Original Article

Sleep duration's association with diet, physical activity, mental status, and weight among Korean high school students

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Background and Objectives: Sleep deprivation is a critical public health problem, especially in Korean adolescents. This study aimed to identify the association between sleep duration and dietary behaviors, physical activity, mental status, and nutritional status among high school students in South Korea. **Methods and Study Design:** Based on the data collected from the 2014 Korea Youth Risk Behavior Web-based Survey, 31,407 high school students who met the inclusion criteria were selected and the association between sleep duration and selected health risk factors was identified using multivariable logistic regression models. **Results:** The average daily sleep duration was 5.7 hours, and the mean BMI was 21.3 kg/m^2. Participants with shorter durations of sleep (<7 hours versus ≥7 hours of sleep) were more likely to feel sad or hopeless (adjusted OR, 1.09; 95% CI, 1.00-1.18), have suicidal ideation (adjusted OR, 1.13; 95% CI, 1.01-1.27), and feel much or very much stressed (adjusted OR, 1.82; 95% CI, 1.66-2.00). Moreover, shorter sleep was associated with less frequent muscle-strengthening exercises, ≥3 times per week (adjusted OR, 0.86; 95% CI, 0.78-0.94), and more frequent cracker consumption, ≥3 times per week (adjusted OR, 1.24; 95% CI, 1.13-1.35). **Conclusions:** High school students in South Korea suffer from extreme sleep deprivation; only 16% of the students were found to have ≥7 hours of sleep during weekdays. Sleep education should be provided to students to improve their physical and mental health.

Key Words: sleep deprivation, dietary behaviors, physical activity, obesity, Korean adolescents

INTRODUCTION

Sleep deprivation is one of the significant public health problems, especially among adolescents in South Korea. One study revealed that in South Korea, 16- to 19-year-old adolescents had the shortest weekday sleep duration (6.87 hours) compared with participants in other age groups: approximately 7.50 hours in those aged 20-50 years, 7.75 hours in those aged 60-69 years, and 8.35 hours in those aged more than 70 years.[1] In adolescents, total sleep duration markedly decreased with age.[2] Another study suggested that mean daily total sleep duration during weekdays was 6.02 hours for 10th graders, 5.62 hours for 11th graders, and only 4.86 hours for 12th graders.[3] The high school students reported that the main reasons for their sleep deprivation were academic pressure and early school start time. Sufficient sleep is critical for proper growth and development and better academic performance.

Sleep deprivation leads to deleterious health consequences. Previous studies have suggested that short sleep duration was associated with higher prevalence of obesity and increased BMI.[4-7] In addition, participants with a short sleep duration were more likely to have higher levels of cholesterol and triglycerides than those with long sleep duration.[8] For a better understanding of the mechanisms involved in sleep deprivation that lead to obesity, it is critical to know how sleep deprivation affects health related behaviors. However, comprehensive research on the current status of sleep deprivation, sleep-related health risk behaviors, and mental status is lacking.

In South Korea, most sleep-related research has focused on adults and has covered various topics such as sleep and obesity, sleep and self-rated health, and sleep and metabolic risk factors.[9-11] However, little is known about how dietary behaviors, physical activity, and mental status are associated with sleep deprivation among adolescents in South Korea. Given the extremely short duration of sleep in adolescents and its harmful health consequences, it is critical to determine the factors associated with sleep deprivation among high school students in South Korea. We investigated two research questions: (1) How dietary behaviors, physical activity, and mental status differ with sleep duration? (2) What is the association between short sleep duration and increased BMI and obesity in Korean high school students?

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MATERIALS AND METHODS

Survey design

The 10th Korea Youth Risk Behavior Web-based Survey was conducted in South Korea in 2014, in which 72,060 middle and high school students were examined.[12] The survey employed multistage, clustering, and stratified sampling options. The dataset comprised a nationally representative sample of Korean adolescents. This study was approved by the Institutional Review Board of the Korea National Institute for Bioethics Policy, South Korea (P01-201507-23-002).

Participants

A total of 35,904 high school students were enrolled in the study and excluded those who did not meet the inclusion criteria; that is, those without anthropometric data (n=1,125), those without sleep duration data (n=3,359), and those out of the age range of 15-18 years (n=13). Thus, the study group comprised 31,407 students.

Demographic and socioeconomic characteristics

The demographic characteristics of participants were assessed, including gender, age (in years), year of high school, and school type (academic high school or vocational high school). Moreover, the perceived economic statuses were evaluated and classified into the following levels: 1) low, 2) lower middle, 3) middle, 4) upper middle, and 5) high. The education levels of the parents of participants were categorized into four groups: 1) middle school or less, 2) high school, 3) college or more, and 4) unknown.

Anthropometric measures

The BMI of participants was calculated by dividing their weight in kilograms by their height in meters squared (kg/m^2). According to age and gender, the participants were classified into four categories, namely underweight, normal weight, overweight, and obese, following the extended international BMI cut-off criteria set for children by the World Obesity Federation.[13]

Sleep duration

Participants were asked their bedtime and wake-up time during the last five weekdays. Sleep duration was calculated by subtracting the bedtime from the wake-up time. The hours of sleep per day were classified into four groups: <5, 5-5.99, 6-6.99, and ≥7 hours.

Dietary behaviors

To evaluate dietary behaviors, the participants were asked the frequency of milk consumption during the past seven days. The responses were categorized into four groups: 1) none, 2) 1-2 times, 3) 3-4 times, and 4) ≥5 times. Moreover, the participants were asked what was their frequency of consumption of the following food items during the past seven days: 1) highly caffeinated drink, 2) fast food, and 3) crackers? The answers to this question were classified into three groups: 1) none, 2) 1-2 times, and 3) ≥3 times.

Physical activity

The frequency of performing physical activity for ≥60 minutes during the past seven days was assessed. The responses were classified into five groups: 1) none, 2) 1-2 days, 3) 3-4 days, 4) 5-6 days, and 5) daily. The frequency of performing vigorous exercise and muscle-strengthening exercises during the past seven days was evaluated. The answers were categorized into four groups: 1) none, 2) 1-2 days, 3) 3-4 days, and 4) ≥5 days. Vigorous exercises were defined as exercises that were accompanied by sweating and very fast breathing. Muscle-strengthening exercises included push-ups, sit-ups, weight lifting, and exercise on the parallel bar or the horizontal bar.

Mental status

The depressive mood of participants by feelings of sadness or hopelessness was assessed. We also evaluated their suicidal ideation during the past year. The responses of participants on "feeling sad or hopeless" and "having suicidal ideation" into two groups: 1) no and 2) yes were categorized. The participants were queried about how much stress they felt in their daily life. The degree of feeling stressed was classified into three groups: 1) never or rarely stressed, 2) a little stressed, and 3) much or very much stressed.

Data analysis

Data management and analysis were conducted using SPSS version 21.0 (SPSS Inc., Chicago, IL). The differences in dietary behaviors, physical activity, and mental status by sleep duration were determined using χ^2 tests. The adjusted OR (AOR) and 95% CI to identify the association between short sleep duration and selected health risk behaviors by using multivariable logistic regression models was calculated.[14] The relationship between short sleep duration and overweight and obesity after adjusting for age and gender was also assessed.[15] Short sleep duration was defined as <7 hours of sleep per day. $p<0.05$ was considered statistically significant in the data analyses.

RESULTS

Demographic characteristics of participants

The total number of participants was 31,407, of which 49.3% were males and 50.7% were females. The mean age of participants was 16.4 years (ranging from 15 to 18 years) (Table 1). Based on the education levels of the parents of participants, the highest proportion of fathers belonged to college or higher education group (48.3%), whereas the highest proportion of mothers belonged to the high school education group (44.8%). Most participants (84.1%) belonged to academic high schools.

Sleep and anthropometric characteristics of participants

The average daily sleep duration was 5.7 hours, and the mean BMI was 21.3 kg/m^2 (Table 1). The proportions of daily sleep duration during weekdays were as follows: 5-5.99 hours (33.8%), 6-6.99 hours (26.9%), <5 hours (23.7%), and ≥7 hours (15.7%). The proportions of participants based on the extended international BMI cut-off criteria set for children by the World Obesity Federation were as follows: normal weight (58.3%), overweight (16.1%), obese (15.4%), and underweight (10.2%).

Table 1. Demographic, sleep, and anthropometric characteristics of participants

	Total (n=31,407)
Gender	
Men	15478 (49.3)
Women	15929 (50.7)
Age (years)	16.4±0.94
Perceived economic status	
High	1594 (5.1)
Upper middle	7102 (22.6)
Middle	15661 (49.9)
Lower middle	5587 (17.8)
Low	1463 (4.7)
Father's education (n=30136)†	
Middle school or less	1139 (3.6)
High school	10824 (34.5)
College or more	15179 (48.3)
Don't know	2994 (9.5)
Mother's education (n=30241)‡	
Middle school or less	1005 (3.2)
High school	14080 (44.8)
College or more	12190 (38.8)
Don't know	2966 (9.4)
Year of high school	
1st year	10284 (32.7)
2nd year	10659 (33.9)
3rd year	10464 (33.3)
School type	
Academic high school	26412 (84.1)
Vocational high school	4995 (15.9)
Number of hours of sleep during weekdays	5.67±1.16
Sleep duration during weekdays	
<5 hours	7431 (23.7)
5-5.99 hours	10603 (33.8)
6-6.99 hours	8442 (26.9)
≥7 hours	4931 (15.7)
Anthropometric characteristics	
BMI	21.3±3.00
Nutritional status	
Underweight	3191 (10.2)
Normal weight	18310 (58.3)
Overweight	5071 (16.1)
Obese	4835 (15.4)

n (%) or mean±SD
†Limited to participants who had a father.
‡Limited to participants who had a mother.

Dietary behaviors by sleep duration

Approximately one in every three participants (34.1%) drank milk ≥5 times during the past seven days (Supplementary Table 1). The proportion of participants who drank milk ≥5 times was lowest in the <5 hours of the sleep group (32.7%) compared with that in the ≥7 hours of the sleep group (35.7%) (p<0.01). The majority of participants (88.8%) consumed no highly caffeinated drinks during the past seven days. However, the percentage of consumption of highly caffeinated drink ≥3 times during the past seven days was 4.2% in the <5 hours of the sleep group, which was significantly higher than that in the other sleep duration groups (p<0.001). Moreover, the percentage of participants who consumed crackers ≥3 times during the past seven days was highest in the <5 hours of the sleep group (38.8%) compared with that in the ≥7 hours of the sleep group (32.6%) (p<0.01).

Physical activity by sleep duration

Only 5% of participants performed ≥60 minutes of daily physical activity during the past seven days; the <5 hours of the sleep group had a lower percentage (3.9%) of daily physical activity than the ≥7 hours of the sleep group (6.8%) (Supplementary table 1). Similarly, the percentage of those who performed vigorous exercise ≥5 days during the past seven days was lowest in the <5 hours of the sleep group (10.1%) compared with that in the ≥7 hours of the sleep group (16.0%) (p<0.001). Moreover, the proportion of those who performed muscle-strengthening exercises ≥5 days during the past seven days was the lowest in the <5 hours of the sleep group (8.9%) compared with that in the ≥7 hours of the sleep group (12.6%) (p<0.001).

Mental status by sleep duration

We investigated the relationship between mental status and sleep duration (Supplementary table 2). More participants expressed a depressive mood by feeling sad or hopeless during the past year (p<0.001): 35.7% in the <5 hours of the sleep group, 29.2% in the 5-5.99 hours of the sleep group, 24.9% in the 6-6.99 hours of the sleep group, and 23.1% in the ≥7 hours of the sleep group. Suicidal ideation during the past year also displayed a similar pattern. The proportion of suicidal ideation was the highest in the <5 hours of the sleep group (16.7%), followed by 12.3% in the 5-5.99 hours of the sleep group, 10.4% in the 6-6.99 hours of the sleep group, and 9.2% in the ≥7 hours of the sleep group (p<0.001). When measuring the degree of feeling stressed in daily life, the proportion of participants who felt much or very much stressed was the highest in the <5 hours of the sleep group (51.8%), followed by 41.8% in the 5-5.99 hours of the sleep group, 35.6% in the 6-6.99 hours of the sleep group, and 30.8% in the ≥7 hours of the sleep group (p<0.001).

Body mass index by sleep duration and gender

We observed a marked difference in association between BMI and sleep deprivation in males and females (Figure 1). For males, BMI was the highest in the <5 hours of the sleep group (22.1 kg/m^2), followed by 21.8 kg/m^2 in the 5-5.99 hours of the sleep group, 21.7 kg/m^2 in the 6-6.99 hours of the sleep group, and 21.4 kg/m^2 in the ≥7 hours of the sleep group. However, BMI varied to a lesser extent with sleep duration in case of females than in males: 21.0 kg/m^2 in the <5 hours of the sleep group and 20.8 kg/m^2 in the ≥7 hours of the sleep group.

Associations of overweight and obesity with short sleep duration

Short sleeping duration was associated with overweight and obesity after adjustment for age and gender (Supplementary table 3). In the multivariable logistic regression model that used participants who slept for <5 hours as a reference, overweight and obese participants (versus normal-weight participants) had higher odds of shorter sleep duration: 5-5.99 hours of sleep (AOR, 0.90; 95% CI, 0.84-0.96), 6-6.99 hours of sleep (AOR, 0.91; 95% CI, 0.85-0.97), and ≥7 hours of sleep (AOR, 0.88; 95% CI, 0.81-0.95).

Table 2. Adjusted likelihood of selected health risk factors by sleep duration

Variables	Adjusted OR (95% CI)† (≥7 hrs is the referent)
Frequency of highly caffeinated drink consumption during the past 7 days	
None	1.00
1-2 times	0.95 (0.85-1.06)
≥3 times	0.94 (0.78-1.13)
Frequency of fast-food consumption during the past 7 days	
None	1.00
1-2 times	1.06 (0.98-1.14)
≥3 times	1.02 (0.92-1.13)
Frequency of cracker consumption during the past 7 days	
None	1.00
1-2 times	1.12 (1.03-1.22)**
≥3 times	1.24 (1.13-1.35)***
Doing physical activity for ≥60 minutes during the past 7 days	
None	1.00
1-2 days	1.08 (1.00-1.17)
≥3 days	1.06 (0.96-1.17)
Doing vigorous exercise during the past 7 days	
None	1.00
1-2 days	1.09 (1.00-1.19)
≥3 days	1.01 (0.91-1.12)
Doing muscle strengthening exercises during the past 7 days	
None	1.00
1-2 days	0.84 (0.77-0.90)***
≥3 days	0.86 (0.78-0.94)**
Feeling sad or hopeless during the past year	
No	1.00
Yes	1.09 (1.00-1.18)*
Suicidal ideation during the past year	
No	1.00
Yes	1.13 (1.01-1.27)*
Degree of feeling stressed	
Never/rarely stressed	1.00
A little stressed	1.39 (1.28-1.51)***
Much/very much stressed	1.82 (1.66-2.00)***

†Odds ratio (OR) and 95% confidence interval (CI) adjusted for age and gender.
*p<0.05, **p<0.01, ***p<0.001 significantly different according to the logistic regression model.

Associations of health risk factors with short sleep duration

Insufficient sleep (<7 hours of sleep) was associated with the following health risk factors: consumption of crackers, performance of muscle-strengthening exercises, feeling of sadness or hopelessness, suicidal ideation, and feeling of stress (Table 2). Participants who slept for <7 hours (versus participants who slept for ≥7 hours) had higher odds of a depressive mood: feelings of sadness or hopelessness (AOR, 1.09; 95% CI, 1.00-1.18), suicidal ideation (AOR, 1.13; 95% CI, 1.01-1.27), and feeling much or very much stressed (AOR, 1.82; 95% CI, 1.66-2.00). However, participants who slept for <7 hours had lower odds of performing muscle-strengthening exercises during the past seven days (AOR, 0.86; 95% CI, 0.78-0.94). Participants with a shorter sleep duration (<7 hours of sleep) were more likely to consume crackers: 1-2 times during the past seven days (AOR, 1.12; 95% CI, 1.03-1.22) and ≥3 times during the past seven days (AOR, 1.24; 95% CI, 1.13-1.35).

DISCUSSION

This study reported that high school students in South Korea had extremely short sleep hours during weekdays. It was found that the average amount of sleep per night during weekdays was only 5.67 hours. The American Academy of Pediatrics recommends 8.5-9.5 hours of sleep as the optimal level of sleep for adolescents.[16] Consistent with other studies, the present research demonstrated that overweight and obese participants had significantly shorter sleep duration compared with normal-weight participants.[4-7]

Short sleep durations result in increased snacking. This study revealed that participants with insufficient sleep (<7 hours of sleep) were more likely to consume crackers

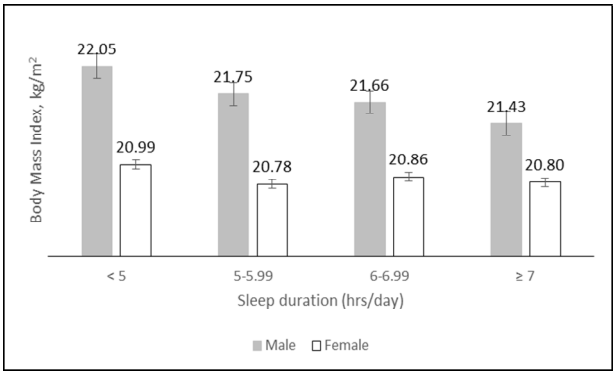

Figure 1. Association of body mass index with sleep duration and gender.

than those with sufficient sleep (≥7 hours of sleep). Crackers, mainly considered a popular snack food, are generally composed of ingredients rich in carbohydrates and sugars. One study indicated that sleep restriction (<5.5 hours per day) significantly increased energy intake from snacks and a higher amount of carbohydrates was mainly consumed between 7 PM and 7 AM.[17] Under circumstances of emotional distress, people tend to consume more sweets and carbohydrates.[18] Several studies found that disrupted and restricted sleep significantly increased the risk of major depression and stress.[19-23] Sleep deprivation activates the stress system and elevates the levels of stress hormones, including cortisol and adrenaline. A lack of sleep could also lead to increased sensitivity to the feeling of depression by increasing cortisol release and the hypothalamic-pituitary-adrenal axis activity.[23] Sleep deprivation leads to changes in hormone levels (decreased levels of leptin and increased levels of ghrelin), which in turn increases appetite and results in obesity.[24,25] Leptin and ghrelin, two important hormones in appetite regulation, have opposing functions; leptin is an appetite suppressor, whereas ghrelin is an appetite promoter. A shorter sleep duration was also associated with increased hunger in healthy young men and a higher intake of energy-dense foods among school children.[26,27] Sleep deprivation leads to a positive energy balance because of a higher energy intake and lower energy expenditure.

Insufficient sleep causes reduced physical exercise and activity and hence reduced energy expenditure. This research demonstrated that participants with insufficient sleep (<7 hours) were less likely to do muscle-strengthening exercises than those with sufficient sleep (≥7 hours). Sleep deprivation leads to a decrease in people's motivation to exercise because of increased fatigue and tiredness.[28] One experimental study indicated that male adults with restricted sleep had significantly decreased daytime physical exercise.[29] Moreover, sleep deprivation resulted in reduced energy expenditure by decreasing non-exercise activity thermogenesis.[30]

This empirical research has a number of strengths. First, a dataset was used that included a nationally representative sample of adolescents from the Korea Youth Risk Behavior Web-based Survey. Second, a comprehensive study was conducted to assess the association between sleep duration and health risk factors (i.e., dietary behaviors, physical activity, and mental status). Third, the BMI criteria used was set by the World Obesity Federation. This allowed international comparisons of the prevalence estimates.[31]

However, this study has a few limitations. First, the analysis of dietary behaviors could not measure the quantitative amount of macronutrients and micronutrients in the food intake. Second, the analysis of physical activity could not provide quantitative data on energy expenditure. Third, although the associations between sleep duration and health risk factors were identified, it was not possible to determine the causal relationships between sleep duration and the nutritional status because of the nature of the cross-sectional study design. Thus, future studies should use: 1) a 24-hour recall interview to measure food consumption, 2) a physical activity diary to assess physical activity and energy expenditure, and 3) a longitudinal study to identify the causal relationship between sleep duration and nutritional status.

This study revealed that one of three participants (33.8%) had 5-5.99 hours of weekday sleep and only 16% of participants had ≥7 hours of weekday sleep. The results of this research offer a few policy and program implications. First, the school start time could be delayed, as this should have a positive effect on the physical health and the mental status of adolescents. In high schools in Korea, the mean school start time is 7:30 am.[32] In addition, most high schools have a night self-study program that starts after regular classes and ends at 10:00 pm.[33] One study reported that the third-year high school students stayed longer, until 11:00 pm, for the self-study program.[34] The American Academy of Pediatrics argued that school start times earlier than 8:30 am would be a contributing factor to sleep deprivation.[16] Therefore, they suggested that school districts strive to adjust school start times, so that high school students get the optimal amount of sleep in the US. Second, healthcare professionals should provide sleep education to high school students and their families with regard to the significance of sleep and its effect on diet, physical activity, and mental status. To improve the health status of adolescents, it is recommended that high schools in South Korea have school intervention programs in place and urgently implement policies such as sleep education and delayed school times.

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AUTHOR DISCLOSURES

The author declares no conflict of interest.

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Supplementary table 1. Changes in dietary behaviors and physical activity with increasing sleep duration

	<5 hrs (n=7,431)	5-5.99 hrs (n=10,603)	6-6.99 hrs (n=8,442)	≥7 hrs (n=4,931)	Total (n=31,407)	χ^2-value
Frequency of milk consumption during the past 7 days						
None	1563 (21.0)	2132 (20.1)	1574 (18.6)	907 (18.4)	6176 (19.7)	27.1*
1-2 times	1923 (25.9)	2678 (25.3)	2167 (25.7)	1246 (25.3)	8014 (25.5)	
3-4 times	1516 (20.4)	2187 (20.6)	1783 (21.1)	1019 (20.7)	6505 (20.7)	
≥5 times	2429 (32.7)	3606 (34.0)	2918 (34.6)	1759 (35.7)	10712 (34.1)	
Frequency of highly caffeinated drink consumption during the past 7 days						
None	6405 (86.2)	9485 (89.5)	7631 (90.4)	4357 (88.4)	27878 (88.8)	103**
1-2 times	712 (9.6)	846 (8.0)	641 (7.6)	430 (8.7)	2629 (8.4)	
≥3 times	314 (4.2)	272 (2.6)	170 (2.0)	144 (2.9)	900 (2.9)	
Frequency of fast-food consumption during the past 7 days						
None	1651 (22.2)	2435 (23.0)	1908 (22.6)	1195 (24.2)	7189 (22.9)	18.9*
1-2 times	4543 (61.1)	6538 (61.7)	5295 (62.7)	2987 (60.6)	19363 (61.7)	
≥3 times	1237 (16.6)	1630 (15.4)	1239 (14.7)	749 (15.2)	4855 (15.5)	
Frequency of cracker consumption during the past 7 days						
None	1261 (17.0)	1662 (15.7)	1523 (18.0)	995 (20.2)	5441 (17.3)	87.2**
1-2 times	3288 (44.2)	5029 (47.4)	3925 (46.5)	2328 (47.2)	14570 (46.4)	
≥3 times	2882 (38.8)	3912 (36.9)	2994 (35.5)	1608 (32.6)	11396 (36.3)	
Doing physical activity for ≥ 60 minutes during the past 7 days						
None	2943 (39.6)	3896 (36.7)	2875 (34.1)	1680 (34.1)	11394 (36.3)	171**
1-2 days	2621 (35.3)	3853 (36.3)	3023 (35.8)	1679 (34.0)	11176 (35.6)	
3-4 days	1129 (15.2)	1802 (17.0)	1505 (17.8)	848 (17.2)	5284 (16.8)	
5-6 days	451 (6.1)	645 (6.1)	650 (7.7)	390 (7.9)	2136 (6.8)	
Daily	287 (3.9)	407 (3.8)	389 (4.6)	334 (6.8)	1417 (4.5)	
Doing vigorous exercise during the past 7 days						
None	2395 (32.2)	3015 (28.4)	2085 (24.7)	1215 (24.6)	8710 (27.7)	240**
1-2 days	3068 (41.3)	4514 (42.6)	3644 (43.2)	2001 (40.6)	13227 (42.1)	
3-4 days	1214 (16.3)	1955 (18.4)	1620 (19.2)	926 (18.8)	5715 (18.2)	
≥5 days	754 (10.1)	1119 (10.6)	1093 (12.9)	789 (16.0)	3755 (12.0)	
Doing muscle strengthening exercises during the past 7 days						
None	4191 (56.4)	5621 (53.0)	4141 (49.1)	2157 (43.7)	16110 (51.3)	228**
1-2 days	1769 (23.8)	2803 (26.4)	2364 (28.0)	1498 (30.4)	8434 (26.9)	
3-4 days	806 (10.8)	1137 (10.7)	1016 (12.0)	653 (13.2)	3612 (11.5)	
≥5 days	665 (8.9)	1042 (9.8)	921 (10.9)	623 (12.6)	3251 (10.4)	

n (%).
*p<0.01, **p<0.001 significantly different.

Supplementary table 2. Changes in mental health status with increasing sleep duration

	<5 hrs (n=7,431)	5-5.99 hrs (n=10,603)	6-6.99 hrs (n=8,442)	≥7 hrs (n=4,931)	Total (n=31,407)	χ^2-value
Feeling sad or hopeless						
No	4775 (64.3)	7511 (70.8)	6337 (75.1)	3793 (76.9)	22416 (71.4)	316**
Yes	2656 (35.7)	3092 (29.2)	2105 (24.9)	1138 (23.1)	8991 (28.6)	
Suicidal ideation						
No	6187 (83.3)	9298 (87.7)	7564 (89.6)	4477 (90.8)	27526 (87.6)	207**
Yes	1244 (16.7)	1305 (12.3)	878 (10.4)	454 (9.2)	3881 (12.4)	
Degree of feeling stressed						
Never/rarely stressed	777 (10.5)	1433 (13.5)	1525 (18.1)	1137 (23.1)	4872 (15.5)	850**
A little stressed	2805 (37.7)	4735 (44.7)	3914 (46.4)	2276 (46.2)	13730 (43.7)	
Much/very much stressed	3849 (51.8)	4435 (41.8)	3003 (35.6)	1518 (30.8)	12805 (40.8)	

n (%).
**p<0.001 significantly different.

Supplementary table 3. Effect of sleep duration on overweight and obese high school students compared with normal-weight participants

Variables	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Sleep duration (hrs/day)		
<5.00	1.00	1.00
5.00-5.99	0.98 (0.91-1.04)	0.90 (0.84-0.96)*
6.00-6.99	1.05 (0.98-1.12)	0.91 (0.85-0.97)*
≥7.00	1.06 (0.98-1.15)	0.88 (0.81-0.95)*
Age (yrs)		
15	1.00	1.00
16	0.84 (0.78-0.90)**	0.83 (0.78-0.89)**
17	0.80 (0.75-0.86)**	0.79 (0.74-0.85)**
18	0.72 (0.66-0.78)**	0.69 (0.63-0.75)**
Gender		
Men	1.00	1.00
Women	0.52 (0.49-0.55)**	0.51 (0.49-0.54)**

*$p<0.01$, **$p<0.001$ significantly different according to the logistic regression model.