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Original Article

Prevalence of adiposity and its association with sleep duration, quality, and timing among 9–12-year-old children in Guangzhou, China

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A R T I C L E I N F O

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A B S T R A C T

Background: Short sleep duration has been reported to be associated with obesity in children, but findings are not consistent. Since few studies have examined the relationship between more complex sleep characteristics and obesity, we examined the association between adiposity and self-reported sleep duration, bedtime, and sleep quality in 9–12-year-old Chinese children using multilevel mixed models.
Methods: 5518 children aged 9–12 years were recruited from 29 randomly selected primary schools in Guangzhou, China in 2014. Standardized questionnaires were used to obtain data to estimate sleep duration on typical weekdays and weekends. Sleep quality data were collected using the Children's Sleep Habits Questionnaire (CSHQ). Trained researchers undertook measurements of weight, height, and waist circumference (WC) for all participating children. Body mass index (BMI) z-scores were derived using the World Health Organization (WHO) child growth reference, and children were classified as overweight or obese using +1 and +2 SD as cut-offs, respectively. Percentage body fat (BF%) was calculated using bioelectrical impedance.
Results: Longer sleep duration was inversely associated with BMI z-score ($\beta = -0.16$, $p < 0.05$), WC ($\beta = -1.11$, $p < 0.05$) and later bedtime was associated with higher BMI z-score ($\beta = 0.03$, $p < 0.05$), WC ($\beta = 1.72$, $p < 0.001$), and BF% ($\beta = 0.15$, $p < 0.05$) in multivariable multilevel mixed models, after adjustment for age, gender, physical activity, parental education level, and average monthly income. No association was seen between sleep quality and adiposity.
Conclusion: Shorter sleep duration and later bedtime are associated with higher adiposity indices in early adolescents from southern China.

Introduction

The prevalence of obesity has been increasing worldwide. Particularly, the prevalence of obesity and overweight are alarming in China, where economic transitions have resulted in changes to the traditional diet, increased sedentary lifestyles, and reduced physical activity.[1,2] Increased body weight may lead to many problems, such as psychosocial problems, lack of confidence, as well as chronic diseases, such as hypertension and type 2 diabetes. Complex factors contribute to childhood adiposity, including biological factors[3] and lifestyle factors, such as sedentary lifestyle and intake of junk foods.[4] However, in recent years, observational research in different age groups from the United States,[5] Canada,[6] and Australia,[7] have reported that shorter sleep duration may be an additional risk factor associated with higher body mass index (BMI) among children.

Apart from this, there is increasing evidence showing that high-quality, adequate sleep is important for an overall healthy body,[5–7] while sleep duration has been decreasing over time among children and adolescents. For example, national surveys in the United States have shown a decline in self-reported sleep duration among newborns to 10-year-olds over the past 50 years by 1.5–2 h,[8] which may be attributable to changes in lifestyle, such as waking up early for

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school and late night activities.[9] Sleep disturbance, characterized by disruptions in quantity, quality, or timing of sleep, frequently occur in children. Depending on the definitions of problematic sleep and methodologies employed, the reported prevalence of sleep disturbances in this age group varies from 20% to 45% in Western populations[10,11] and is towards the higher end[12] or may be even higher in young children in China.[13] However, few studies have been conducted on the relationship between more complex sleep characteristics and different obesity indices in China. One study has been undertaken in Shanghai[14] on early adolescents, which found that short sleep duration was associated with higher adiposity indices.

In this study, we investigated the association between adiposity and self-reported sleep duration, sleep quality, and bedtime using different measures of adiposity in Chinese children aged 9–12 years.

Methods

Study design and subjects

The analysis presented in this paper comes from a sub-group of participants drawn from a larger cross-sectional study. The aim of the larger study was to determine the prevalence and risk factors for childhood overweight/obesity in primary school-aged children in Guangzhou. A multi-stage stratified cluster random sampling method was used to obtain a representative sample. Using a random number generator, five of the ten urban districts were first selected. Within each of the selected districts, schools were stratified by public (residents) or private (migrant) status, and six primary schools were randomly chosen, with a 2:1 ratio from each stratum. Within each school, two classes per year group (from grade 1 to 5) were randomly selected, from which all pupils (mainly age 6–12 years) were invited to take part. Children were excluded if they had serious health problems, including any physical and psychological condition that was felt by teaching staff to compromise their participation in the study (e.g., children with major disability or serious cognitive or psychological dysfunction). Permission for the study was not obtained for one of the private schools in our sampling frame, leaving 29 participating schools.

Written informed consent was sought from the parents of 11,445 eligible children aged 6–12 years (on behalf of their children), resulting in 9917 participants (86.6% of eligible participants) (Fig. 1). Data collection took place from April to June 2014, with anthropometric measurements undertaken in school by trained research staff using standardized procedures and instruments. All children had measures of height and weight. The parents of all participating children were asked to complete a questionnaire that inquired about sociodemographic and lifestyle characteristics, and children in grade 3 and above (around 9 years old and above) were asked to complete a student questionnaire ($n = 5518$). More detailed measures, such as blood pressure and percentage body fat (BF%), were undertaken on a randomly selected sub-sample across all school grades (approximately 50% of the total sample). The number of children with complete data for this analysis was 2795 (1500 boys and 1295 girls aged 9–12 years).

Data collection and measurements

Socio-demographic questionnaire

Data on parental demographic characteristics, such as parental educational level (junior high school and below/middle high school/university and above) and average household income, were collected through the parent/guardian questionnaire.

Physical activity was assessed using the following item: *"Please estimate on average, how long your child spends on each of the following activities each day."* Physical activity level was classified into four categories: sitting (e.g., classroom work, homework, reading, watching TV, playing computer, sewing, eating, or sitting in car or bus); light physical activities (e.g., getting dressed or undressed, tidying a room, feeding or playing with pets, imaginary play, playing a musical instrument, or cooking); moderate physical activity (e.g., playing in the garden, playground games, walking, bicycling [slow/moderate speeds], swimming for fun, dancing, or gymnastics); and vigorous physical activity (e.g., running, bicycling [fast speeds], football, tennis, rugby, roller-skating, or length swimming).

The student questionnaires included questions on the following: district, school, grade, class, gender, age, and sleep information. The completed questionnaires were reviewed by trained staff and uploaded into the database.

Children were asked to report evening bedtime and wake-up time for weekdays and weekends in the preceding week. The average sleep duration was calculated as the weighted average of weekday and weekend sleep durations using the formula: [(weekday sleep duration $\times 5$)+(weekend sleep duration $\times 2$)]/7. The calculated average sleep duration was then classified into four groups based on the mean and standard deviation of the total sample ($n = 5518$). Groups were defined as: shortest (≤ -1 standard deviation [SD]; $n = 734$, range: 6.25–8.61 h); shorter (−1 SD to the mean; $n = 2181$, range: 8.61–9.61 h); longer (mean to 1 SD; $n = 1912$, range: 9.61–10.61 h); and longest (≥ 1 SD; $n = 691$, range: 10.61–13.09 h) sleep duration (eFig. 1). Those who reported sleep duration >±3 SD from the median were excluded as implausible values. Twenty-one items from the Children's Sleep Habit Questionnaire (CHSQ)[15] were included in the parents' questionnaire, covering five subscales (bedtime resistance, sleep onset delay, sleep duration, night waking, and daytime sleepiness). A total sleep disturbance score was calculated from the items, from 20 to 60, with a higher score indicative of greater sleep disturbance. The Chinese version of the CSHQ was developed via translation and back translation and has been used previously with proven excellent sensitivity and reliability.[16]

Anthropometric measurements

Height and weight were measured with subjects wearing light clothing and without shoes. Height was recorded to the nearest 0.1 cm with a TGZ type height tester (Dalian, China). Weight was measured to the nearest 0.1 kg using an electronic scale (JH-1993T; Weighing Apparatus Co. Ltd., Dalian, China). Body mass index (BMI; $[weight(kg)]/[height(m)]^2$) was calculated, and BMI standard deviation scores (BMI z-score) were derived using the age (calculated by subtracting the date of birth from the date of examination) and sex-specific World Health Organization (WHO) growth reference for school-aged children, which were further classified as non-overweight (≤ 1 SD), overweight (>1 SD) and obese (>2 SD).[17] Waist circumference (WC) was measured to the nearest 0.1 cm at the midpoint between the bottom of the rib cage and the top of the iliac crest at the end of exhalation. A MyoTape waistline measurer was employed with the subject standing without clothing covering the waist area. WC measurements were performed twice, and the average of the two measurements was calculated for use in the analyses. Waist-to-height ratio (WHtR) was calculated by dividing average WC (cm) by height (cm).

In a subsample of 2795 subjects, bioelectrical impedance analysis was performed to assess body composition using a single-frequency ImpediMed machine (ImpDF50; Impedimed Pty Ltd, Queensland, Australia). Leads were attached to each child's wrists and ankles when he or she was lying down (after voiding the bladder). From the

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