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Physical Activity, Study Sitting Time, Leisure Sitting Time, and Sleep Time Are Differently Associated With Obesity in Korean Adolescents

A Population-Based Study

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Abstract: Low physical activity, long leisure sitting time, and short sleep time are risk factors for obesity, but the association with study sitting time is unknown. The objective of this study was to evaluate the association between these factors and obesity.

We analyzed the association between physical activity, study sitting time, leisure sitting time, and sleep time and subject weight (underweight, healthy weight, overweight, and obese), using data from a large population-based survey, the 2013 Korea Youth Risk Behavior Web-based Survey. Data from 53,769 participants were analyzed using multinomial logistic regression analyses with complex sampling. Age, sex, region of residence, economic level, smoking, stress level, physical activity, sitting time for study, sitting time for leisure, and sleep time were adjusted as the confounders.

Low physical activity (adjusted odds ratios [AORs] = 1.03, 1.12) and long leisure sitting time (AORs = 1.15, 1.32) were positively associated with overweight and obese. Low physical activity (AOR = 1.33) and long leisure sitting time (AOR = 1.12) were also associated with underweight. Study sitting time was negatively associated with underweight (AOR = 0.86) but was unrelated to overweight (AOR = 0.97, 95% confidence interval [CI] = 0.91–1.03) and obese (AOR = 0.94, 95% CI = 0.84–1.04). Sleep time (<6 hours; ≥6 hours, <7 hours; ≥7 hours, <8 hours) was adversely associated with underweight (AORs = 0.67, 0.79, and 0.88) but positively associated with overweight (AORs = 1.19, 1.17, and 1.08) and obese (AORs = 1.33, 1.36, and 1.30) in a dose–response relationship.

In adolescents, increasing physical activity, decreasing leisure sitting time, and obtaining sufficient sleep would be beneficial in maintaining a healthy weight. However, study sitting time was not associated with overweight or obese.

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Abbreviations: AORs = adjusted odd ratio, CI = confidence interval, KCDC = the Korean Centers for Disease Control and Prevention, KYRBWS = the Korea Youth Risk Behavior Web-based Survey, OR = odd ratio.

INTRODUCTION

In the United States, childhood and adolescent obesity has tripled from 5% in 1971 to 1974 to 17% in 2009 to 2010.[1] In Korea, childhood and adolescent obesity has increased from 5.8% in 1997 to 9.7% in 2005.[2] In a modernized society, the need for physical activity decreases.[3] The development of television and the personal computer has increased the likelihood of long sitting times.[4,5] Moreover, chronic sleep deprivation is becoming epidemic worldwide.[6] Many studies have shown that these risk factors contribute to increasing obesity in adults and adolescents.

Physical activity is associated with obesity in a dose–response relationship.[7,8] Sedentary behavior, such as sitting or reclining, is associated with obesity in adolescents.[3,9,10] Moreover, sedentary behavior is associated with obesity independent of physical activity.[11] Sleep deprivation is another risk factor for obesity.[12] The increasing prevalence of sleep deprivation coincides with an increased incidence of obesity.[13] Physical activity, sedentary behavior, and sleep time are distributed in a 24-hour day. Therefore, these factors are associated with one another.[14]

In the present study, we evaluated 4 different types of behaviors (physically active day, study sitting time, leisure sitting time, and sleep time) and their association with adolescent weight using a large, nationwide, population-based sample. We hypothesized that lower physical activity, higher sitting time for study or leisure, and short sleep time would be associated with obesity. To the best of our knowledge, this study is the first to differentiate between types of sitting time (ie, study and leisure) and to evaluate their association with obesity.

MATERIALS AND METHODS

Study Population and Data Collection

The ethics committee of the Korean Centers for Disease Control and Prevention (KCDC) approved the survey. Written informed consent was obtained from each student's parents for use in the survey.

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This cross-sectional study relied on data from the Korea Youth Risk Behavior Web-based Survey (KYRBWS). The study focused on 1 nation using statistical methods based on complex sampling and adjusted, weighted values. The KYRBWS conducted in 2013 were analyzed. These data were collected by the KCDC. Korean adolescents from the 7th through 12th grades voluntarily and anonymously completed the self-administered questionnaire. The survey response rate was 96.4%. The validity and reliability of the KYRBWS were documented by other studies.[15,16] The surveys evaluated the data using stratified, 2-stage (schools and classes) clustered sampling based on data from the Education Ministry. The sample was weighted by statisticians who performed poststratification and considered nonresponse rates and extreme values.

Of a total of 72,435 participants, the following participants were excluded from the study: participants who did not complete the sleep time question or who slept fewer than 2 hours (n = 14,933 participants); participants who did not record the study sitting time or leisure sitting time (n = 2403 participants); and participants who did not record their height or weight (n = 1330 participants). A total of 53,769 participants (n = 26,819 males; n = 26,950 females), ranging in age from 12 to 18 years, were included in the study (Figure 1).

SURVEY

Independent Variables

Days of physical activity was measured by the number of days of exercise that lasted more than 60 min, a sufficient time to increase the heart rate or respiration, in the last 7 days. Because the mean days of physical activity was 1.9, physical activity was divided into 2 days or less (low physical activity group) and more than 2 days (high physical activity group). Study sitting time and leisure sitting time in the last 7 days were also recorded. Study sitting time included sitting time while at school or a private institution, while using a computer for studying and while watching educational broadcasting. Leisure sitting time included watching TV, playing videogames, surfing the internet for nonstudy purposes, and interacting with friends. Study sitting time was measured in hours and minutes. The mean daily sitting time was calculated by adding the week-day and weekend sitting times with 5/7 and 2/7 weights, respectively. The mean study sitting time and mean leisure sitting time were 6.3 and 3.0 hours, respectively. Thus, study sitting time was divided into 6 hours or less (short study sitting group) and more than 6 hours (long study sitting group), and leisure sitting time was divided into 3 hours or less (short leisure sitting group) and more than 3 hours (long leisure sitting group). Sleep time in the last 7 days was also evaluated. The times to fall asleep and wake up were measured to within 10 min. Duration of sleep time was calculated by subtracting the falling asleep time from the wake-up time. The mean daily sleep time was calculated by adding week-day and weekend sleep times with 5/7 and 2/7 weights, respectively. Sleep time was divided into 4 groups: <6 hours; ≥ 6 hr, <7 hr; ≥ 7 hr, <8 hr; and ≥ 8 hr.

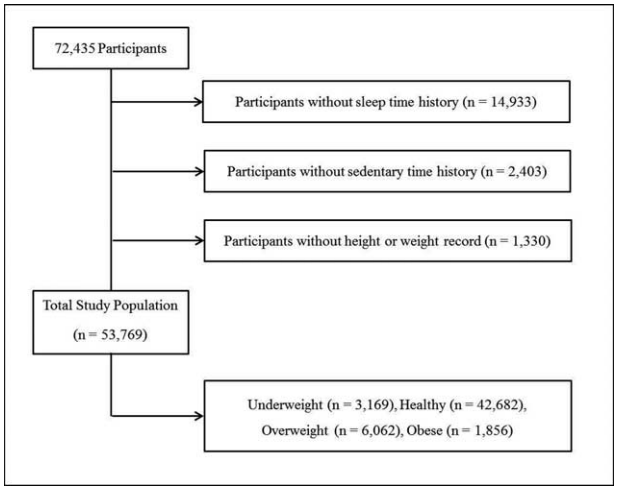

FIGURE 1. A schematic illustration of participant selection in the present study. Among a total of 72,435 participants ages 12 to 18 years, individuals with incomplete survey data were excluded from the study. The data of the 53,769 participants from whom complete data were obtained were analyzed.

Dependent Variables

The obesity levels were categorized into 4 groups according to the Centers for Disease Control and Prevention guidelines regarding body mass index (kg/m^2) for children and teens[17]: obese $\geq$95th percentile; overweight $\geq$85th percentile and $<$95th percentile; healthy weight $\geq$5th percentile and $<$85th percentile; and underweight $<$5th percentile.

Confounding Variables

Region of residence was divided into 3 groups according to administrative district: large city; small city; and rural area. Economic level was categorized into 5 levels from highest to lowest. Participants were asked how many days they had smoked in the last month, and the question was categorized into the following 4 groups: 0 days a month; 1 to 5 days a month; 6 to 19 days a month; and $\geq$20 days a month. The stress level of the participants was divided into 5 groups: severe, moderate, mild, a little, and no stress.

Statistical Analysis

Differences in mean age, physical exercise day, study sitting time, and leisure sitting time among underweight, healthy weight, overweight, and obese subjects were compared using linear regression analysis with complex sampling. The rate differences in sleep time, sex, region of residence, economic level, smoking, and stress level were compared using chi-squared tests with Rao–Scott correction.

Odd ratios (ORs) were calculated for days of physical exercise, study sitting time, leisure sitting time, and sleep time using the following methods: simple multinomial logistic regression with complex sampling (unadjusted); multinomial logistic regression with complex sampling adjusted for age and sex (model 1); multinomial logistic regression with complex sampling adjusted for model 1 plus region of residence, economic level, smoking, and stress level (model 2); and multinomial logistic regression with complex sampling adjusted for model 2 plus physical activity, study sitting time, leisure sitting time, and sleep time (model 3).

Two-tailed analyses were conducted, and P values <0.05 were considered to indicate statistical significance. Adjusted odd ratios (AORs) and 95% confidence intervals (CIs) were calculated. After applying the weighted values recommended by the KYRBWS, all of the results were recorded as weighted values. The results were statistically analyzed using SPSS v. 21.0 (IBM, Armonk, NY).

RESULTS

Of total 53,769 participants, there were 3169 (5.9%) underweight, 42,682 (79.4%) healthy weight, 6062 (11.3%) overweight, and 1856 (3.5%) obese subjects. The mean age, physical activity, and sitting time for study and leisure were different among the weight categories. In the obese group, the proportion of subjects with at least 8 hours of sleep was highest, and the proportion with <6 hours of sleep was lowest. The obese group showed the highest male rate. The proportion of the highest and middle-high economic level was highest in the obese group. The smoking rate was highest in the underweight group (all $P < 0.001$; Table 1).

In the unadjusted model, compared with the healthy weight group, low physical activity (≤2 days) was positively associated with underweight (OR = 1.28) and negatively associated with overweight (OR = 0.86) and obese (OR = 0.72). Study sitting time (>6 hours) was negatively associated with underweight (OR = 0.88), overweight (OR = 0.82), and obese (OR = 0.61). Leisure sitting time (>3 hours) was positively associated with underweight (OR = 1.09), overweight (OR = 1.12), and obese (OR = 1.21). Obtaining <6 hours (OR = 0.63) or between 6 and 7 hours of sleep (OR = 0.79) was negatively associated with the obese group (both $P < 0.001$; Table 2).

To adjust for likely confounding factors, we calculated AORs. In model 3 (full adjusted model), low physical activity (≤2 days) was clearly associated with underweight (AOR = 1.33) and obese (AOR = 1.12). Study sitting time (>6 hours) was negatively associated with underweight (AOR = 0.86). However, study sitting time was not associated with overweight (AOR = 0.97, 95% CI = 0.91–1.03) and obese (AOR = 0.94, 95% CI = 0.84–1.04). Leisure sitting time (>3 hours) was positively associated with underweight

TABLE 1. General Characteristics of Participants According to Obesity

		Obesity				
	Total	**Underweight**	**Healthy**	**Overweight**	**Obese**	***P* Value**
Total number, n	53,769	3169	42,682	6062	1856	
Total number, %	100	5.9	79.4	11.3	3.5	
Estimated number, %	100	6.0	79.4	11.2	3.4	
Age, yr	15.0	15.4	15.0	14.8	14.5	<0.001*
Physical exercise, d	1.9	1.6	1.9	2.0	2.2	<0.001*
Sitting time for study, h	6.3	6.2	6.5	6.0	5.2	<0.001*
Sitting time for leisure, h	3.0	3.0	2.9	3.0	3.2	<0.001*
Sleep time, %						<0.001†
<6 h	24.3	23.4	24.9	22.6	18.4	
≥6 h, <7 h	25.9	27.1	26.0	25.5	24.2	
≥7 h, <8 h	27.0	26.9	26.8	27.6	31.1	
≥8 h	22.7	22.6	22.4	24.3	26.3	
Sex, %						<0.001†
Male	51.6	56.6	47.6	64.8	94.2	
Female	48.4	43.4	52.4	35.2	5.8	
Region, %						0.575
Large city	44.4	44.9	44.6	44.0	42.3	
Small city	49.0	48.7	48.9	48.9	50.8	
Rural area	6.6	6.4	6.5	7.0	6.9	
Economic level, %						<0.001†
Highest	7.0	7.2	6.8	7.8	9.2	
Middle high	25.5	22.7	25.6	25.8	27.1	
Middle	48.1	49.8	48.4	46.2	43.5	
Middle low	15.6	15.8	15.6	15.7	16.0	
Lowest	3.8	4.5	3.7	4.6	4.3	
Smoking, %						<0.001†
0 d a month	91.5	91.0	91.6	92.2	89.4	
1–5 d a month	2.3	5.3	2.3	2.3	3.8	
6–19 d a month	1.4	4.5	1.4	1.4	2.0	
≥20 d a month	4.8	7.5	4.8	4.2	4.9	
Stress level, %						<0.001†
No	2.7	2.6	2.7	2.8	4.1	
A little	14.3	15.3	14.1	14.4	16.7	
Moderate	42.0	41.8	41.9	42.3	43.7	
Severe	30.3	30.3	30.7	29.2	25.2	
Very severe	10.6	10.0	10.6	11.4	10.2	

* Linear regression analysis with complex sampling, significance at $P < 0.05$.
† Chi-squared test with Rao–Scott correction, significance at $P < 0.05$.

TABLE 2. Odds Ratios of Physical Activity (d), Sitting Time for Study (h), Sitting Time for Leisure (h), and Sleep Time (h) for Underweight, Overweight, and Obesity Using Simple Multinomial Logistic Regression Analysis With Complex Sampling (Reference = Healthy Weight)

	Underweight		Overweight		Obese		
	AOR	95% CI	AOR	95% CI	AOR	95% CI	*P* Value
Physical activity, d							<0.001*
≤2	1.28	1.19–1.41	0.86	0.81–0.90	0.72	0.65–0.80	
>2	1		1		1		
Sitting time for study, h							<0.001*
≤6	1		1		1		
>6	0.88	0.82–0.95	0.82	0.78–0.87	0.61	0.55–0.69	
Sitting time for leisure, h							<0.001*
≤3	1		1		1		
>3	1.09	1.01–1.17	1.12	1.06–1.19	1.21	1.09–1.35	
Sleep time, h							<0.001*
<6	0.93	0.83–1.04	0.83	0.76–0.91	0.63	0.53–0.74	
≥6, <7	1.03	0.92–1.16	0.90	0.83–0.98	0.79	0.68–0.92	
≥7,<8	1.00	0.89–1.11	0.95	0.88–1.03	0.99	0.86–1.13	
≥8	1		1		1		

AOR = adjusted odds ratio, CI = confidence interval.
* Significance at $P < 0.05$.

(AOR = 1.12), overweight (AOR = 1.15), and obese (AOR = 1.32). Compared with receiving at least 8 hours of sleep, less sleep was negatively associated with underweight in a dose–response relationship (<6 hours AOR = 0.67; ≥6 hours, <7 hours AOR = 0.79; ≥7 hours, <8 hours AOR = 0.88); receiving <8 hours of sleep was also positively associated with overweight (<6 hours AOR = 1.19; ≥6 hours, <7 hours AOR = 1.17; ≥7 hours, <8 hours AOR = 1.08) and obese (<6 hours AOR = 1.33; ≥6 hours, <7 hours AOR = 1.36; ≥7 hours, <8 hours AOR = 1.30) in a dose–response relationship (Table 3).

DISCUSSION

Consistent with previous studies,[7,8] low physical activity (≤2 days) was positively associated with obese. Low physical activity was also positively associated with underweight. Other studies have supported these results, finding that underweight adolescents were 1.2 to 1.6 times more likely to be physically inactive than healthy weight subjects.[18,19] In another study, the healthy weight group exhibited higher physical activity than the underweight, overweight, and obese groups.[20] Low income and nutritional status could explain the low physical activity in underweight subjects.[19] However, the low economic level could not be explained in this study because we adjusted the economic level of each participant, and economic level was not associated with underweight (Table 1). Nutritional status and other factors that were not considered in the present study could explain the findings, as physical activity and weight status may be affected by various confounders. Nevertheless, there were no noticeable changes in the AORs among models 1, 2, and 3 (Supplements 1 and 2; Table S3, http://links.lww.com/MD/A494), which applied different levels of confounders. Thus, unconsidered confounders could provide an explanation.

In many reports, sedentary time was associated with obesity independent of physical activity.[3,9,10] Moreover, in a randomized controlled study, reducing sedentary time decreased body weight.[21] Sedentary behavior can be divided into mentally active or passive sedentary time and may affect weight status differently. However, few studies have categorized types of sedentary time for this purpose. Previously, mentally passive sedentary time was associated with overweight, whereas mentally active sedentary time was not associated with overweight in the elderly.[22] Therefore, we evaluated the 2 types of sedentary behavior in adolescents: study sitting time and leisure sitting time. Leisure but not study sitting time was related to overweight and obese (Table 3). This finding suggests that these 2 sitting times act differently. One explanation is that leisure sitting time such as watching television increases caloric intake with the advertisement of food,[5] whereas study sitting time may not affect caloric intake. In another study among working adults, leisure sitting time displayed a stronger association with obesity than occupational sittingtime.[23] Like occupational sitting time among adults, study sitting time among adolescents may have a weak relationship with obesity. The implication is that studies should focus on leisure sedentary time rather than study sedentary time to solve the adolescent obesity problem.

Study sitting time was adversely associated with underweight, whereas leisure sitting time was positively associated with underweight in this study. Increased sedentary behavior was associated with underweight in several previous reports[24] but not in others.[25] These inconsistent results may be a consequence of failing to categorize types of sedentary behavior. The present study demonstrated that sedentary time was associated differently with underweight, depending on how it was categorized. Leisure sedentary time was associated with underweight as well as overweight and obese, whereas study sitting time was not. These results suggest the importance of focusing on leisure sedentary time rather than study sitting time even in underweight adolescent groups. Study sitting time has no apparent harmful effect on obese, overweight, and underweight subjects.

TABLE 3. Adjusted Odds Ratios of Physical Activity (d), Sitting Time for Study (h), Sitting Time for Leisure (h), and Sleep Time (h) for Underweight, Overweight, and Obesity Using Multinomial Logistic Regression Analysis With Complex Sampling (Reference = Healthy Weight) Adjusted for Age, Sex, Region of Residence, Economic Level, Smoking, Stress Level, Physical Activity, Sitting Time for Study, Sitting Time for Leisure, and Sleep Time

	Underweight		Overweight		Obese		
	AOR	95% CI	AOR	95% CI	AOR	95% CI	*P* Value
Physical activity, d							<0.001*
≤2	1.33	1.23–1.45	1.03	0.97–1.10	1.12	1.01–1.25	
>2	1		1		1		
Sitting time for study, h							0.002*
≤6	1		1		1		
>6	0.86	0.80–0.94	0.97	0.91–1.03	0.94	0.84–1.04	
Sitting time for leisure, h							<0.001*
≤3	1		1		1		
>3	1.12	1.04–1.20	1.15	1.08–1.22	1.32	1.18–1.47	
Sleep time, h							<0.001*
<6	0.67	0.58–0.76	1.19	1.07–1.31	1.33	1.11–1.59	
≥6, <7	0.79	0.70–0.90	1.17	1.07–1.28	1.36	1.17–1.57	
≥7, <8	0.88	0.78–0.98	1.08	1.00–1.17	1.30	1.14–1.49	
≥8	1		1		1		

AOR = adjusted odds ratio, CI = confidence interval.
* Significance at $P < 0.05$.

In previous reports, sleep was associated with obesity in a U-shaped relationship. Both short sleep (<7 hours) and long sleep (more than 8 hours) increased the likelihood of obesity.[26,27] Consistent with these studies, short sleep was progressively related to overweight and obese in the present study. Previous reports regarding the relationship between underweight and sleep are controversial.[28–30] In this study, short sleep was negatively associated with underweight, which suggests that short sleep may increase weight gain even in underweight subjects. The reference sleep time was set to 8 hours or more because the mean sleep time was 7 hours. In Korea, 77.3% of adolescents sleep <8 hours, and only 5.0% of adolescents sleep more than 9 hours. Therefore, we could not evaluate the U-shaped association between excessive sleep and obesity.

This study has several advantages over previous studies. This study simultaneously evaluated physical activity, sedentary behavior, and sleep time. These behaviors should be evaluated simultaneously because increasing 1 behavior implicates a decrease in another.[14] The long sleep group (≥8 hours) showed the highest physical activity and the shortest study time (Supplement 3, http://links.lww.com/MD/A494). When adjusting sleep time, physical activity and leisure sedentary time were still related to obesity. This study distinguished sitting time between study and leisure, and these 2 sitting types were differently associated with obesity. This finding helps us to understand the relationship between sedentary behavior and obesity. This study used a large population-based sample, and statisticians weighted the sample to reflect the population.

Despite these advantages, this study has several limitations. First, this study used self-reported measurements of sedentary behavior and moderate physical activity. The self-reported measures could be influenced by recall bias. However, the objective measurement using an accelerometer also has a bias related to incomplete data and measurement error.[31] In several reports,[32] self-reported sedentary behavior showed a better association with obesity than the objective measurement. Second, we measured a physically active day rather than daily physical activity time; in contrast, sitting time and sleep time were assessed as daily time. Therefore, we could not calculate the summation of daily activity. Furthermore, we did not separately measure moderate and vigorous physical activity. Third, the study was subject to the same limitations that affect all cross-sectional studies, including the potential for reverse causality; therefore, our calculated ORs should be interpreted with caution.

CONCLUSION

Increasing physical activity, decreasing leisure sitting time, and increasing sleep time appear to be helpful for adolescents in maintaining a healthy weight. Additionally, these factors are associated with underweight. Study sitting time was not associated with overweight and obese.

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