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Original Article

Sleep Duration and Overweight among Elementary Schoolchildren: A Population-based Study in Japan

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Although a number of studies have investigated the relationship of sleep duration to overweight and obesity, studies conducted among population-based elementary schoolchildren have been limited in Japan. The aim of the present study was to investigate the relationship between sleep duration and overweight among elementary schoolchildren in Japan. The study subjects were all fourth-grade schoolchildren (9 or 10 years of age) in Ina-town, Saitama Prefecture, Japan from 1999 to 2008. Information concerning each subject's sex, age, and lifestyle was obtained using a self-administered questionnaire, while measurements of his or her height and weight were carried out. Childhood overweight was determined according to the definition established by the International Obesity Task Force. Data from 3,433 children were analyzed. In logistic regression analysis, a statistically significant dose-response relationship was observed between sleep duration and overweight among boys (p for trend = 0.014) but not among girls (p for trend = 0.149). Short sleep duration was associated with childhood overweight, and the sex difference in the association was observed. These findings suggested that it is important to consider sleep duration as part of any program to prevent overweight among elementary schoolchildren, especially among boys.

Key words: sleep, overweight, schoolchildren, Japan

The prevalence of childhood overweight has increased in most parts of the world [1, 2]. Childhood obesity can lead to a number of additional problems, including poor glucose tolerance and a higher risk of type 2 diabetes, hypertension, social exclusion, and depression [2]. Moreover, adiposity in childhood influences adult mortality and morbidity [3]; in particular, risk of cardiovascular disease and mortality from all causes is elevated in those who

were overweight during childhood [4]. Therefore, preventing children from becoming overweight or obese is very important from a public health standpoint.

Childhood obesity has been reported to be associated with genetic factors [5-7], socio-demographic factors [7, 8], and lifestyle factors such as physical activity levels [9, 10] and diet [11, 12]. Concerning lifestyle factors, evidence has steadily grown over the past decade that supports the role of short sleep duration as a novel risk factor for weight gain and obesity [13]. Some studies showed the association between sleep duration and overweight among adolescents [12,

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14], while other studies reported the relationship between sleep and obesity among preschool children [15, 16]. However, studies conducted among population-based elementary schoolchildren have been limited in Japan. Accordingly, the aim of the present study was to investigate the relationship between sleep duration and overweight among elementary schoolchildren in Japan.

Materials and Methods

The town of Ina, which is located in Saitama Prefecture, Japan, has conducted a unique health-promotion program since 1994, in addition to the annual national health checkups performed in accordance with the School Health Law of Japan. The program consists of the administration of a questionnaire survey, and blood and physical examinations for fourth and seventh graders. Several studies about this program have been reported [17–23]. The present study was conducted as part of the program.

Study subjects. The subjects of this study were all fourth-grade schoolchildren (9 or 10 years of age) from Ina during 1999–2008. Informed consent prior to participation in the study was obtained from the parent or guardian of each child. This study protocol was approved by the Medical Ethics Committee of Showa University School of Medicine.

Questionnaire survey. The following information was collected using a self-administered questionnaire completed by each child: sex, age, exercise other than physical education class (daily, sometimes, none), and snack after dinner (always, often, little, none). The parent or guardian of each subject was asked to complete a self-administered questionnaire regarding their child's birth weight, wake-up time, and bedtime, as well as family information (whether the child was an only child, and parents' height and weight). Wake-up time and bedtime were obtained from the questions "What time does your child get up in the morning?" and "What time does your child go to bed?" respectively. Sleep duration was calculated from the wake-up time and bedtime.

Anthropometric measurements. The height and weight of each subject were measured in the school's infirmary or in a designated room to protect subjects' privacy during the procedures. For the anthropometric measurements, the subjects wore light

clothing but no shoes or socks. Height was measured to the nearest 0.1 cm using a stadiometer and body weight was measured to the nearest 0.1 kg using a scale. Body mass index (BMI) was calculated as weight (kg) divided by height (m) squared. These measurements were recorded annually from 1999 to 2008.

Definition of overweight. Childhood overweight (including obesity) was determined according to the age- and sex-specific cut-off points proposed by the International Obesity Task Force [24]. Overweight (including obesity) in parents was defined as a BMI equal to or more than 25 kg/m², according to the World Health Organization criteria [25].

Data analysis. In the analysis, wake-up time, bedtime, and sleep duration (hours) were used as categorical variables including before 6:30, 6:30–6:59, and 7:00 or later; before 22:00, 22:00–22:59, and 23:00 or later; and 10.0+, 9.0–9.9, 8.0–8.9, and < 8.0, respectively.

To compare various characteristics between the overweight and non-overweight groups of children, the Chi-squared or the Wilcoxon rank-sum test was used separately according to sex. To evaluate the relationship between sleep duration and overweight, a logistic regression analysis was performed separately according to sex, and we calculated the odds ratio (OR) and the 95% confidence interval (95% CI). We first estimated crude OR and then adjusted for potential confounders. Variables that have been reported to be related to overweight [7, 8, 12, 15, 26] were considered as potential confounders. Wake-up time and bedtime were not entered into the logistic regression model because sleep duration was not independent of the two variables. Snack after dinner and exercise were not used as confounders because these variables could be intermediate variables in the relationship between sleep duration and overweight. A *p* value of less than 0.05 was considered statistically significant. All statistical analyses were performed using Statistical Analysis System (SAS, version 9.2).

Results

Among 3,640 subjects, 22 refused to participate in the program (participation rate: 99.4%) and 185 were excluded because of incomplete data. Thus, data from a total of 3,433 subjects were analyzed.

The characteristics of the overweight and non-overweight study participants (boys) are shown in Table 1. The proportion of being an only child was significantly higher in the overweight group. Boys with one or both parents being overweight were more frequently found in the overweight group. Statistically significant differences between the overweight and non-overweight groups were observed in birth weight and exercise.

The characteristics of the overweight and non-overweight study participants (girls) are shown in

Table 2. Girls with one or both parents being overweight were more frequently found in the overweight group. Statistically significant differences between the overweight and non-overweight groups were observed in birth weight and snack after dinner. The proportion of being an only child in the overweight group was higher than that in the non-overweight group, although statistical significance was not observed.

Next, the crude and adjusted ORs of sleep duration for overweight were calculated among each sex (Table 3). When compared to children with 10 or

Table 1 Characteristics of study participants (boys) according to overweight or not

Characteristics	Non-overweight (n = 1,438)	Overweight (n = 333)	P value ^a
Age (years)	9.0 (9.39)	9.0 (9.38)	0.768
Birth weight (g)			
<2,500	9.8	7.5	0.023
2,500–3,999	88.7	88.9	
4,000+	1.5	3.6	
Only child (%)	8.8	15.0	<0.001
Parent's overweight (%)			
Both	2.2	9.3	<0.001
Either	24.3	41.1	
None	73.5	49.6	
Exercise (%)			
Daily	62.9	52.5	0.002
Sometimes	23.9	31.1	
None	13.2	16.5	
Snack after dinner (%)			
Always or Often	51.8	51.7	0.966
Seldom or None	48.2	48.3	
Wake-up time (%)			
Before 6 : 30	36.1	37.8	0.561
6 : 30–6 : 59	27.8	29.1	
7 : 00 or later	36.2	33.0	
Bedtime (%)			
Before 22 : 00	62.1	58.6	0.356
22 : 00–22 : 59	33.6	35.7	
23 : 00 or later	4.3	5.7	
Sleep duration (hours) (%)			
10.0+	16.8	11.7	0.087
9.0–9.9	61.2	62.5	
8.0–8.9	19.8	22.8	
<8.0	2.2	3.0	

Except where indicated percentage (%), values are median (mean).

^aChi-squared test or Wilcoxon rank-sum test.

Table 2 Characteristics of study participants (girls) according to overweight or not

Characteristics	Non-overweight (n = 1,431)	Overweight (n = 231)	P value ^a
Age (years)	9.0 (9.39)	9.0 (9.37)	0.667
Birth weight (g)			
< 2,500	10.8	8.2	0.005
2,500–3,999	88.4	88.7	
4,000+	0.8	3.0	
Only child (%)	9.2	13.0	0.073
Parent's overweight (%)			
Both	2.5	11.3	<0.001
Either	26.2	35.5	
None	71.4	53.3	
Exercise (%)			
Daily	39.8	33.6	0.055
Sometimes	32.8	31.4	
None	27.4	35.0	
Snack after dinner (%)			
Always or Often	48.7	56.1	0.036
Seldom or None	51.3	43.9	
Wake-up time (%)			
Before 6 : 30	36.1	39.0	0.670
6 : 30–6 : 59	30.5	29.9	
7 : 00 or later	33.5	31.2	
Bedtime (%)			
Before 22 : 00	57.9	54.6	0.529
22 : 00–22 : 59	38.0	40.3	
23 : 00 or later	4.1	5.2	
Sleep duration (hours) (%)			
10.0+	13.8	13.9	0.090
9.0–9.9	61.1	53.7	
8.0–8.9	22.7	28.6	
< 8.0	2.4	3.9	

Except where indicated percentage (%), values are median (mean).

^aChi-squared test or Wilcoxon rank-sum test.

more hours of sleep per night, significantly increased ORs among boys were observed for those with 9.0–9.9h of sleep (adjusted OR: 1.50, 95% CI: 1.02–2.19), 8.0–8.9h of sleep (1.65, 1.07–2.55), and less than 8h of sleep (2.38, 1.05–5.37). On the other hand, statistically significant ORs were not found among those in the model using girls with 10 or more hours of sleep as a reference. Regarding the association between sleep duration and overweight, a significant dose-response relationship was observed among boys (p for trend = 0.014) but not among girls (p for trend = 0.149).

Discussion

In the present study, some baseline characteristics were significantly different between the non-overweight and overweight groups. For example, children with one or both parents being overweight were more frequently found in the overweight group. Previous study showed that most important variables associated with childhood obesity are family variables, and

Table 3 Crude and adjusted odds ratios of sleep duration for overweight by sex

	Total n	Overweight n (%)	Crude		Adjusted ^a	
			OR	95% CI	OR	95% CI
Among boys (n = 1,771)						
Sleep duration (hours)						
10.0+	281	39 (13.9)	1.00		1.00	
9.0–9.9	1,088	208 (19.1)	1.47	1.01–2.12	1.50	1.02–2.19
8.0–8.9	361	76 (21.1)	1.66	1.09–2.52	1.65	1.07–2.55
<8.0	41	10 (24.4)	2.00	0.91–4.41	2.38	1.05–5.37
			<i>P</i> for trend = 0.016		<i>P</i> for trend = 0.014	
Among girls (n = 1,662)						
Sleep duration (hours)						
10.0+	230	32 (13.9)	1.00		1.00	
9.0–9.9	998	124 (12.4)	0.88	0.58–1.33	0.83	0.54–1.27
8.0–8.9	391	66 (16.9)	1.26	0.80–1.99	1.14	0.71–1.81
<8.0	43	9 (20.9)	1.64	0.72–3.73	1.52	0.65–3.53
			<i>P</i> for trend = 0.064		<i>P</i> for trend = 0.149	

OR, odds ratio; CI, confidence interval.

^aAdjusted for age, birth weight, only child, parental overweight.

parental obesity is probably the most important of the family variables [27]. In fact, a number of studies have shown the relationship between parental overweight and childhood overweight or obesity [6, 7, 12, 16, 26]. Our study results were consistent with these previous results. In addition, the status of being an only child was more frequently observed in the overweight group. Being an only child was also reported to be a risk factor for overweight in an earlier study [28].

The basic cause of obesity is an imbalance between energy intake and energy expenditure [29], and physical activity, which is a component of the energy expenditure in the energy balance, could be associated with overweight in our study, as children who don't exercise other than physical education class were more frequently found in the overweight group. Several studies have shown the relationship between physical activity and overweight [9, 10, 12, 30]. For instance, physical inactivity was reported to be associated with childhood overweight/obesity [30], while physical activity levels were shown to be lower in overweight and obese boys and girls than normal-weight youth [10]. Accordingly, our study results were not inconsistent with other study results.

In the present study, fewer hours of sleep brought about a higher OR for overweight, and the dose-

response relationship was statistically significant, as shown in Table 3. Furthermore, the relationship remained even after adjustment for potential confounders including age, parental overweight, only child status, and birth weight. Previous studies have reported the association between sleep duration and overweight or obesity [7, 14, 31], which was consistent with our study results. The reason for the association between sleep duration and overweight could be the reduction of energy expenditure due to sleep deprivation. Past study showed that sleep deprivation leads to a feeling of fatigue [32]. This tiredness may lead to reductions in physical activity [13] and reduced energy expenditure, resulting in overweight. In fact, shorter sleep duration was associated with lower physical activity level in the present study; the proportions of no exercise were 19.5%, 15.4%, 13.4%, and 12.5% among boys with less than 8.0, 8.0–8.9, 9.0–9.9, and 10.0 or more hours of sleep, respectively.

In this study, wake-up time or bedtime was not significantly associated with overweight. The results persisted even if the analysis was conducted among members of the shorter sleep duration (less than 9 h) group or among members of the longer sleep duration group (9 or more hours), which were determined by the median of the sleep duration in this study (9 h).

These study results suggested that wake-up time or bedtime itself has no substantial impact on childhood overweight. Although further studies will be needed to validate the relationship between overweight and wake-up time or bedtime among schoolchildren, it could be important to consider both wake-up time and bedtime for the prevention of childhood overweight, because shorter sleep duration was related to earlier wake-up time and later bedtime in the present study; the medians of wake-up time were 6:00, 6:30, 6:30, and 7:00 among children with less than 8.0, 8.0–8.9, 9.0–9.9, and 10.0 or more hours of sleep, while those of bedtime were 23:00, 22:00, 21:00, and 21:00 among children with less than 8.0, 8.0–8.9, 9.0–9.9, and 10.0 or more hours of sleep, respectively.

The impact of sleep duration on overweight varied by sex in this study; short sleep duration was significantly associated with overweight among boys, whereas no significant association between sleep duration and overweight was observed among girls. Among boys, the proportion of overweight was lowest in the group with 10 or more hours of sleep, while it was lowest in the group with 9.0–9.9h of sleep among girls. These results suggested that “10 or more hours of sleep” or “9.0–9.9h of sleep” might be the appropriate time for the decrease of the risk of overweight among fourth-grade (aged 9 or 10 years) boys or girls, respectively, although further studies are needed to elucidate the biological mechanisms that explain the sex difference between sleep duration and overweight and to examine the appropriate sleep duration for the prevention of overweight in another population.

One limitation of this study was that the information on sleeping habits was based on a self-administered questionnaire completed by the parent or guardian of each subject rather than actigraphy or polysomnography, which is the gold standard for documenting sleep, although the expense and burden of this testing method limits its utility for epidemiologic studies [33]. Therefore, the sleep duration in this study might be longer than actual sleep duration assessed by polysomnography, because parents could report times for getting out of bed and going to bed, rather than actual times for waking and going to sleep. However, even if this propensity occurred, the misclassification of sleep duration is considered non-differential, since sleep duration calculated by reported wake-up time and bedtime could be uniformly overes-

timated in both the overweight and the non-overweight groups. Accordingly, the observed association in this study could be weaker than what might truly be present, but the validity of the study result was not affected.

A second limitation is that the possibility of residual confounding is not deniable in this study, although the effect of potential confounders was considered in multivariate analysis. For example, our study results might have been affected by energy intake, which we did not measure in this study. In addition, socio-economic status, which has been reported as a risk factor for obesity [34, 35], was not evaluated in the present study, because this item was not included in the questionnaire. However, several studies have adjusted for socio-economic status in multivariate analysis and have found that the sleep-obesity association persists [7, 15, 30]. Moreover, total hours or minutes of nap was not considered in this study. However, a previous study reported that total hours of naps was not related to obesity [16]. Finally, the present study could not determine the causal relationship between sleep and overweight, since this is a cross-sectional study. Therefore, the possibility of reverse causality cannot be denied. To confirm the causality, longitudinal studies are required in the future.

In conclusion, sleep duration was associated with overweight in elementary schoolchildren, and a sex difference was observed with the association. The results of the present study suggested that it is important to consider sleep duration as part of any program aimed at preventing overweight among elementary schoolchildren, especially among boys.

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