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The Association between Self-reported Sleep Duration and Body Mass Index among Korean Adolescents

Ban Hyung Lee,[1]* Seung-Gul Kang,[2] Jae-Won Choi,[3]* and Yu Jin Lee[3]

[1]Seoul National University College of Medicine, Seoul, Korea; [2]Department of Psychiatry, Gachon University School of Medicine, Incheon, Korea; [3]Department of Psychiatry and Center for Sleep and Chronobiology, Seoul National University College of Medicine, Seoul, Korea

*Ban Hyung Lee and Jae-Won Choi equally contributed to this work.

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Address for Correspondence:
Yu Jin Lee, MD
Department of Psychiatry and Center for Sleep and Chronobiology, Seoul National University College of Medicine, 101, Daehak-ro, Jongno-gu, Seoul 03080, Korea
E-mail: leeyj1203@gmail.com, ewpsyche@snu.ac.kr

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Previous research has shown that lack of sleep is related to Body Mass Index (BMI) in adolescence. This study was designed to investigate the association between sleep duration and BMI among Korean adolescents. We conducted a school-based cross-sectional study of 3,785 adolescents (males: 58.2%, females: 41.8%) in middle and high school between the ages of 11 and 18 years (mean age 15.26 ± 1.45). Using a self-reported questionnaire, we obtained information regarding weekday sleep duration, weekend sleep duration, height, weight, time spent at private tutoring institutes, socioeconomic status and scores on the Beck Depression Inventory (BDI). We investigated the association between self-reported sleep duration and BMI. After adjusting for confounding factors including age, gender, time spent at private tutoring institutes, academic performance, economic status and BDI scores, longer sleep duration on both weekdays and weekends was associated with decreased BMI ($P = 0.002$ and $P < 0.001$, respectively) for both genders. Increased weekend catch-up sleep duration was associated with decreased BMI in females ($P = 0.038$), but not in males ($P = 0.343$). The results of the present study indicated that longer sleep duration on weekdays and weekends in adolescents was associated with lower BMI. Longer weekend catch-up sleep may compensate effects of insufficient sleep on BMI for female adolescents.

Keywords: Adolescents; Sleep Duration; Body Mass Index; Catch Up Sleep

INTRODUCTION

Obesity is currently one of the most important indices of an unhealthy lifestyle, representing a medical concern and not merely a cosmetic problem (1). Due to changes in lifestyle and eating habits, the obesity rate among children is increasing worldwide (2). Investigations in the USA and Brazil showed that an additional 0.5% of the total pediatric population is becoming overweight each year. In Canada, Australia, and Europe, the rates are even higher, with an additional 1% of the total pediatric population becoming overweight each year (3).

Korea is no exception to this phenomenon, due to westernization and lifestyle changes. The prevalence of obesity among Korean middle school students has been reported to be 7.3% in 2010 (4), which was lower than 20.5% of USA in 2011-2014 (5). However, the average Body Mass Index (BMI) in Korean adolescents has increased by 5.7 among males and 6.2 among females over the past 23 years (6).

Korean adolescents are getting less sleep than they have in the past (7). High school students are at the greatest risk for insufficient sleep, since they are required to compete in university entrance examinations (8). A previous study compared sleep duration in six countries including Korea, the USA, England, Germany, Sweden and Finland, and showed that Korean adolescents had the shortest sleep duration (7).

Several studies have demonstrated an association between body weight and sleep duration. In a cross-sectional study of Portuguese children, short sleep duration was related to weight gain (9). Another study took a longitudinal approach, studying a sample of the USA high school students aged 14 to 18 years and concluded that increased sleep for children in the 90th BMI percentile contributed to weight reduction (10).

However, several factors which can influence body weight or sleep duration in adolescents should be considered to assess the relationship between BMI and sleep duration. Korean adolescents also showed a high prevalence of depression. According to research on Korean high school students, 18.5% of all students exhibited depression or a depressed mood, a rate that is higher than that observed among western adolescents (11). Depression has been reported by several studies to be associated with being overweight and short sleep duration (12-14). A meta-analysis of longitudinal studies revealed a reciprocal link between obesity and depression (15).

Adolescents do not have enough time to devote to exercise

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due to academic loading, which may result in uncontrolled body weight and poor sleep quality (16). In addition, there have been evidences that low socioeconomic status is related to obesity among children and adolescents (17,18).

There is a lack of research investigating the association between sleep duration and body mass index among Korean adolescents while for controlling academic factors and depressed mood. It is also difficult to evaluate sleep deficiency individually for participants, such as students, who have fixed schedules on weekdays. Therefore this study was designed to investigate the relationship between BMI and sleep duration, categorized as sleep duration on weekdays, weekends and weekend catch-up sleep; the study controlled for significant confounding factors, such as depressed mood, time spent at private tutoring institutes, academic performance, and socioeconomic status.

MATERIALS AND METHODS

Participants

Participants were recruited from middle and high schools in Incheon, Korea. Questionnaires were distributed to students at nine middle schools and seven high schools.

A total of 4,553 middle- and high-school students (grades 7-10) was recruited in this study. Finally 3,785 adolescents, of which 2,203 (58.2%) were males and 1,582 (41.8%) were females, completed entire questionnaires were included for analysis. The ages of the participants ranged from 11 to 18 years (mean age 15.26 ± 1.45 years). We obtained information regarding weekday sleep duration, weekend sleep duration, height, weight, time spent at private tutoring institutes, academic performance, socioeconomic status, and BDI scores (representing depressed mood) from the self-report questionnaire.

Assessment

Sleep durations on weekdays and weekends were assessed using a self-reported questionnaire. To determine sleep duration on weekdays, we included the question, "On average how many hours do you sleep on weekdays (Monday to Friday)?" The question used to determine sleep duration on weekends was "On average how many hours do you sleep on weekends (Saturdays or Sundays and holidays)?" Individual weekend catch-up sleep durations were calculated by subtracting the weekday sleep duration from the weekend sleep duration. BMI was calculated as weight/height^2 (kg/m^2). Both weight and height were obtained by means of open questions in the questionnaire.

The Korean version of the 21-item Beck Depression Inventory (BDI) was administered to evaluate the students' depressive symptoms. As in previous research, participants with a score of 10 or higher were defined as having depressed mood. The Korean version of BDI has been standardized and shown to have adequate reliability (19).

In addition, the self-report questionnaire included an item regarding the amount of time spent at private tutoring institutes and a self-report of academic performance that consisted of a Likert scale of 1-4, where 1 = among the top ten students in the class, 2 = 10th-20th place in the class, 3 = 20th-30th place in the class, and 4 = below 30th place in the class. The total time spent daily at private tutoring institutes was determined by asking students how many hours per day they time spent at private tutoring institutes.

Socioeconomic status (SES) was determined using a Likert scale of 1-5, where 1 = within the top 20 percent bracket for SES, 2 = in the 20%-40% bracket for SES, 3 = in the 40%-60% bracket for SES, 4 = in the 60%-80% bracket for SES, and 5 = within the bottom 20% bracket for SES.

Statistical analysis

Data analyses were performed using the Statistical Package for the Social Sciences (SPSS 16.0; SPSS Inc., Chicago, IL, USA). Means and standard deviations were calculated separately for each gender group as well as for the total group of participants. For comparisons between gender groups, independent *t*-tests were conducted for continuous variables, and the χ^2 test was used for categorical variables.

To analyze the relationship between sleep duration (weekdays, weekend and catch-up sleep duration) and BMI, we used a partial correlation analysis, controlling for age, gender, and BDI as confounding factors. Furthermore, a linear regression analysis was performed to investigate the relationship of weekday, weekend and catch-up sleep durations with BMI scores, controlling for the confounding factors of age, gender, BDI, socioeconomic status, academic performance, and time spent at private tutoring institutes. In all analyses, *P* values of less than 0.05 were considered to indicate statistical significance.

Ethics statement

Written informed consent was obtained from at least one parent of each participating student. Assent by participants was provided verbally. Before administering the questionnaires in the class, the school teachers distributed an information sheet that provided detailed information about our study to the participating students. Students were given the opportunity to ask any additional questions, and they were instructed to take their time to consider whether they wished to participate in the study and to indicate their decision. In the case of adolescents who were classified as high risk with respect to their mental health based on the self-report questionnaires, the participants themselves and their parents were notified of the results, and further psychiatric evaluation was recommended. The institutional review board of Gachon University of Medicine and Science approved the study protocol.

RESULTS

Comparisons of socio-demographic variables, sleep duration, BMI and BDI between males and females

Table 1 presents sleep duration (divided into weekdays, weekends and weekend catch-up sleep duration), socioeconomic status, self-reported academic performance, BMI, and BDI for the total group. The mean age for the total group was 15.26 ± 1.45 years and the mean sleep duration (in hours/day) was 7.03 ± 1.29 on weekdays, 8.86 ± 1.63 on weekends, and 1.83 ± 1.53 for weekend catch-up sleep. Sleep duration on weekdays was significantly longer for males (average sleep duration: 7.16 ± 1.22 [males], 6.86 ± 1.37 [females]; $t = 7.05$, $P < 0.001$). Sleep duration on weekends was significantly longer for females (average sleep duration: 8.78 ± 1.66 [males], 8.97 ± 1.58 [females]; $t = 3.52$, $P < 0.001$). The weekend catch-up sleep duration was significantly longer for females (average sleep duration: 1.62 ± 1.54 [males], 2.11 ± 1.47 [females]; $t = 9.76$, $P < 0.001$).

The average BMI among all participants was 20.26 ± 3.34 and was significantly higher among males (average BMI [kg/m^2]: 20.73 ± 3.62 [males], 19.61 ± 2.76 [females]; $t = 10.35$, $P < 0.001$). The average score on the BDI was 10.32 ± 7.43 and was significantly higher among females (average BDI: 9.01 ± 6.69 [males], 12.14 ± 8.01 [females]; $t = 13.03$, $P < 0.001$). The average time spent at private tutoring institutes for all participants was 2.97 ± 3.27 (hours/day). Males exhibited significantly longer time spent at private tutoring institutes (3.12 ± 3.41 [males], 2.76 ± 3.05 [females]; $t = 3.24$, $P < 0.001$). Academic performance was assessed using a Likert scale of 1-4 and the breakdown of scores for each gender was as follows: 1: 28.87%, 2: 35.11%, 3: 25.44%, 4: 10.59% (males) and 1: 28.68%, 2: 31.83%, 3: 27.97%, 4: 11.45% (females). Socioeconomic status was assessed using a Likert scale of 1-5 and the breakdown of scores for each gender was: 1: 1.97%, 2: 20.49%, 3: 59.52%, 4: 15.46%, 5: 2.56% (males) and 1: 0.83%, 2: 13.78%, 3: 69.39%, 4: 13.90%, 5: 2.10% (females) (Tables 1 and 2).

Correlations between sleep duration, scores on BDI and BMI controlling for age and gender

Weekday sleep duration, weekend sleep duration and weekend catch-up sleep were correlated with scores on BDI among the total group after controlling for age and gender ($r = -0.130$, $P < 0.001$; $r = -0.040$, $P = 0.015$; $r = 0.052$, $P = 0.001$, respectively). In males, weekday and weekend sleep duration were inversely correlated with BDI ($r = -0.179$, $P < 0.001$; $r = -0.051$, $P = 0.016$,

Table 2. The association between sleep duration and BMI for all participants

Variables	Total (n = 3,785)
Sleep duration on weekdays	
Adjusted R^2	0.043
β	-0.064
P	0.002
Sleep duration on weekends	
Adjusted R^2	0.044
β	-0.066
P	< 0.001
Weekend catch-up sleep	
Adjusted R^2	0.041
β	-0.033
P	0.056

Multiple linear regression; Dependent variables: BMI; Independent variables: age, gender, BDI, economic status, academic performance, time spent at private tutoring institutes.
BMI = Body Mass Index, BDI = Beck Depression Inventory.

Table 1. Comparisons of sociodemographic data, sleep duration, BMI and BDI between males and females

Parameters	Total (n = 3,785)	Males (n = 2,203)	Females (n = 1,582)	T/χ^2	*P* value
Age, yr	15.26 ± 1.453	15.39 ± 1.39	15.09 ± 1.52		
Sleep duration on weekdays, hr/day	7.03 ± 1.29	7.16 ± 1.22	6.86 ± 1.37	7.05	< 0.001
Sleep duration on weekends, hr/day	8.86 ± 1.63	8.78 ± 1,66	8.97 ± 1.58	3.52	< 0.001
Weekend catch-up sleep duration, hr/day	1.83 ± 1.53	1.62 ± 1.54	2.11 ± 1.47	9.76	< 0.001
Time at private tutoring institutes, hr/day	2.97 ± 3.27	3.12 ± 3.41	2.76 ± 3.05	3.24	< 0.001
Academic performance, No. (%)				48.24	< 0.001*
Among the top ten students in the class	1,076 (28.79)	630 (29.87)	446 (28.68)		
10th-20th in the class	1,261 (33.74)	766 (35.11)	495 (31.83)		
20th-30th in the class	990 (26.49)	555 (25.44)	435 (27.97)		
Below 30th in the class	409 (10.94)	231 (10.59)	178 (11.45)		
Socioeconomic status, No. (%)				7.13	0.211*
In the top 20 percent bracket for SES	56 (1.49)	43 (1.97)	13 (0.83)		
20%-40% bracket for SES	664 (17.69)	448 (20.49)	216 (13.78)		
40%-60% bracket for SES	2,389 (63.64)	1,301 (59.52)	1,088 (69.39)		
60%-80% bracket for SES	556 (14.81)	338 (15.46)	218 (13.90)		
In the bottom 20% bracket for SES	89 (2.37)	56 (2.56)	33 (2.10)		
BMI, kg/m^2	20.26 ± 3.34	20.73 ± 3.62	19.61 ± 2.76	10.35	< 0.001
BDI	10.32 ± 7.43	9.01 ± 6.69	12.14 ± 8.01	13.03	< 0.001

Values represent means ± SD; Analysis of *t*-test, equal variances assumed (Same results in equal variances not assumed).
BMI = Body Mass Index, BDI = Beck Depression Inventory.
*χ^2 test.

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respectively). However, weekend catch-up sleep was positively correlated with BDI (r = 0.086, P < 0.001). In females, weekday and weekend sleep duration were inversely correlated with BDI (r = -0.175, P < 0.001; r = -0.088, P < 0.001, respectively). Moreover, weekend catch-up sleep duration was correlated with BDI (r = -0.068, P = 0.007).

Weekday sleep duration, weekend sleep duration and weekend catch-up sleep were inversely correlated with BMI among the total group after controlling for age and gender (r = -0.051, P = 0.002; r = -0.066, P < 0.001; r = -0.034, P = 0.036, respectively). In males, weekday and weekend sleep duration were inversely correlated with BMI (r = -0.045, P = 0.033; r = -0.046, P = 0.030, respectively). However, weekend catch-up sleep was not correlated with BMI (r = -0.018, P = 0.401). In females, weekday and weekend sleep duration were inversely correlated with BMI (r = -0.067, P = 0.008; r = -0.109, P < 0.001, respectively). Moreover, weekend catch-up sleep duration was also inversely correlated with BMI (r = -0.065, P = 0.010).

After controlling for age and gender, scores on BDI was correlated with BMI (r = -0.030, P = 0.068) among the total group. In males, scores on BDI was correlated with BMI (r = 0.055, P = 0.009). In females, scores on BDI was not correlated with BMI (r = 0.028, P = 0.259).

The association between sleep duration and BMI

Table 2 presents associations between sleep duration (divided into weekdays, weekends and weekend catch-up sleep duration) and BMI for the total group. Sleep durations on weekdays and weekends were negatively associated with BMI for the total group of participants. However, weekend catch-up sleep duration was not associated with BMI in the linear logistic regression models with the independent variables of age, gender, BDI, economic status, academic performance and time spent at private tutoring institutes (β = -0.064, P = 0.002; β = -0.066, P < 0.001; β = -0.033, P = 0.056, respectively).

Table 3. The association between sleep duration and BMI for participants divided by gender

Variables	Males (n = 2,203)	Females (n = 1,582)
Sleep duration on weekdays		
Adjusted R^2	0.019	0.018
β	-0.055	-0.091
P	0.034	0.007
Sleep duration on weekends		
Adjusted R^2	0.020	0.023
β	-0.049	-0.105
P	0.027	< 0.001
Weekend catch-up sleep		
Adjusted R^2	0.018	0.016
β	-0.021	-0.057
P	0.343	0.038

Multiple linear regression; Dependent variables: BMI; Independent variables: age, BDI, economic status, academic performance, time spent at private tutoring institutes.
BMI = Body Mass Index, BDI = Beck Depression Inventory.

Table 3 presents the relationships between sleep duration and BMI in two groups divided by gender. In males, decreased weekday and weekend sleep durations were associated with high BMI (β = -0.055, P = 0.034; β = -0.049, P = 0.027; β = -0.021, respectively). Weekend catch-up sleep duration was not associated with BMI (β = -0.021, P = 0.343).

In females, decreased weekday and weekend sleep durations were associated with high BMI (β = -0.091, P = 0.007; β = -0.105, P < 0.001, respectively). Moreover, increased weekend catch-up sleep was also associated with low BMI (β = -0.057, P = 0.038).

DISCUSSION

In present study, we found that adolescents with longer weekday and weekend sleep durations tended to have lower BMI. Moreover, females with longer durations of weekend catch-up sleep tended to have lower BMI.

Several studies have investigated the relationship between sleep duration and being overweight (9,10,20). Our results are consistent with these previous studies. In a study of European adolescents, shorter sleep duration was associated with higher levels of adiposity markers including BMI, body fat, and waist circumferences (21). In the study of Norwegian adolescents, short sleep is associated with BMI, but the association was stronger in girls similarly to our results (22). Another study focused on the effect of weekend sleep compensation on weight with the results that increased weekend catch-up sleep may reduce the risk of overweight and obesity (23), which were partially consistent with the present results.

In spite of the fact that previous studies have been conducted, there has been few research controlling for academic factors and depressed mood. The association between depression and sleep duration cannot be neglected due to the relatively high prevalence of depression among adolescents (11). A meta-analysis of longitudinal studies reported the relationship between obesity and depression (15). Therefore, it is essential to investigate the relationship between sleep duration and BMI while adjusting for depressed mood. The current study may differ from those in that we focused on controlling for confounding factors that may affect both sleep duration and BMI in adolescents, such as time spent at private tutoring institutes, academic performance, socioeconomic factors, and BDI as a measure of depressed mood.

The relationship between short sleep duration and increased BMI may be explained by eating habits. Sleep restriction also affect adolescent by increasing appetite of sweet desserts which can contribute to body weight (24). In addition, students who sleep less tend to skip breakfast and this is also reported to be associated with an increase in BMI (25).

Furthermore, disturbances to natural circadian rhythms due to insufficient sleep may be another explanation for the link be-

tween sleep duration and BMI. Recent investigation suggests that habitual variation of sleep rhythms is associated with increased food consumption and disrupted metabolism (26). Abnormal sleep patterns change circadian body clocks and contribute to greater variation in circulating levels of nutrients and hormones. As a result of this variation at the molecular level, subsequent changes to mechanisms involving adipocytes may lead to greater weight gain (27). Moreover, other studies have shown that longer sleep duration has a physiological effect on leptin, which is a hormone involved in the control of appetite (28). Longer sleep duration reduces nighttime eating habits and helps the metabolism to function well, which may explain the association between sleep duration and BMI.

We found gender differences in sleep duration. On weekdays, males slept for an average of 7.16 hours, and the females slept less, for an average of 6.86 hours in the present study. Meanwhile, males slept for 8.78 hours on weekends and females slept slightly more—8.97 hours. Other research that analyzed sleep duration using time diaries reported similar results, indicating that females slept less on weekdays but more on weekends compared with males (29). They spend more time dressing and applying make-up and consequently have to get up earlier in the morning, thereby exacerbating the sleep deficit on school days.

Gender differences were also found in the association between sleep duration and BMI. Our results showed that weekend catch-up sleep was negatively associated with BMI for females, but not for males. It is consistent with prior result (30). There can be several possible reasons for this result. It is known that insufficient sleep heightens the activity of stress system (31). Stress may influence eating behavior and it also stimulates the production of a cortisol hormone that is related to obesity (32). Shorter sleep on weekdays in females may result in heightened stress system. Longer weekend catch-up sleep may have played a critical role in reducing stress. This effect is thought to be why longer weekend catch-up sleep is negatively related to low BMI. However males slept relatively longer on weekdays, thereby causing less avidity of stress system due to sleep deprivation, in addition to being generally more tolerant of stress than females (33). Moreover, the strongest gender differences among adolescents may be apparently derived from the effects of sex steroid hormones, which affect both metabolism and sleep quality (34,35). These hormonal differences may underlie the gender difference in the association between weekend catch-up sleep and BMI.

In contrast to this compensatory effect of weekend catch-up sleep on BMI in female adolescensts, some studies suggest that weekend catch-up sleep cannot mitigate the risk of psychological problem. In these studies, increased weekend catch-up sleep as an indicator of insufficient weekday sleep was associated with poor performance on attention tasks and with an increased risk of suicidality among adolescents (14,36). This suggests that there may be important differences between the psychological and physical effects of insufficient sleep in adolescence such that short term sleep compensation may be effective in promoting recovery related to the physical metabolism, but not to psychological problems.

This study has several limitations. First, the information on sleep duration gathered was by self-reported questionnaire rather than by objective measurement. Hence, we cannot rule out the possibility of recall bias. Second, our questionnaire did not address naps or daytime sleep. It would be helpful to design a questionnaire to take this issue into account. Third, height, weight, and information on socioeconomic status was self-reported. This information may be considered to be sensitive to adolescents. Objective measures of height and weight would allow for greater precision and accuracy. In addition, information on socioeconomic status by parents would be more accurate.

Despite these limitations, the present study makes a valuable research contribution due to its presentation of data from a large number of participants. The association between BMI and sleep duration (divided into weekdays, weekends and catch-up sleep on weekends) is analyzed by gender. Moreover, this study adjusts for time at private tutoring institutes, academic performance, socioeconomic factors, and BDI as significant confounders.

In conclusion, longer sleep durations on weekdays and weekends in adolescents were associated with lower BMI while adjusting for the confounding factors. Moreover, longer duration of weekend catch-up sleep correlates with decreased BMI for female adolescents. Weekend catch-up sleep may compensate effects of insufficient sleep on BMI for female adolescents.

DISCLOSURE

The authors have no potential conflicts of interest to disclose.

AUTHOR CONTRIBUTION

Study design and protocol: Lee YJ. Literature searches: Kang SG, Choi JW. Statistical analysis: Lee BH. Writing: Lee BH, Choi JW. Agreeing with manuscript results and conclusions: all authors.

ORCID

Ban Hyung Lee http://orcid.org/0000-0003-1629-9345
Seung-Gul Kang http://orcid.org/0000-0003-4933-0433
Jae-Won Choi http://orcid.org/0000-0002-4253-126X
Yu Jin Lee http://orcid.org/0000-0001-5195-2579

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