Impact of total sleep duration on blood pressure in preschool children

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ABSTRACT

The onset of some adult diseases, *e.g.*, cardiovascular disease, is known to be associated with lifestyles in childhood. The objective of this study was to clarify the relationship between total sleep duration (TSD) and systolic and diastolic blood pressure (SBP and DBP) among 117 children at ages 5–6 years. Parents reported their children's typical bedtimes and wake times for weekdays, and questions about mandatory nap times were answered by the preschool teachers. In the children, the mean TSD, SBP, and DBP were 624 ± 57 (standard deviation) min, 99 ± 10 mmHg, and 62 ± 9 mmHg, respectively. When the children were divided into quartile groups based on TSD, the SBP was significantly higher in the highest group (TSD > 660 min) than in the lowest group (TSD $\leq$ 585 min). The TSD was significantly correlated with SBP ($r = 0.265$) but not with DBP ($r = 0.105$), these relationships were similar when TSD and possible confounders such as age and body mass index were set as independent variables of multiple regression analysis. These findings suggest that sleep duration in preschool children is associated with SBP, and extremely short or long sleep may invite subclinical health problems.

Extremely long or short sleep is known to be associated with several sleep and health problems in the general population (10, 15). However, whether such an association is applicable to children remains unclear. Especially, little evidence has been established concerning the effect of sleep duration on cardiovascular disease (CVD) in children, though various factors disturbing children's nocturnal sleep—video game-playing and television-viewing habits and parental employment—exist in developed countries, and sleep habits are associated with motor handicap or mental impairment (1, 6, 16, 17, 19, 20). The onset of some adult diseases such as hypertension and CVD has been reported to be linked with lifestyles in childhood (11, 13). For the prevention of the on-

set of CVD during youth, it is therefore crucial to examine cardiovascular effect of lifestyle-related sleep behaviors in childhood.

Only an association between shortening of nocturnal sleep and low systolic blood pressure (SBP) has been suggested in preschool children (21). Nevertheless, a new question could be raised as to the difference of effects between nocturnal sleep duration and total sleep duration among such children, inasmuch as daytime naps may compensate for any sleep insufficiency on the previous night. Also, since school-age children rarely take daytime naps (7, 23), it is questionable whether nursery school children really need obligatory nap times. In this research, a cross-sectional study was carried out to clarify the relationship between total sleep duration and blood pressure among preschool children.

MATERIALS AND METHODS

The nature of the procedures used in this study was explained to parents at four nursery schools and two

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kindergartens in Akita, northern Japan; and, their preschool children, who did not have past or present histories of serious illness such as heart, kidney, neurological or metabolic disease, were invited to participate in the study. Initially, 134 preschool children took part in this study (21), but 17 children were excluded because we could not confirm whether they did actually sleep during the mandatory nap time. In total, 79 kindergarteners and 38 nursery school children were enrolled. According to information from the preschool teachers and parents, there were no children suffering from any obvious disease such as obstructive sleep apnea syndrome or upper airway resistance syndrome, and it took 15 min or less to go to preschool by automobile or on foot. The study was performed with the written informed consent of the parents and approval of the ethical review committee at the Akita University School of Medicine, between June and July 2005. Nursery schools in Akita have mandatory nap times of about 90 min (range, 60 to 105 min) in the afternoon, but kindergartens, in principle, have no nap times.

Using a questionnaire, parents reported their children's typical bedtimes and wake times for weekdays, the regularity of the times, birthdays, the number of siblings and their birth order, and parental occupations. After collecting the questionnaires, nocturnal sleep duration (min) was computed from the difference between bedtime and wake time for weekdays. Total sleep duration was then defined as the nocturnal sleep duration plus mandatory nap duration. Data on height and body weight for each child were obtained from their preschools, and the body mass index (BMI, kg/m^2) was calculated as an obesity index.

Blood pressure was measured twice by a single trained examiner with a mercury sphygmomanometer, 2 min after sitting in a chair with backs supported and arms bared and supported at heart level. The average of two measurements was used in the analysis. SBP and diastolic blood pressure (DBP) were defined as the first and the fifth Korotkoff sounds. The electrocardiogram (ECG) was also measured to check heart abnormality with the Pocket-ECG WEC-7101 (Nihon Kohden Co, Tokyo). In consideration of breakfast and lunch times, the tests were carried out between 10:00 and 11:30 on weekdays.

After the preschool children were divided into quartile groups based on total sleep duration (*i.e.*, the 25th, 50th, and 75th percentiles of total sleep duration), the mean variance of blood pressure

among the four groups was tested by one-way analysis of variance and the Scheffe multiple comparison test was employed to examine the difference between two of the four groups. The significance of the association between total sleep duration and blood pressure was analyzed by the Pearson product-moment correlation coefficient (*r*). Also, multiple regression analysis was used to adjust for possible confounders such as age, sex, BMI (5), and institute. The "institute" variable was scored as "nursery school" = 1 and "kindergarten" = 2. All analyses, with two-sided *p* values, were performed with the Statistical Package for the Biosciences (12).

RESULTS

There were no children with either abnormal beats or ventricular extrasystoles on ECG, and no child took medication or caffeine-containing products on the morning of the examination. Characteristics in the preschool children are shown in Table 1. Among the quartile groups based on total sleep duration (*i.e.*, 510~585 min, 586~610 min, 611~660 min, and 661~765 min), the mean SBP was significantly higher in the highest group (total sleep duration > 660 min) than in the lowest group (total sleep duration $\leq$ 585 min) as illustrated in Fig. 1. In the preschool children, total sleep duration was significantly correlated with SBP ($r = 0.265$, $p = 0.0039$), but not with DBP ($r = 0.105$, $p = 0.26$); also, the SBP was significantly related to the total sleep duration and BMI, when total sleep duration and possible confounders such as age and sex were set as independent variables of multiple regression analysis (Table 2).

DISCUSSION

In the present study, the average total sleep duration ($\pm$ SD) on weekdays, calculated from nocturnal sleep duration and mandatory nap time, was 624 ± 57 min, and this was of course longer than the nocturnal sleep duration (575 ± 42 min) in Japanese preschool children at the same ages (21). The average total sleep duration in our subjects at ages 5–6 years is consistent with those in the U.S. (2), Switzerland (7), and Iceland (23). Likewise, our subjects had SBP/DBP similar to those in other Japanese children aged 5 years, *e.g.*, $101 \pm 10/53 \pm 8$ mmHg for 856 boys and $102 \pm 10/54 \pm 9$ mmHg for 801 girls (4). Despite the potential limitations involved in observational research, reported total sleep durations and measured blood pressure could be used in a survey

Table 1 Characteristics of 117 preschool children in Japan

	Mean $\pm$ SD	5~95 percentile
Girls (number)	79 (67.5%)	
Age (months)	69 $\pm$ 4	63~74
Height (cm)	111.6 $\pm$ 5.2	104.1~119.8
Body weight (kg)	19.5 $\pm$ 2.4	16.3~24.1
Body mass index (kg/m ²)	15.3 $\pm$ 1.2	13.9~17.8
Only child (number)	24 (20.5%)	
Mother with job (number)	66 (56.4%)	
Total sleep duration (min)	624 $\pm$ 57	540~735
Bedtime (hour)	21 : 17 $\pm$ 41	20 : 00~23 : 00
Wake time (hour)	06 : 57 $\pm$ 32	06 : 00~08 : 00
Systolic blood pressure (mmHg)	99 $\pm$ 10	82~114
Diastolic blood pressure (mmHg)	62 $\pm$ 9	50~79

Fig. 1 Systolic and diastolic blood pressure (SBP and DBP) among quartile groups of 117 preschool children based on total sleep duration. The mean variance was statistically significant in SBP (one-way analysis of variance, $p=0.033$) but not in DBP ($p=0.52$). The box-whisker plots are comprised of three horizontal lines of the 25th, 50th and 75th percentiles and vertical lines drawn from the box to the most extreme point within 1.5 interquartile ranges, and the signs ($\oplus$ and $\bullet$) represent the mean value and outlying values, respectively. The Scheffe multiple comparison test, with p value, was used to compare two of the four groups.

that requires data on relative differences within a given population (22).

The principal finding of this study is that total sleep duration was significantly related to SBP in the preschool children, even when multiple regression analysis was used to adjust for age, sex, BMI, and institution (Table 2). This result assumes that SBP depended on mean sleep duration in the preschool children. In addition, since the SBP tended to be high in the highest quartile group and to be low in the lowest quartile group as compared to the other three quartile groups (Fig. 1), extremely long or short sleep time may invite subclinical health problems, as suggested in the general population (10, 15). On the other hand, no link was seen between DBP and total sleep duration.

We have already reported that SBP, together with cardiac autonomic activities, was significantly decreased in preschool children with short nocturnal sleep (< 600 min) as compared to those with long nocturnal sleep (≥ 600 min), but the SBP did not have any close relation to nocturnal sleep duration in using multiple regression analysis with independent variables of age, sex, Kaup index, and institute (21). By contrast, the link between total sleep duration and SBP, as mentioned above, was statistically significant, albeit the change in the SBP was small (Fig. 1). The disagreement between the present and previous results was attributable to the presence/absence of a daytime nap. Based on these findings, both sleep habits representing nocturnal sleep duration and total sleep duration appear to be associated with SBP in preschool children; also, their daytime naps may have compensated for the homeostasis of blood pressure to some extent, while it was reported that the afternoon nap seemed to cause delayed sleep onset but was not a result of sleep deficit (3).

Table 2 Relations of total sleep duration (TSD), age, sex, body mass index (BMI), and institute variable to systolic and diastolic blood pressure (SBP and DBP): results of multiple regression analysis

	Standardized regression coefficients					R ²
	TSD	Age	Sex	BMI	Institute	
SBP	0.213*	0.085	0.073	0.227*	0.141	0.153**
DBP	0.096	0.150	0.098	0.306**	0.020	0.135**

* $p < 0.05$, ** $p < 0.01$.

R represents the multiple correlation coefficient.

With regard to possible confounders, we considered age, sex, BMI, and institute (*i.e.*, nursery school or kindergarten) in the data analysis. Childhood obesity is known to represent an important risk factor for hypertension and CVD in later life (18), and the BMI in our subjects was significantly related to both SBP and DBP (Table 2). A similar finding has been observed in obese and nonobese children at ages 0.1–6.9 years (5). Also, total sleep duration declines rapidly in the first decade of life (2, 7, 23) and blood pressure also increases with progressive age in childhood (5, 13); in the present study, however, age was not significantly related to SBP or DBP because of the small range of age. In addition, blood pressure and sleep duration may be affected by various factors — daily activities and diets or nocturnal urinary behavior (9) — other than age and BMI in preschool children, though it was impossible to examine all of such factors. Actually, all independent variables, used in this study, explained only 15.3% of the total variations of SBP among the preschool children (Table 2). For this reason, the association between total sleep duration and SBP would have become more tenuous. Taken together, these findings suggest that our data were not heavily influenced by any confounding bias because the internal consistency seems to have been preserved within our results.

In conclusion, we suggest that SBP be associated with usual sleep duration in preschool children. The implication is that the potential onset of lifestyle-related diseases during childhood may originate from forcing adult lifestyles on children; namely, nursery school children frequently show short nocturnal sleep duration and delayed bedtime as compared to kindergarteners (8, 21), and the delayed bedtime in the former would probably be due to the fact that most mothers with nursery school children work outside and often come home late for dinner (14). In light of the present outcomes, we would like to recommend that parents let their children at ages 5–6 years sleep for a total of 10–11 h because such children cannot correct their life environments by

themselves. Further studies with a large number of age-specific children will be necessary to clarify the effects of sleep duration on various health problems including blood pressure.

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