail: xmshen@online.sh.cn.

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Shanghai, including 3 urban districts (central urban district of Jing'an, commercial district of Xuhui, and industrial district of Yangpu) and 2 non-urban districts (suburban district of Jiading and rural island of Chongming). Two kindergarten classes were chosen randomly from each district, yielding a total of 10 kindergarten classes designated as key sites in the study. A total of 1386 children between the ages of 3 and 4 years from these 10 kindergarten classes were enrolled when their parents brought them for a kindergarten entrance medical check-up. This study was approved by the institutional review board of Shanghai Children's Medical Center.

Consent was signed by parents at the medical check-up, and they filled out a questionnaire about their children's sleep patterns, general characteristics of their children, and family demographics. Parents were asked about their children's sleep during a "typical" recent week. Information collected included children's bedtime and nighttime sleep end time, daytime nap duration (6 groups from 0 to ≥3 hours), night awakenings (yes/no; with the definition being >2 night-waking episodes per night associated with calling parents back, ≥4 nights a week), bedtime in evening (≤8 pm, 8-10 pm, and ≥10 pm). Nighttime sleep duration (grouped as <9 hours, 9.0 to approximately 9.4 hours, 9.5 to approximately 9.9 hours, 10 to approximately 10.4 hours, 10.5 to approximately 10.9 hours, and ≥11 hours), was calculated as nighttime sleep end time minus bedtime.

Information for each child included sex, birth weight (</≥4000 g), exclusive breastfeeding in first 4 months (yes/no), appetite (>/≤peers), and physical activity (</≥peers). Information on family characteristics included residence geography, parent's education level (</≥high-school), household income (≥/<3000 yuan/month), age of mother at delivery (≥/<30 years), caregivers' nighttime sleep (</≥8 hours, calculated in the same manner as that in children), caregivers' bedtime(</≥23:00), and co-sleeping (yes/no, with definition being caregiver and children regularly sharing a bed all night, ≥5 days/week).

Psychometric properties of the questionnaire were examined; internal consistency (Cronbach alpha 0.78) and test-retest reliability (correlation coefficients were 0.85-0.91) were acceptable.

Heights and weights were measured by trained health workers: height to nearest 0.1 cm with stadiometer, and weight to nearest 0.1 kg (stadiometer and weight scale; Hisun, China). The stadiometer and scale were both checked for accuracy by health workers before measurement. Obesity was defined as BMI (weight in kg/height in m^2) ≥95th percentile. The reference standards of the 95th percentiles for BMI in the study were from the Third National Growth Survey in children <7 years old in 9 cities of China, which was performed in 1995.[13]

Continuous variables were expressed as means and SDs, and categorical variables were expressed as percent of total. All statistical analyses used SPSS statistical software package for Windows version 11.0.1 (SPSS Inc, Chicago, Illinois). Significance was defined as a P value <.05 (2 tails).

In the first stage, the strength of the relationship between potential risk factors and obesity was evaluated with logistic regression analysis. To control for potential risk factors for obesity, we evaluated short sleeping hours after adjustment of risk factors, which were independently significant ($P < .10$). Model 1 is adjusted for the children's age, sex, appetite, birth weight, and mother's age at delivery. Model 2 is additionally adjusted for socioeconomic factors: parental and maternal education, geographical area, household income. In the second stage of analysis, to identify factors that affect children's nighttime sleep duration, we used a multivariable regression with children's nighttime sleep duration (continuous variable) as the dependent variable, and independent factors in the model included 3 continuous variables (children's age, caregiver's sleep duration, and parental age) and 7 categorical variables (sex, caregiver's bedtime, co-sleeping, educational level of parents, family income, and geographic area).

RESULTS

There were no refusals to participate. Children not brought by parents or chief caregivers were not enrolled. Reasons for exclusion included birth gestation <37 weeks or ≥42 weeks (n = 73) and missing anthropometric data (n = 2). A total of 1311 subjects were included (659 boys, 652 girls).

The mean age was 3.77 ± 0.51 years for boys and 3.75 ± 0.52 years for girls. The prevalence of obesity was 10.3% in boys and 6.9% in girls ($\chi^2 = 4.854$, $P < .02$). Potential correlates of children's nighttime sleep duration, including sex, age, birth weight, appetite, geographical area, parental education level, household income, and mother's age at delivery, were significantly associated with childhood obesity (Table I).

In all logistic regression models, both before and after inclusion of potential confounding factors, obesity was related to short sleep time (Table II). Children who slept <9 hours or 9.0 to approximately 9.4 hours per night were more likely to be obese than children who slept ≥11 hours. (odds ratio [OR], 4.76; 95% CI, 1.28-17.69; $P < .05$; OR, 3.42; 95% CI, 1.12-10.46; $P < .05$) after adjusting for confounders. Of the potential confounders aforementioned, these were risk factors for obesity: appetite greater than peers (OR, 6.06; 95% CI, 3.82-9.61; $P < .001$), urban living (OR, 1.81; 95% CI, 1.11-2.96; $P < .05$), birth weight ≥4000 g (OR, 2.23; 95% CI, 1.23-4.05; $P < .01$), father's education level greater than high-school graduate (OR, 0.41; 95% CI, 0.20-0.81; $P < .05$), household income ≥3000 yuan/month (OR, 1.63; 95% CI, 1.02-2.60; $P < .05$), and mother's age at delivery ≥30 years (OR, 1.72; 95% CI, 1.02-2.90; $P < .05$).

The caregiver and the child's nighttime sleep duration were positively related (Table III). Bedtime of the caregiver and education level of the mother were negatively associated with the child's nighttime sleep duration. Children who co-slept with parents had less sleep. Living area, age of parent, education level of father, family income, and the child's age and sex did not relate to children's nighttime sleep duration (all $P > .05$).

Table I. Relationship between potential risk factors and obesity in children 3 to 4 years old

Potential risk factors	Prevalence of childhood obesity (n = 1311)	Univariable odds ratio (95% CI)	*P* value
Sleep patterns of children			
Nighttime sleep duration (hours)			.017
<9	14.55 (8/55)	5.32 (1.53-18.50)	
9~9.4	11.74 (31/264)	4.16 (1.44-12.05)	
9.5~9.9	6.19 (14/226)	2.06 (0.67-6.41)	
10~10.4	9.11 (48/527)	3.31 (1.11-8.85)	
10.5~10.9	7.27 (8/110)	2.45 (0.72-8.37)	
≥11	3.10 (4/129)	1.00	
Bedtime in the evening			
≤8 pm	5.66 (12/212)	1.00	.200
Between 8 and 10 pm	9.02 (80/885)	1.66 (0.87-3.10)	
≥10:00	9.81 (21/214)	1.81 (0.87-3.79)	
Night-wakings			
Yes	5.78 (7/121)	1.00	.220
No	8.91 (106/1190)	0.63 (0.29-1.38)	
Daytime nap duration (hours)			
≤1	4.62 (8/173)	1.00	.595
1.5	6.36 (11/173)	0.84 (0.40-1.79)	
2	9.50 (66/695)	1.30 (0.78-2.17)	
2.5	8.05 (7/87)	1.08 (0.44-2.64)	
≥3	10.67 (8/75)	1.48 (0.63-3.49)	
Missing	12.04 (13/108)	—	
Children's characteristics			
Age, continuous, (1 month units)	8.6 (113/1311)	0.29 (0.18-0.46)	<.001
Sex			.027
Boys	10.32 (68/659)	1.00	
Girls	6.90 (45/652)	0.64 (0.44-0.96)	
Birth weight (g)			
<4000	7.88 (94/1193)	1.00	.006
≥4000	16.10 (19/118)	2.24 (1.31-3.81)	
Missing	0 (0/4)	—	
Exclusive breast feeding in the first 4 months			.763
Yes	8.81 (72/851)	1.00	
No	8.95 (41/458)	1.06 (0.71-1.59)	
Missing	0 (0/2)	—	
Appetite			<.001
More than peers	16.32 (79/484)	4.55 (2.99-6.92)	
The same as or less than peers	4.11 (34/827)	1.00	
Physical activity			.674
Less than peers	7.22 (7/97)	0.85 (0.38-1.88)	
Same as or more than peers	8.42 (93/1104)	1.00	
Missing	11.82 (13/110)	—	
Family information			
Geographical area			.001
Urban	10.96 (75/684)	1.91 (1.27-2.87)	
Rural	6.06 (38/627)	1.00	
Father's education level			.003
<high-school graduate	4.96 (17/343)	1.00	
≥high-school graduate	9.85 (95/964)	2.10 (1.23-3.57)	
Missing	25 (1/4)	—	
Mother's education level			
<high-school graduate	6.57 (26/396)	1.00	.068
≥high-school graduate	9.58 (87/908)	1.51 (0.96-2.38)	
Missing	0 (0/7)	—	

Table I. Continued

Potential risk factors	Prevalence of childhood obesity (n = 1311)	Univariable odds ratio (95% CI)	*P* value
Household income (yuan/month)			
<3000	6.73 (66/981)	1.00	<.001
≥3000	14.19 (45/317)	2.29 (1.53-3.43)	
Missing	15.38 (2/13)	—	
Age of mother at delivery (years)			
<30	7.87 (83/1055)	1.00	.055
≥30	11.76 (30/255)	1.56 (1.00-2.43)	
Missing	0 (0/1)	—	
Bedtime of caregiver			
<23:00	8.29 (94/1134)	1.00	.332
≥23:00	10.53 (18/171)	1.30 (0.77-2.22)	
Missing	16.7 (1/6)	—	
Night time sleep duration of caregiver			
<8 hours	6.23 (27/289)	1.13 (0.72-1.77)	.608
≥8 hours	8.38 (85/1014)	1.00	
Missing	12.5 (1/8)	—	
Co-sleeping			
Yes	8.23 (74/899)	0.86 (0.57-1.29)	.452
No	9.49 (39/411)	1.00	
Missing	0 (0/1)	—	

Values are percentages (numbers) unless stated otherwise.

Table II. Cross-sectional logistic regression analyses for children 3 to 4 years old

Average nighttime sleep (hours)	Model 1* obese versus non-obese (n = 1306)	Model 2† obese versus non-obese (n = 1284)
<9	5.12 (1.40-18.71)	4.76 (1.28-17.69)
9	3.94 (1.31-11.90)	3.42 (1.12-10.46)
9.5	1.92 (0.59-6.19)	1.78 (0.55-5.82)
10	2.96 (1.01-8.67)	2.70 (0.92-7.97)
10.5	1.89 (0.53-6.82)	1.70 (0.47-6.24)
≥11	1.00	1.00

Data are presented as OR (95% CI).
*In model 1, nighttime sleep duration is adjusted for age, sex, appetite, birth weight, and mother's age at delivery.
†In model 2, nighttime sleep duration is additionally adjusted for socioeconomic factors such as parental and maternal education, geographical area, and household income.

Table III. ß coefficients from multivariate regression model for nighttime sleep duration in children aged 3 to 4 years (n = 1271)

	β	SE	*P* value
Night time sleep duration of caregiver	0.131	0.022	<.001
Bedtime of caregiver	−0.154	0.026	<.001
Cosleeping	−0.073	0.041	.008
Highest education level of mother	−0.122	0.027	.001

Geographic area, age of parent, education level of father, family income, and children's age and sex were also included in the model, but were not significant.

DISCUSSION

In this study, obesity was associated with shorter nighttime sleep in preschool children. The caregivers'sleep schedules and the practice of co-sleeping were closely related to sleep duration. As in earlier studies,[14-17] good appetite and heavier birth weight were risk factors for obesity in preschool children. In addition, higher education level of the father, higher household income, and urban living were risk factors of obesity in our study.

Compared with studies in adults, there are fewer studies in children, especially in younger children. Three studies from France, Germany, and Canada showed a dose-dependent decrease in obesity prevalence by duration of sleep in children ages 5, 5 to 6, and 5 to 10 years, respectively.[10-12] Only one recent study showed that daily sleep duration <12 hours in infancy was a risk factor for overweight and adiposity in 3-year-old children, but the children in the study were from families with high education and income levels, and the results may not be generalizable to socioeconomically disadvantaged populations.[18] Our study did not show a negative linear trend in the prevalence of obesity by duration of sleep. Rather, only the children sleeping <9.5 hours were more likely to be obese. Sleep curtailment has been associated with reduced levels of the adipocyte-derived hormone, leptin, and increased levels of the stomach-derived hormone, ghrelin. Both changes are associated with increased hunger sensation and could be a physiological mechanism for sleep-obesity relationships.[7,19]

Daytime sleep is very common in preschool children in China. However, there was no association between daytime sleep and obesity in this study.

Decreased sleep time has become common in children and adults.[20,21] Contrary to the findings in adolescents, in which there was no correlation between parents and adolescents in sleep schedules and sleep-wake patterns,[22] our study found that preschool children whose caregivers slept later or less also had shorter sleep duration. In adolescents, sleep-wake patterns are more likely affected by extra-familial social demands and mood status.[22] However, in early life, parental life styles and attitudes likely have direct influence on children's sleep patterns.[21] The prevalence of co-sleeping in China was much higher than reported in other countries, which might explain the close relationship between caregivers' and children's sleep patterns. Children whose mothers had higher education levels slept less. Evening educational/social demands on the parents might result in later parental bedtimes and directly influence sleep patterns of children. From these findings, we suggest that, in addition to limiting food intake and increasing physical activity, helping children to establish good sleep habits may be helpful in the prevention of childhood obesity.

Many factors may be associated with childhood obesity. As in many other studies, good appetite and higher birth weight were risk factors for obesity in our study.[14-16] Children in urban areas or with fathers of high education and high income levels were more likely to be obese. In China, children in urban areas or in families with high income levels have more access to food of animal origin, western-style foods, dairy products, and other energy-dense food than do rural, lower-income families.[23] There may also be differences in physical activity.

There were important potential limitations to this study. Sleep duration was based on parental report, which may have caused bias because parents may have reported when they placed the child in bed, rather than when the child fell asleep; thus the sleep time may have been overestimated. However, a close relationship between actigraph measures and parent reported sleep in children 1 to 5 years old has been reported.[21] Parental, especially maternal obesity, a known risk factor for children's obesity, was not evaluated. Birth weight could partly reflect maternal body weight, but a mother's obesity may affect her child's obesity through extra-intrauterine influences.[15] Questions about physical activity with peers may not accurately reflect time spent playing outdoors. This may explain why our data do not confirm a negative relationship between physical activity and obesity. We suggest that increasing parental awareness of the importance of sleep and helping parents to establish an appropriate sleep schedule for young children may be useful in the prevention of childhood obesity.

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