Short sleep duration is associated with specific food intake increase among school-aged children in China: a national cross-sectional study

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Abstract

Background: The relationship between sleep duration and food intake is unclear. This study aims to examine the relationship among children aged 6–17 years in China.

Methods: The sample consisted of 70,519 children aged 6–17 years, which were randomly selected from 7 representative areas from China, from September to November, 2013. In the structured questionnaire, children reported daily sleep hours (less than 7 h, 7–9 h and more than 9 h), weekly food intake amount (including vegetables, fruit, sugar beverages and meat), physical activity and sedentary time. The relationship of sleep duration with vegetable, sugar beverage, fruit and meat intake was evaluated by multi-nominal logistic regression and multi-variable adjusted.

Results: A total of 62,517 children (51.6% boys) completed the study. Short sleep duration (SSD, < 7 h) was independently associated with increased sugar beverage intake (SBI, Odd Ratio, OR: 1.29, 95% CI: 1.19–1.40) but decreased vegetable (VI, OR: 0.94, 95% CI: 0.90–0.98) & fruit intake (FI, OR: 0.94, 95% CI: 0.88–0.99). Stratified by age and gender, SSD increased SBI for boys of both young (6–12 years) & older (13–17 years) groups and older girls (ORs: 1.25, 1.25, 1.49, 95% CI: 1.08–1.44, 1.04–1.50, 1.22–1.81, respectively), but decreased VI and FI for older girls (ORs: 0.84& 0.81, 95% CI: 0.74–0.96& 0.68–0.96, respectively).

Conclusions: Among school-aged children in China, short sleep duration was associated with increased risks of more sugar beverage intake among those younger and boys but less vegetable & fruit intake among those older and girls. Longitudinal research is needed to clarify the causation in between.

Keywords: Sleep duration, Food intake, Sugar beverage, Vegetable, Fruit

Background

Sleep is an important modulator of growth, maturation, and health in children and adolescents [1]. However, the average sleep duration has been decreasing worldwide for decades [2] as a marker of modern society progress. The US Gallup polls affirm that modal sleep tended to last 8 h in 1979 compared with 6.6 h in 1998 [3]. As for children, a recent report from Sweden confirms a gradual decrease in the number of children who acquired the recommended sleep hours for children and adolescents [4]. Similar trends are reported in China and Australia [5, 6]. Thus, short sleep is, indeed, a global phenomenon.

Research corroborates that short sleep may lead to endocrine alternation [7], including the decreased levels of leptin, glucose tolerance, and insulin sensitivity and the increased levels of ghrelin, hunger, and appetite [8]. In addition, certain studies affirm a linkage between short sleep and specific behaviour changes, such as less physical activity, highly sedentary behaviour [7], and food intake [9]. This affirmation is based on energy balance hypothesis, which elucidates that short sleep causes additional energy expenditures, thereby causing the body to automatically reserve energy via reducing activity and increasing food intake [10].
A few studies [11–13] address short sleep and food intake among children, but the results affirm a discrepancy in the relationship between sleep duration and carbohydrate intake. As the experimental study observes that short sleep duration increased children’s fat and carbohydrate intake [11], an observational study among preschool children verifies that short sleep is linked to decreased carbohydrate intake [12]. On the one hand, the well-controlled experimental condition may hinder the generalization of these conclusions. Although several observational studies confirm a relationship between sleep duration and unhealthy food intake, the big age ranges from preschool children to adolescents and the followed natural sleep requirement decrease, along with more freedom of food choice [12–14] may hinder the generalizability of these conclusions.

Sleep duration generally decreases when children get old and reach adulthood, especially after puberty [15]. Thus, children with rapid growth may possibly be more affected by sleep duration compared with adults who have a relatively stable sleep patterns and physical conditions [16]. However, current epidemiologic studies usually focus on adults [17–19]. In this case, exploring the relationship between different diet intakes and sleep durations in a large representative child population is necessary. On the other hand, sleep duration and diet intake are gender- and age-related, but information on the two variables are limited. In addition, this association remains obscure in the Chinese children population, considering that Chinese children have different dietary habits with western children [20], and the sleep-diet change rapidly during children growth, this research with wide range of age groups is significantly urgent.

We aim to examine the relationship between different sleep durations (short, middle, and long) and food intakes among Chinese schoolchildren and further explore the gender- and age-dependent effect thereof. Given that human beings acquire different nutrients and potential health-related risks from different foods, we focused on four food groups that Chinese children usually consume daily [21, 22]. These are sugar beverages, meat, fruits, and vegetables. In addition, we also described the food intake per gender and age. We expected that short sleep duration would be related to high food intake with high energy density, such as sugar beverages, and that the association between sleep duration and food intake amount is age- and gender-dependent.

**Methods**

**Participates enrollment**

Seven research centers were chosen in China (located in Beijing, Tianjing, Liaoing, Ningxia, Shanghai, Changsha, and Guangzhou, respectively), for they represent the population for the northern (Beijing, Tianjing), northeastern (Liaoing), northwestern (Ningxia), eastern (Shanghai), central (Changsha), and southern (Guangzhou) parts of China [23]. The detail of the recruitment of children and the survey of baseline information for all the centers were described in our previous published protocol [17]. In total, there were 70,519 children aged 6–17 years agreed to take part into the national survey. The study was approved by the Sun Yat-sen University Ethics Committee, and all parents/guardians of children signed the informed consent.

**Anthropometric measurement**

Anthropometric measurement was performed to all of children from September to November 2013. Height (centimeter, cm) and weight (kilogram, kg) were measured by qualified technicians in the corresponding school. Details of measurement and body mass index (BMI) calculation could be found in our published article [6].

**Questionnaire survey**

A standardised questionnaire that developed on the basis of the information, motivation, and behavioural skills model [24] was designed to collect demographic data (examination date, birth date, gender, education level of mother, and monthly household income), physical activity and sedentary lifestyle (weekly hours of high-level and middle-level physical activities, walking, and sedentary behaviours), and dietary intake (daily intake of meat, sugar beverages, fruits, and vegetables). Details of the questionnaire including social demographic information, daily food intake, daily physical activity/edentary behavior, sleep duration and quality control procedure have been described in our published article [6].

**Statistical analysis**

Data were inputted using EpiData 3.0 software (EpiData Association, Odense, Denmark) and analyzed using Statistical Package for the Social Sciences (SPSS, version 22.0, IBM Corporation, New York). Descriptive statistics were calculated for all the variables, including continuous variables (presented as mean values± standard deviation or median with quartile) and categorical variables (presented as proportions). The differences of categorical variables were evaluated by chi-square tests. For continuous variables, t-tests (normal distribution) or Mann-Whitney U test (abnormal distribution) were used to evaluate gender differences and age group differences. The association between sleep duration (independent variable) and food intake (dependent variable) was evaluated by multi-nominal logistic regression models, which were initially adjusted for age and gender (model 1); intensive physical activity, moderate physical activity, walking, sedentary behaviour, mother’s educational level, and household income were subsequently introduced into the model (model 2). Cluster data from 7 research centers were also introduced into the model, and a robust standard error was used to minimize
the effect that the data obtained from different areas may have. The results were reported by odds ratios (ORs) and corresponding 95% confidence intervals (CIs). The LSD group was considered as the reference group in the regression models. *p* values less than 0.05 were considered statistically significant.

**Results**

**Baseline characteristics of the study population**

A total of 8002 children were excluded because they did not provide essential information in their questionnaires (sleep duration or at least one type of food intake). The sample comprised 62,517 children. Their mean age was 10.82, and 48.4% were girls. Compared with the retained participants, those excluded from the analysis had no difference in age, the percentage of males, or baseline BMI. Table 1 describes the baseline characteristics of the participants. Compared with younger children (aged 6–12 years), older children (aged 13–17 years) had higher mean values of BMI, daily walking time, PC game time, and homework time (all *p* < 0.001) but lower mother’s educational level and household income (all *p* < 0.001). A total of 7.5% younger children and 37.1% older children reported SSD per night. In total, daily diet intakes servings were 0.41, 1.16, 1.28, and 1.79 (SBI, MI, FI, VI, respectively). Compared with the younger group, older children had higher daily SBI and meat intake (both *p* < 0.001) but lower mean values of FI and VI (both *p* < 0.05). Compared with girls, boys in the sample had higher BMI, IPA, MPA, walking, TV watching, PC game time, and household income but lower mother’s educational level (all *p* < 0.01). In addition, fewer boys reported SSD but had higher SBI, MI, and FI relative to girls (all *p* < 0.001).

Figure 1 depicts diet intakes curves by age and gender. VI and FI increased among children aged 6–10 years, decreased during 11–14 years and finally remained stable among children aged 15–17 years (Fig. 1a and b). Boys and girls showed a similar pattern. Children aged 6–10 years also had an increased MI amount, and a clear gender-specific effect can be observed (Fig. 1c). In addition, for children of all ages, boys had more meat intake than girls. SBI increased gradually during the age of 6–14 among boys (0.2–0.8 serves/ day) and girls (0.2–0.4 serves/ day) and then slightly decreased during the age of 15–17. The trend affirmed that children tend to have less sleep hours as they grow up (Fig. 2) and that gender-specific patterns are similar between boys and girls.

**Association between diet intake and sleep duration**

Table 2 summarises the association between different volume of diet intakes and sleep duration. After age and gender are adjusted, per serve increase of SBI was associated with increased risk of MSD (OR: 1.08, 95% CI: 1.04–1.12) and SSD (1.20, 1.15–1.26), per serve of decrease of VI and FI were associated with increased risk of MSD (OR: 0.96 and 0.97, 95% CI: 0.94–0.98 and 0.95–0.99, VI and FI, respectively) and SSD (OR:0.91 and 0.91, 95% CI: 0.89–0.93 and 0.88–0.94) compared with the LSD group (Table 2). After physical activity/inactivity, education level of mother, and household income were adjusted, the analysis confirmed a similar trend (all *p* < 0.05, model 2, Table 2).

After age was stratified, and multi-variable was adjusted, per serve increase of SBI was associated with increased risk of MSD (OR: 1.12, 95% CI: 1.03–1.22) and SSD (OR: 1.32, 95% CI: 1.18–1.47), per serve decrease of VI was associated with increased risk of MSD (OR: 0.96, 95% CI: 0.93–0.99) among children aged 6–12 years, compared with the LSD group (Table 3). As to those aged 13–17 years, compared with LSD group, per serve increase of SBI was associated with increased risk of SSD (OR: 1.25, 95% CI: 1.07–1.46), per serve decrease of FI was associated with increased risk of MSD (OR: 0.88, 95% CI: 0.80–0.97) and SSD (OR: 0.83, 95% CI: 0.74–0.93) (Table 3).

We further stratified the dataset by gender. Among younger boys aged 6–12 years, increased risk of MSD and SSD were associated with per serve increase of SBI (OR: 1.12 and 1.25, 95% CI: 1.01–1.24 and 1.08–1.44, MSD and SSD, respectively) and increased risk of MSD was also associated with per serve decrease of FI (OR: 0.92, 95% CI: 0.87–0.98) (Table 3). As to young girls, increased risk of SSD were associated with per serve increase of SBI (OR: 1.49, 95% CI: 1.22–1.81) and VI (OR: 1.14, 95% CI: 1.03–1.28) (Table 3). For older boys aged 13–17 years, increased risk of SSD were associated with per serve increase of SBI (OR: 1.25, 95% CI: 1.04–1.50) but per serve decrease of VI (OR: 0.84, 95% CI: 0.73–0.97) (Table 3), as to girls with same age, increased risk of MSD and SSD were associated with per serve decrease of VI (OR: 0.86 and 0.84, 95% CI: 0.77–0.97 and 0.74–0.96; MSD and SSD, respectively) and FI (OR: 0.85 and 0.81, 95% CI: 0.73–1.00, 0.68–0.96; MSD and SSD, respectively) (Table 3).

**Discussion**

Short sleep duration of children has become an international epidemic in recent years, and the sleep-related morbidity has increased in many countries [25]. Food intake alternation is believed to be linked to short sleep but has not been fully explored yet, particularly in the Chinese population. Using a national cross-sectional study with 62,517 children aged 6–17 years, we studied sleep duration’s role (independent variable) in food intake (dependent variable), and found that the short sleep duration (less than 7 h) prevalence was 17.6% and was higher in girls and older children. Importantly, SSD was related to the increased SBI among 6- to 12-year-old children and 13- to 17-year-old boys. For girls aged 13–17 years, FI and VI are positively associated with sleep duration. Generally, the results of this study validate that the association between
short sleep duration and food intake is age- and gender-dependent. Insufficient sleep duration is associated with increased chances for drinking sugar beverages among younger children and boys, but decreased chances for eating vegetables and fruits among older children and girls.

Insufficient sleep is associated with the intake of food with high glycemic index (GI) [26]. On the basis of the hypothesis, short sleep leads to over energy expenditure [27]. Consequently, the body needs to recover energy rapidly, and high GI food increases blood glucose quickly. From another point of view, short sleep causes metabolic change, which increases ghrelin and decreased leptin secretion [8]. Experimental studies corroborate that metabolic change caused by sleep deprivation results in several hedonic food choices [28], which may also explain the increased high GI food, such as sugar beverage. In our study, we also affirmed an association between increased SBI and SSD/MSD. Although the relationship is cross-sectional, the association trend is in agreement with the hypothesis that the longitudinal study tested [29].

Table 1 Sample characteristics across age and gender groups in the national school-based survey

| Child characteristics, mean ± SD, median with quartile or % | All (n = 62,517) | 6–12 years old (n = 40,924) | 13–18 years old (n = 20,593) | P Value for age groups | Boys (n = 32,257) | Girls (n = 30,260) | P Value for gender |
|---|---|---|---|---|---|---|---|
| Female | 48.4 | 47.3 | 50.5 | < 0.001 | 0 | 100 | < 0.001 |
| Age (years) | 10.82(3.30) | 8.98(1.88) | 14.64(1.37) | < 0.001 | 10.92(3.91) | 11.06(3.22) | < 0.001 |
| Height (cm) | 145.82(17.09) | 137.87(12.62) | 163.50(8.41) | < 0.001 | 148.25(18.10) | 145.57(14.84) | < 0.001 |
| Weight (kg) | 40.94(15.53) | 34.50(11.49) | 55.78(12.79) | < 0.001 | 43.71(17.17) | 40.25(13.72) | < 0.001 |
| BMI (kg²/m²) | 18.78(3.84) | 17.71(3.42) | 20.74(3.79) | < 0.001 | 19.13(4.03) | 18.42(3.59) | < 0.001 |
| Family income (%) | < 0.001 | < 0.001 |
| < 5000 yuan/month | 28.0 | 27.0 | 29.9 | < 0.001 | 27.1 | 29.0 |
| > 5000 yuan/month | 14.2 | 15.2 | 12.3 | < 0.001 | 14.0 | 14.4 |
| Not known | 57.8 | 57.8 | 57.8 | < 0.001 | 58.9 | 56.6 |
| Maternal educational level (%) | < 0.001 | 0.004 |
| < 9 years | 47.4 | 43.4 | 56.0 | < 0.001 | 48.1 | 46.6 |
| 9–12 years | 26.2 | 27.0 | 24.4 | < 0.001 | 25.9 | 26.5 |
| > 12 years | 26.4 | 29.6 | 19.6 | < 0.001 | 26.0 | 26.9 |
| Physical activity (Hours/day) | 0.21 (0.05, 0.57) | 0.21 (0.02, 0.57) | 0.23 (0.07, 0.57) | < 0.001 | 0.29 (0.07, 0.67) | 0.19 (0.01, 0.48) | < 0.001 |
| IPA | 0.22 (0.00, 0.64) | 0.23 (0.00, 0.64) | 0.21 (0.00, 0.57) | < 0.001 | 0.25 (0.00, 0.67) | 0.21 (0.00, 0.50) | < 0.001 |
| MPA | 0.48 (0.14, 1.00) | 0.42 (0.00, 1.14) | 0.50 (0.14, 1.00) | < 0.001 | 0.50 (0.14, 1.00) | 0.43 (0.14, 1.00) | < 0.001 |
| Walking | 3.50 (1.75, 7.23) | 5.25 (3.50, 8.17) | 3.50 (0.00, 7.00) | < 0.001 | 4.67 (2.33, 8.17) | 3.50 (1.17, 7.00) | < 0.001 |
| TV watching | 2.33 (0.00, 7.00) | 3.50 (0.00, 7.00) | 3.50 (0.00, 7.00) | < 0.001 | 3.50 (0.00, 7.00) | 2.33 (0.00, 7.00) | < 0.001 |
| PC game | 7.25 (7.00, 17.50) | 10.50 (7.00, 14.00) | 15.75 (10.50, 21.00) | < 0.001 | 10.50 (7.00, 17.50) | 14.00 (7.00, 18.00) | < 0.001 |
| Homework | 25.3 | 35.0 | 6.7 | < 0.001 | 26.5 | 24.1 |
| Sleep duration | 57.1 | 57.5 | 56.3 | < 0.001 | 57.9 | 56.2 |
| SSD | 17.6 | 7.5 | 37.1 | 15.6 | 19.7 |
| Diet intake (serves/week) | 10 (7, 14) | 10 (7, 14) | 10 (7, 14) | 0.41 | 10 (7, 14) | 10 (7, 14) | 0.27 |
| Sugar Beverage | 1 (0, 3) | 10 (2, 5) | 10 (2, 5) | < 0.001 | 2 (0, 4) | 1 (0, 2) | < 0.001 |
| Meat | 1 (1, 19) | 7 (3, 8) | 7 (3, 10) | < 0.001 | 7 (4, 12) | 6 (3, 7) | < 0.001 |
| Fruits | 7 (4, 14) | 7 (5, 14) | 7 (3, 12) | < 0.001 | 7 (4, 12) | 7 (4, 14) | < 0.001 |
| Vegetables | 10 (7, 14) | 10 (7, 14) | 10 (7, 14) | 0.41 | 10 (7, 14) | 10 (7, 14) | 0.27 |

BMI Body mass index, IPA intensive physical activity, MPA moderate physical activity, LSD Long sleep duration, MSD Middle sleep duration, SSD Short sleep duration. Sample characteristics are presented as Mean ± Standard deviation (normally distributed, age, height, weight and BMI), Median with quartile (median, Q25 and Q75, including physical activity, sedentary behaviours and diet intake) and frequency (%), family income, maternal educational level and sleep duration.
Our results complied with previous research that asserts that VI and FI are negatively associated with insufficient sleep [13], but the mechanism is still unclear. One hypothesis on hedonic eating behaviour after short sleep [30] is that children tend to eat unhealthy food and avoid healthy food because the latter provides far less energy density per unit volume [31]. This affirmation makes evolutionary sense as food with high energy density supported human survival in ancient times. In this case, this type of food could be a protective mechanism as avoiding vegetables and fruits can save limited stomach volume for high energy food because short sleep itself could be treated as stress [32]. Another potential mechanism indicates that lack of sleep leads to considerable eating in general. In addition, the types of food available to the youth late at night are likely to be convenience items, such as fast food,
as opposed to vegetables that typically require fair preparation and are eaten with meals [13].

Although numerous studies reported a sleep-diet relationship, the age dependent effect was seldom addressed [12, 14, 33, 34]. Considering that the OR values are relatively small, stratified analysis had been made in order to decrease the potential co-founding effect of age and gender (Table 3). Our data reported that food intake and sleep duration are affected by age (Figs. 1 and 2). Sleep duration declined, and the food intake pattern changed during puberty. Thus, we performed the analysis using stratified data by age groups, and took the reported puberty onset time of Chinese children (12 years old) [35] as a cut-off point. Although the recommended sleep duration for children is 9 h, certain studies corroborate that sleep decline is acceptable during puberty [36]. In our study, children aged 6–12 years have increased SBI (Table 3). This finding may be because older children need less sleep, and girls further require shorter sleep durations relative to boys of the same age [40]. Interestingly, although the association between sleep duration and SBI weakens by age, its association with VI is strengthened. After age and gender are stratified, only girls aged 13–17 years had less VI when sleep was less than 9 h (Table 3). Sleep duration decrease would lead to total energy intake growth [8]. However, we did not find an increased chance of SBI, FI, and MI among these girls. In our study, other food types, such as rice and wheaten food that Chinese people eat most, were not included. Thus, we cannot conclude that children may increase rice and wheaten food intake as a replacement.

No study has currently reported the association between sleep duration and meat intake. Meat is considered protein rich, and certain studies confirm that short sleep may decrease the need for protein intake [41]. However, MI did not change in each age and gender group in our study. The MI level is relatively low in the Chinese population compared with that of Western countries [42]. Alternatively, the main source of dietary protein in China is usually soy products [43]. Thus, the short sleep effect on protein intake may reflect not on MI but on soy food instead. Another potential mechanism is the fat intake increase on short sleepers [44]. Thus, the short sleep effect on protein intake may reflect not on MI but on soy food instead. As meat is a main source of fat intake, the effect of a decrease in protein could be buffered by an increased intake of fats, which may also explain the unchanged MI in our study.

Certain studies affirm the association between sleep and diet intake, especially because SBI may be bidirectional [45]. Although no study has reported that sugar leads to a sleep decline before, carbohydrate intake may
Girls (n = 10,912) and boys (n = 10,681) were included in the study, with a sample size of 21,576 and stratified by age and gender. The results showed that sugar beverages had a significant negative impact on sleep duration, with an odds ratio of 1.11 (95% CI: 0.96–1.27) for girls and 1.12 (95% CI: 1.01–1.24) for boys. Vegetable intake also had a similar effect, with an odds ratio of 1.01 (95% CI: 0.97–1.05) for girls and 1.00 (95% CI: 0.95–1.05) for boys. Meat intake did not show a significant effect on sleep duration for either gender.

In conclusion, the potential relationship between sleep and food intake is also worthy of note. High-quality diet and adequate sleep duration represent a relatively healthy lifestyle. In this study, vegetable and fruit intake among those older and girls had a negative impact on sleep duration, whereas meat intake among those younger and boys, but decreased vegetable and fruit intake among those older and girls. Longitudinal research is necessary to clarify the causation in between, as well as the gender- and age-specific effect. In addition, studies that focus on a wider range of food species are also necessary.

**Abbreviations**

FI: Fruit intake; LSD: Long sleep duration; MI: Meat intake; MSD: Middle sleep duration; SBI: Sugar beverage intake; SSD: Short sleep duration; VI: Vegetable intake

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Further reading

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