Weekend catch-up sleep is associated with decreased risk of being overweight among fifth-grade students with short sleep duration

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SUMMARY

Previous studies have reported a relationship between short sleep duration and childhood overweight. Although school-aged children tend to compensate for weekday sleep deficit by increasing weekend sleep duration, the association between weekend catch-up sleep and childhood overweight remains unclear. This study aimed to examine the relationship between weekend catch-up sleep and being overweight in children. A total of 936 school children (48.2% boys) aged 10 or 11 years participated in this school-based cohort study. Anthropometric measurements including height and body weight were carried out. We obtained data on sleep patterns, lifestyle and parent characteristics using questionnaires. The main outcome measure was childhood overweight. After adjusting for the relevant confounding variables (age, sex, breakfast eating, screen time and parental obesity), longer sleep on weekdays and weekends was associated with decreased odds of childhood overweight (OR: 0.68; 95% CI: 0.54–0.86; OR: 0.64; 95% CI: 0.53–0.77, respectively). Participants with increased catch-up sleep duration during weekends also had decreased odds of being overweight (OR: 0.67; 95% CI: 0.53–0.85). There was an interaction between weekday sleep duration and weekend catch-up sleep in relation to childhood overweight, and this effect of weekend catch-up sleep on being overweight was stronger as the participants slept less on weekdays ($P = 0.024$). These results indicate that weekend catch-up sleep is independently associated with decreased risk of being overweight in fifth-grade students, and this effect can be varied by the weekday sleep duration. A prospective study is required to confirm this observation.

INTRODUCTION

Childhood obesity has become a global public health issue because of its increasing prevalence and persistence into adulthood (Ogden *et al.*, 2006; Wang and Lobstein, 2006). Most clinical trials use nutrition and physical activity interventions to fight against the global epidemic of childhood obesity (Kamath *et al.*, 2008; Whitlock *et al.*, 2008). However, these interventions appear insufficiently effective: thus, other methods have been proposed, with consideration of other contributory factors. Among the potential contributory factors to childhood obesity, sleep deprivation has received particular attention recently (Hasler *et al.*, 2004).

Sleep deficiency is very common in teenagers in modern society (Yang *et al.*, 2005). The duration of time devoted to sleep by school-aged children and adolescents tended to decline over the past few decades, which is attributable to earlier school start times and an increase in extracurricular

activities (Iglowstein *et al.*, 2003), especially on school days (Carskadon and Acebo, 2002). Previous studies have shown that reduced sleep is associated with negative health outcomes, such as insulin resistance and weight gain (Patel and Hu, 2008; Spiegel *et al.*, 2005). Within competitive social and school environments, school children are likely to shorten the amount of time spent sleeping during school terms, which is a cause for serious concern in the public health domain.

School-aged children and adolescents tend to compensate for sleep deprivation experienced during the school week by sleeping more on weekends (Crowley *et al.*, 2007; Szymczak *et al.*, 1993), and this trend increases as teenagers age (Yang *et al.*, 2005). If weekend catch-up sleep can reduce the risk of childhood obesity, it may be considered a feasible and practical approach to the prevention and treatment of obesity in teenagers. Nevertheless, most investigations have used the mean duration of sleep throughout the week, and have not differentiated between weekdays and weekends. Moreover, few studies have shown a relationship between weekend catch-up sleep and obesity among children and adolescents (Wing *et al.*, 2009).

We selected fifth-grade students to participate in this study for two reasons: first, fifth graders have been reported having the youngest age at which students compensate for weekday sleep deprivation by increasing weekend sleep duration; and second, because fifth graders are least influenced by pubertal development, which might act as a potential confounding variable by changing circadian rhythms (Carskadon *et al.*, 1993; Ohayon *et al.*, 2004; Yang *et al.*, 2005). Therefore, the aims of the present study were to examine the relationships between weekday and weekend sleep duration and childhood overweight, and to investigate whether weekend catch-up sleep is related to a decrease in the risk for being overweight among students in this age group.

MATERIALS AND METHODS

Study population

In this study, we carried out a cross-sectional analysis of sleep patterns and childhood obesity in Korean Children-Adolescent Study (KoCAS), a cohort of school-aged children and adolescents in Seoul and Gyeonggi Province in Korea. Of the students aged 10–11 years from 13 elementary schools who participated in the study, 1530 healthy children without cancer, hypertension, diabetes and any history of medication that could potentially influence sleep and weight were included in the original cohort. Of the participants, 594 were excluded due to missing data on sleep duration (n = 188), covariates (n = 374) and anthropometric measurements (n = 32). The remaining 936 children (female 485; 51.8%) constituted the final sample. There were no significant differences in age, mean sleep duration of weekdays and weekends, and frequency of being overweight between the final study population and the excluded group (n = 374) who had information on anthropometric and sleep data. Written informed consent was obtained from all the participants and their parents before initiating the study. The study protocols were approved by the institutional review board of the Inje University Seoul-Paik Hospital and the Korean Centre for Disease Control and Prevention in March 2009.

Measures

Anthropometric measurements were performed on all the students at their schools. Height was measured to the nearest 0.1 cm with the use of a wall-mounted stadiometer, and weight was measured without shoes to the nearest 0.1 kg, using a calibrated digital electric scale. Body mass index (BMI) was calculated as weight height^{-2} (kg m^{-2}). Childhood overweight for children aged 10 or 11 years was defined as within the 85th percentile or higher (21.71 kg m^{-2} for males; 20.71 kg m^{-2} for females) of the age- and sex-specific BMI norms recorded in the 2007 Korean National Growth Charts (Korean Center for Disease Control and Prevention, 2007).

Questionnaire-based survey

Information on sleep duration was obtained from the data over the previous week reported by the parents of the participants. Data on usual sleep duration during each weekday and Saturday and Sunday were obtained using questionnaires to measure parent-report of child sleep duration between June and July 2009 (e.g. 'How many hours of sleep did your child get at night as usual? Please fill the data on each day with your child's sleep time on hourly basis.'). The mean sleep duration from Sunday to Thursday was used as a composite measure of weekday sleep duration, and the mean sleep duration from Friday to Saturday was used as a measure of weekend sleep duration. We examined sleep duration as a continuous measure rather than categorizing it.

Weekend catch-up sleep was calculated as weekend sleep duration minus weekday sleep duration.

The potential confounding factors were sex, parental obesity, level of maternal (main caregiver) education, monthly family income, time spent watching TV or using computers, time spent doing homework or reading and physical activity, and missing breakfast. Parental obesity was defined by either a maternal or paternal BMI of $\geq$ 25 kg m^{-2} (Asia-Pacific guideline for obesity; Kim *et al.*, 2004). The amount of physical activity undertaken was estimated by the self-reported frequency of engaging in moderately intense physical activity for 30 min or more each week, and was measured on a scale ranging from never to more than 5 days per week. 'Moderately intense physical activity' was defined as an activity that induced a slight increase in breathing frequency and heart rate and may cause light

sweating, such as walking briskly, playing football (non-competitive), swimming slowly, and cycling at <10 miles h^{-1}.

Statistical analyses

Data on potential risk factors obtained from overweight participants and non-overweight participants were compared by using the chi-square test and Student's *t*-test. Univariate analysis was used to identify covariates for the model. To assess the relationships between childhood overweight and sleep duration during weekdays and weekends, we calculated the adjusted odds ratio (OR) and 95% confidence intervals (CI) with a multivariable binary logistic regression model after controlling for all the significant variables identified by the univariate analyses.

We also evaluated the independent contribution of weekend catch-up sleep duration to the odds for childhood overweight using the model. The interaction between weekday sleep duration and weekend catch-up sleep duration in relation to childhood overweight was tested using the logistic models by adding interaction terms. During the interaction analysis, the weekday sleep duration and the weekend catch-up sleep were transformed by centering; that is, we subtracted their respective mean values from each data on weekday and weekend sleep catch-up sleep durations. This was done to reduce the possibility of multicollinearity. We also tested the two-way interaction between sex with sleep duration and catch-up sleep.

All the statistical analyses were conducted using SPSS 14.0 (SPSS, Chicago, IL, USA).

RESULTS

The data showed that 17.7% of the participants met the criteria for being overweight. The mean age of the participants was 10.86 ± 0.31 years. Children slept significantly longer on weekends than weekdays. Significantly, overweight participants were more likely to have obese parents, watch TV or use a computer longer, sleep less on weekdays and weekends, and eat breakfast less frequently than did non-overweight participants. We found no significant differences between the two groups in the level of maternal education, time spent reading or doing homework, or physical activity (Table 1).

After controlling for confounding factors (age, sex, eating breakfast, screen time and parental obesity), longer sleep on weekdays and weekends was associated with decreased odds of childhood overweight (OR: 0.68; 95% CI: 0.54–0.86; OR: 0.64; 95% CI: 0.53–0.77, respectively). Among the confounding variables identified by univariate analysis, there was a significant negative relationship between eating breakfast everyday and childhood overweight. Conversely, parental obesity contributed to being overweight in the participants (Table 2). Furthermore, in multiple regression analysis, adjusting for the confounding variables used above and weekday sleep duration, there were lower odds of being overweight among participants with a greater increase in catch-up sleep duration during weekends (OR: 0.67; 95% CI: 0.53–0.85; Table 3).

The interaction between weekday and weekend catch-up sleep duration was significant ($P = 0.024$), and the effect of

Table 1 Characteristics of non-overweight and overweight fifth-grade students

	Non-overweight (n = 770)	*Overweight (n = 166)*	P*
Sex (female)	410 (53.2)	75 (45.8)	0.059
Eating breakfast (everyday)	553 (71.8)	100 (60.2)	0.003
Moderately intense physical activity for 30 min or longer (≥3 times $week^{-1}$)	523 (67.9)	116 (69.9)	0.623
Screen time† ≥2 h	204 (26.5)	58 (34.9)	0.028
Monthly family income <$2000	62 (8.1)	18 (10.8)	0.243
Maternal highest educational level			
Below college or professional	281 (36.5)	64 (38.6)	0.618
Parental obesity			
Either parent's BMI ≥25 kg m^{-2}	261 (33.9)	87 (52.4)	<0.001
Sleep duration			
Weekdays (h)	8.3 (0.7)	8.0 (0.7)	0.001
Weekends (h)	8.8 (0.8)	8.5 (0.9)	<0.001
Weekend catch-up (h)	0.5 (0.8)	0.3 (0.7)	0.029

The data are presented as the number (%) for categorical variables or as the mean (SD) for continuous variables.
*The *P*-values were obtained from the independent *t*-tests for continuous variables and chi-square tests for categorical variables.
†Time spent watching TV or using computers.
BMI, body mass index.

Table 2 Multiple logistic regression results for being overweight in fifth-grade students

Variables	*Model 1 Adjusted OR (95% CI)*	*Model 2 Adjusted OR (95% CI)*
Weekday sleep duration (h)	0.68 (0.54–0.86)	–
Weekend sleep duration (h)	–	0.64 (0.53–0.77)
Age (years)	0.46 (0.26–0.81)	0.48 (0.27–0.84)
Sex* (female)	0.66 (0.46–0.81)	0.71 (0.50–1.01)
Eating breakfast (everyday)	0.63 (0.44–0.91)	0.60 (0.42–0.86)
Screen time† ≥2 h	1.31 (0.90–1.91)	1.32 (0.91–1.91)
Parental obesity		
Either parent's BMI ≥25 kg m^{-2}	2.10 (1.48–2.95)	2.19 (1.55–3.11)

*Boys are used as reference group for computing the odds ratio.
†Time spent watching TV or using computers.
BMI, body mass index; CI, confidence interval; OR, odds ratio.

Table 3 Logistic regression analyses for the relationship between weekend catch-up sleep and being overweight in fifth-grade students

Variables	*Crude OR (95% CI)*	*Adjusted OR (95% CI)*
Weekday sleep duration (h)	0.70 (0.56–0.87)	0.60 (0.47–0.77)
Weekend catch-up sleep duration (h)	0.79 (0.64–0.98)	0.67 (0.53–0.85)
Age (years)	0.53 (0.31–0.92)	0.47 (0.27–0.82)
Sex* (female)	0.72 (0.52–1.01)	0.70 (0.49–0.99)
Eating breakfast (everyday)	0.59 (0.42–0.84)	0.61 (0.42–0.88)
Screen time† ≥2 h	1.49 (1.04–2.13)	1.32 (0.90–1.91)
Parental obesity		
Either parent's BMI ≥25 kg m^{-2}	2.15 (1.53–3.02)	2.17 (1.53–3.09)

*Boys are used as reference group for computing odds ratio.
†Time spent watching TV or using computers.
BMI, body mass index; CI, confidence interval; OR, odds ratio.

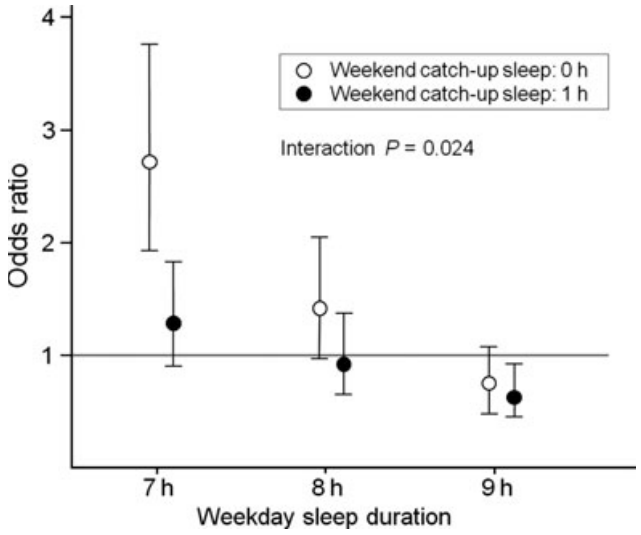

Figure 1. Odds ratios for being overweight associated with weekend catch-up sleep duration (0/1 h), according to weekday sleep duration (7, 8 and 9 h). With the mean value of weekday sleep duration (8.32 h) and weekend catch-up sleep duration (0.44 h) used as the references, the adjusted odds ratios (circles) with 95% confidence intervals (I bars) of no catch-up sleep (open circles) and 1 h of catch-up sleep (dark circles) on weekends are presented for 7, 8 and 9 h of weekday sleep duration, respectively, after controlling for age, sex, time spent watching TV or utilizing computers, and parental obesity.

weekend catch-up sleep on childhood overweight was stronger in participants with shorter sleep duration on weekdays than in those with longer weekday sleep duration (Fig. 1). For instance, with the mean value of weekday sleep duration (8.32 h) and weekend catch-up sleep duration (0.44 h) used as the references, the adjusted ORs with 95% CI of no catch-up sleep and 1 h of catch-up sleep during weekends were 2.74 (1.92–3.91) and 1.27 (0.89–1.81), respectively, in participants with 7 h of weekday sleep duration. The adjusted ORs of no catch-up sleep and 1 h of catch-up sleep were 1.42 (95% CI: 0.99–2.03) and 0.93 (95% CI: 0.65–1.33), respectively, in participants with 8 h of weekday sleep duration, and 0.73 (95% CI: 0.51–1.05) and 0.68 (95% CI: 0.48–0.97), respectively, in those who slept 9 h on weekdays. As another example, the adjusted OR with 95% CI comparing the effect of 1 h of weekend catch-up sleep on being overweight among children with shorter weekday sleep duration (7 h) versus that among children with longer weekday sleep duration (9 h) was 1.87 (95% CI: 1.31–2.67).

DISCUSSION

The present study investigated the association between weekday sleep duration and weekend catch-up sleep and the risk of being overweight among fifth-grade students. We found that increased weekend catch-up sleep duration was significantly associated with decreased risk of being overweight. We also found that the effect of weekend catch-up sleep on childhood overweight varied according to weekday sleep duration.

Previous studies have reported significant variations in the sleep patterns of teenagers over the course of 1 week within a school term (Gulliford *et al.*, 1990). Children aged 10 years and over slept longer on weekends than on weekdays. The present study also showed that fifth-grade students slept significantly longer on weekends than on weekdays [mean (SD): weekday 8.32 (0.79) h versus weekend 8.76 (0.94) h, $P < 0.01$]. Although an earlier study reported that short sleep duration could not be considered a predictor or a risk factor of obesity (Calamaro *et al.*, 2010), its role as a predictor of risk for overweight/obesity has been explained in other studies in terms of increase in appetite and related hormonal changes, such as reduced leptin levels and increased ghrelin and cortisol levels (Cappuccio *et al.*, 2008; Chaput *et al.*, 2007; Patel and Hu, 2008; Taheri *et al.*, 2004), and generally accepted. In accordance with the previous research, we observed that longer sleep duration on weekdays and weekends was associated with decreased odds of being overweight in participants. Moreover, we found that the odds of being overweight decreased with a greater increase in catch-up sleep duration during the weekend among fifth-grade students. These results are in accordance with those emerging from the study conducted by Wing *et al.* (2009). However, it should be noted that Wing's study included a wider age span (5–15 years), and used self-reported weight and height data instead of anthropometric measurements. Given that the weekday sleep duration of children younger than 9 years was similar to or longer than their weekend sleep duration, we need to clarify the effect of weekend catch-up sleep among children aged 10 or 11 years, as this age group has been reported to be the youngest group sleeping longer on weekends than on weekdays

(Thorleifsdottir *et al.*, 2002). One previous study reported that a sufficient period of sleep 'recovery' stabilized metabolic and endocrine-related changes (e.g. decreased acute insulin responsiveness to glucose, elevated evening cortisol concentrations, increased sympathetic muscle tone and deteriorated functioning of hypothalamic–pituitary–adrenocortical activity) caused by sleep deficiency (Spiegel *et al.*, 1999). This finding raises the possibility that catch-up sleep during weekends may serve as a buffer that attenuates the detrimental impact of sleep deprivation on endocrine-related and metabolic functioning, and facilitates an efficient recovery from energy dysregulation. These effects may affect the relationship between sleep curtailment and being overweight.

The link between weekend catch-up sleep and decreased risk of childhood overweight may be mediated by factors related to lifestyle, such as screen time and skipping breakfast. Participants who experienced weekend catch-up sleep to compensate for weekday sleep deprivation may spend less time viewing screen media, thus leading to a decreased risk of being overweight. However, an inverse association, independent of screen time, between weekend catch-up sleep and childhood overweight emerged in this study. In addition, skipping breakfast is a well-known risk factor for being overweight, and one that is connected to a nocturnal lifestyle that alters glucose and insulin metabolism (Qin *et al.*, 2003). Students who catch up with sleep on the weekend miss out on breakfast (Tin *et al.*, 2011). However, our results showed that a significant association of weekend catch-up sleep with decreased odds of childhood overweight was not changed, even after adjustment for breakfast skipping.

It was interesting for us to observe a significant interaction between weekday sleep duration and weekend catch-up sleep duration in terms of childhood overweight. The effect of weekend catch-up sleep duration on being overweight in participants was stronger as weekday sleep duration decreased. This interaction indicates that the effect of weekend catch-up sleep on childhood overweight may be apparent in children with short sleep duration on weekdays. In a recent meta-analysis, the researchers (Chen *et al.*, 2008) suggested that the association between sleep duration and obesity might be stronger in boys than in girls. However, the two-way interaction of sex between sleep duration and catch-up sleep was examined and was not significant ($P = 0.16$).

Our study has some limitations. First, napping and daytime sleepiness were not covered by our questionnaire. Second, sleep data were collected in June and July (summer in Korea), so that while we could exclude seasonal effects, we could not generalize these findings for other seasons. Third, information on sleep duration was based on parental reports on usual sleep duration of each day rather than objective measurements, such as actigraphy or polysomnography, the validity of parent-reported sleep duration has been supported by one previous study (Sekine *et al.*, 2002). Moreover, the feasibility of using actigraphy or polysomnography in a population-based study is limited because of the complexity of these procedures and their costs. Because this study used a cross-sectional design, a prospective study is needed to confirm the present observations.

In conclusion, these results indicate that weekend catch-up sleep is independently associated with decreased risk of being overweight in fifth-grade students, and this effect can be varied by the weekday sleep duration. Our findings have important implications for the development of a practical approach to issues related to being overweight, and suggest that adjusting sleep duration on weekends may ameliorate endocrine-related and metabolic disturbances resulting from short sleep duration during weekdays. Additional prospective studies are required to demonstrate this association among teenagers.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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