



## The Association between Sedentary Lifestyle and Adolescent Obesity in Korea

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### Abstract

**Backgrounds:** Obesity is becoming more prevalent worldwide. Among the many obesity-related factors in adults, lifestyle is pivotal. Owing to a lack of information on obesity in adolescents, we examined the association between sedentary lifestyle and obesity in Korean adolescents.

**Methods:** Our analysis comprised 61,179 middle and high school students selected from the 2016 Youth Health Behavior Online Survey. Using survey data, sedentary times corresponding to leisure and studying were determined. Obesity was defined as a body mass index  $\geq 25$  kg/m<sup>2</sup>, and obesity risk was calculated via logistic regression.

**Results:** The percentages of male and female students with obesity were 17.1% and 8.3%, respectively. Moderate or vigorous physical activity reduced the obesity rate in boys but not girls. In both, weekly sedentary times for leisure above the median predicted an increased risk of obesity (boys: odds ratio, 1.16; 95% confidence interval, 1.09-1.23;  $P < 0.001$ ; girls: odds ratio, 1.25, 95% confidence interval; 1.15-1.37;  $P < 0.001$ ).

**Conclusions:** A sedentary lifestyle in adolescents was associated with obesity. Our findings provide insight into the health behaviors of adolescents, which should aid the implementation of future youth obesity-management programs. Further study of the relationship between lifestyle and obesity is recommended.

**Keywords:** Adolescent obesity; Physical activity; Sedentary lifestyle

**Abbreviations:** BMI: Body-mass index; TV: Television; KYRBS: Korean Youth's Risk Behavior Survey; ST: Sedentary Time

### Introduction

In 1998, the World Health Organization recognized obesity as a treatment-requiring disease. Regardless, the prevalence of obesity has risen in both adults and children [1]. In Korean adolescents, it increased steadily from 8.2% in 2005 to 12.8% in 2016, with boys showing a steeper increase than girls [2]. In these studies, obesity was defined as a body mass index (BMI)  $\geq 25$  kg/

m<sup>2</sup>. Obesity during childhood and adolescence is associated with unhealthy dietary habits (e.g., high-fat and high-calorie diets) and physical behaviors (e.g., a sedentary lifestyle and minimal physical activity) [3]. When continued, these habits and behaviors can cause adulthood obesity, with potential complications such as cardiovascular disease, hyperlipidemia, and diabetes [4]. Moreover, children with obesity struggle with psychosocial issues such as an inferiority complex, depression, and negative self-esteem [5].

Sedentary lifestyle refers to sitting or lying down while awake, where very little energy is consumed [6]. Unfortunately, it is becoming more common in advanced countries. In children and adolescents, sedentary behavior includes working or studying while sitting at a desk at school and watching Television (TV) or playing computer games during leisure time [7]. It can lead to obesity in

this age group, particularly in those individuals who watch TV for extended periods, as well as other health problems, highlighting the need for early intervention. In adults, a sedentary lifestyle is a risk factor for obesity, as well as cardiovascular disease and osteoporosis [8-10]. Several studies have examined the association between sedentary lifestyle and exercise, metabolic diseases, and body weight in adults [10-12]. However, only a few studies have assessed the relationship between sedentary lifestyle and obesity in Korean adolescents. Accordingly, the objective of the present study was to determine the amount of time allocated the different sedentary activities and the association between sedentary lifestyle and obesity in Korean adolescents who participated in the 2016 Korean Youth's Risk Behavior Survey (KYRBS).

## Materials and Methods

### Materials

The present study used raw data from the 12<sup>th</sup> KYRBS (2016) conducted by the Korea Centers for Disease Control and Prevention on 7<sup>th</sup> to 12<sup>th</sup> grade students (twelve to eighteen years old ages). The KYRBS is anonymous and self-reporting; its goals are to identify the health behaviors of Korean youths and to generate the baseline data for planning and assessing youth health promotion projects. The 12<sup>th</sup> KYRBS included 400 middle and 400 high schools and stratified the participants according to city/province, city size, regional group, school level (middle school, regular high school, and specialized high school), and school type (boys-only, girls-only, and coed) for proportional allocation. The stratified cluster sampling method was used for sample selection: in the first stage, the schools were systematically sampled by sorting the list of schools according to stratum; in the second stage, a single classroom in each grade of the schools sampled in the first stage was randomly sampled. The survey came up with 102 indices based on 117 questions in 15 categories, including smoking, drinking, physical activity, dietary habits, obesity and weight control, mental health, injury and safety awareness, oral health, personal hygiene, sexual behavior, atopy and asthma, internet addiction, and health equity.

### Subjects

The 12<sup>th</sup> KYRBS targeted 67,975 students from 800 schools throughout Korea, among whom 65,528 from 798 schools were included in the present study (participation rate, 96.4%). After excluding 4,344 students who did not provide weight, height, and/or Sedentary Time (ST) information, the final number of students in our analysis was 61,179. In this study, total study group was divided into two groups by gender.

### Variables

Using the definition of obesity by the Korean Society for the Study of Obesity, subjects with a BMI <25 kg/m<sup>2</sup> were classified

as without obesity (normal weight), while those with a BMI ≥25 kg/m<sup>2</sup> were classified as with obesity. General characteristics included school level (middle or high school) and socioeconomic status (upper and upper-middle, middle, or low and lower-middle). Moderate physical activity was defined as states with increased heart rate above the normal level or caused shortness of breath were performed for at least 60 minutes, 5 or more days per week. Vigorous physical activity was defined as exercises such as jogging, soccer, basketball, taekwondo, hiking, and speed swimming were performed at least 20 minutes per day, 3 or more days per week. Health-related behaviors were categorized as smoking, drinking alcohol, and dietary habits. Drinking and smoking statuses were based on the number of days within the past 30 days on which the subject consumed one or more servings of alcohol or smoked at least one cigarette, respectively. Dietary habits were sub-categorized as eating breakfast at least 3 times a week, drinking soft drinks at least 3 times a week, and eating fast foods at least 3 times a week.

ST represented the average time (minutes) per day that the subject spent sitting on weekdays and weekends, either studying or at leisure. Hence, there were four ST categories: weekday/study, weekend/study, weekday/leisure, and weekend/leisure. ST for study included time spent studying at and after school, doing homework on the computer, and watching educational TV programs. ST for leisure included watching TV, playing video games, internet surfing, and chatting. The median ST was used to divide the subjects into the 'less than median time' and 'above median time' groups.

### Statistical Analysis

Frequency analyses of the general characteristics and health behaviors of the subjects were performed, with the results presented as descriptive statistics. Distribution of the STs for study and leisure during weekdays and weekends are presented as mean and standard deviation, using Student's t-test and one-way analysis of variance to evaluate the mean differences. For associations between ST and obesity, binominal logistic regression analysis was performed using variables that showed significant differences with respect to ST and obesity as adjustment variables. The significance level was set at 5%, and all analyses were performed by using SPSS version 20.0 software.

### Results

The distributions of the general characteristics of the subjects are shown in (Table 1). The percentage of male students with obesity was 17.1%, and the percentage of female students with obesity was 8.3%. The percentages of male and female students performing moderate physical activities were 19.4% and 7.2%, respectively, while the percentages for vigorous physical activities were 50.6% and 25.7%, respectively. Male students who performed

moderate or vigorous physical activities had shorter STs in all four categories (weekday/study, weekend/study, weekday/leisure, and weekend/leisure) than those who did not perform moderate or vigorous physical activities (Table 2). Male students with obesity had longer weekday/study and weekend/leisure STs than those without obesity. Female students who performed moderate physical activities had shorter STs in all four categories, whereas those who performed vigorous physical activities had shorter STs in two categories only (weekday/study and weekend/study) (Table 3). Female students with obesity had longer STs than those without obesity in all categories excepting weekday/study.

n (%)	Total	
	Male students	Female students
Body-mass Index (kg/m <sup>2</sup> )		
< 25	26150 (82.9)	27177 (91.7)
≥ 25	5387 (17.1)	2465 (8.3)
School Type		
Middle school	15593 (49.4)	14381 (48.5)
High school	15944 (50.6)	15261 (51.5)
Socio-economic Status		
Low-Lower middle	4866 (15.4)	4459 (15.0)
Middle	14277 (45.3)	14989 (50.6)
Upper middle-upper	12394 (39.3)	10194 (34.4)
Moderate Physical Activity (days/week)		
0-4	25413 (80.6)	27497 (92.8)
7-May	6124 (19.4)	2145 (7.2)
High-intensity Physical Activity (days/week)		
0-2	15580 (49.4)	22029 (74.3)
7-Mar	15957 (50.6)	7613 (25.7)
Experience of smoking		
No	28681 (90.9)	28935 (97.6)
Yes	2856 (9.1)	707 (2.4)
Experience of drinking		
No	26437 (83.8)	26102 (88.1)
Yes	5100 (16.2)	3540 (11.9)
Eating Breakfast (more than 3 times/week)		
No	8646 (27.4)	8577 (28.9)
Yes	22891 (72.6)	21065 (71.1)
Drinking Soft drinks (more than 3 times/week)		
No	21383 (67.8)	23409 (79.0)
Yes	10154 (32.2)	6233 (21.0)
Eating Fast food (more than 3 times/week)		
No	26086 (82.7)	25235 (85.1)
Yes	5451 (17.3)	4407 (14.9)

**Table 1:** Basic characteristics of study population.

Variables	ST for study				ST for leisure			
	on weekdays		on weekend		on weekdays		on weekend	
	Mean±S.E	P	Mean±S.E	P	Mean±S.E	P	Mean±S.E	P
Body-mass Index (kg/m <sup>2</sup> )								
< 25	396.2±1.8	<0.001	195.0±1.3	0.083	136.7±0.8	0.289	249.2±2.7	<0.001
≥ 25	416.3±4.0		200.7±3.0		138.7±1.8		267.9±2.7	
School Type								
Middle	329.4±2.1	<0.001	149.2±1.3	<0.001	146.3±1.1	<0.001	260.2±1.6	<0.001
High	468.3±2.4		241.7±1.9		128.0±1.0		244.8±1.5	
Socio-economic Status								
Low-Lower middle	385.7±4.1	<0.001	152.0±2.8	<0.001	150.7±2.0	<0.001	285.9±3.1	<0.001
Middle	397.9±2.4		183.4±1.7		137.3±1.0		256.5±1.6	
Upper middle-upper	407.1±2.6		227.7±2.0		131.5±1.1		234.6±1.6	
Moderate Physical Activity (days/week)								
0-4	408.1±1.8	<0.001	201.9±1.4	<0.001	138.1±0.8	0.003	255.0±1.2	<0.001
7-May	363.3±3.5		171.4±2.5		132.7±1.7		241.8±2.4	
High-intensity Physical Activity (days/week)								
0-2	415.3±2.4	<0.001	204.0±1.8	<0.001	139.7±1.0	<0.001	260.9±1.6	<0.001
7-Mar	384.4±2.2		188.1±1.6		134.5±1.0		244.2±1.5	
Experience of smoking								
No	403.7±1.7	<0.001	200.1±1.3	<0.001	135.8±0.7	<0.001	252.5±1.1	0.816
Yes	358.7±5.5		155.1±3.8		150.0±2.6		251.6±3.8	
Experience of drinking								
No	399.1±1.8	0.482	198.8±1.3	<0.001	135.4±0.8	<0.001	250.8±1.2	0.001
Yes	402.3±4.1		181.2±3.0		145.7±1.9		260.8±2.8	
Eating Breakfast (more than 3 times/week)								
No	363.7±3.1	<0.001	164.7±2.1	<0.001	148.0±1.4	<0.001	265.2±2.2	<0.001
Yes	413.2±1.9		207.8±1.4		132.9±0.8		247.6±1.2	
Drinking Soft drinks (more than 3 times/week)								
No	411.6±2.0	<0.001	204.1±1.5	<0.001	128.6±0.8	<0.001	243.2±1.3	<0.001
Yes	374.4±2.9		179.0±2.0		154.9±1.4		271.9±2.0	
Eating Fast food (more than 3 times/week)								
No	402.9±1.8	<0.001	196.7±1.3	0.178	123.4±0.8	<0.001	249.1±1.2	<0.001
Yes	384.1±4.0		192.5±2.9		155.3±1.9		268.7±2.7	
Abbreviations: SE; Standard error								

**Table 2:** Distribution of Sedentary Time (ST) for study and for leisure in male students.

Variables	ST for study				ST for leisure			
	on weekdays		on weekend		on weekdays		on weekend	
	Mean±S.E	P	Mean±S.E	P	Mean±S.E	P	Mean±S.E	P
Body-mass Index (kg/m <sup>2</sup> )								
< 25	514.2±1.6	0.281	249.4±1.3	0.031	146.1±0.7	0.039	267.3±1.2	<0.001
≥ 25	520.4±5.5		239.2±4.5		151.2±2.4		294.2±4.3	
School Type								
Middle	434.9±2.1	<0.001	192.8±1.5	<0.001	159.4±1.0	<0.001	282.9±1.7	<0.001
High	590.0±2.2		301.0±2.0		134.5±0.9		257.0±1.5	
Socio-economic Status								
Low-Lower middle	497.5±4.1	<0.001	201.2±3.1	<0.001	158.2±1.9	<0.001	296.6±3.2	<0.001
Middle	513.4±2.2		234.6±1.7		148.3±1.0		274.3±1.6	
Upper middle-upper	524.3±2.7		289.7±2.3		138.9±1.1		250.7±1.9	
Moderate Physical Activity (days/week)								
0-4	519.4±1.6	<0.001	251.8±1.3	<0.001	147.2±0.7	<0.001	270.7±1.2	<0.001
7-May	455.6±5.5		206.2±4.4		138.3±2.5		254.9±4.2	
High-intensity Physical Activity (days/week)								
0-2	527.1±1.8	<0.001	256.9±1.5	<0.001	146.1±0.8	0.276	270.5±1.3	0.188
7-Mar	478.9±3.0		224.2±2.4		147.8±1.4		267.0±2.3	
Experience of smoking								
No	517.0±1.6	<0.001	251.1±1.3	<0.001	145.7±0.7	<0.001	269.1±1.2	0.028
Yes	422.8±9.4		141.5±7.2		180.4±6.0		289.3±9.1	
Experience of drinking								
No	514.7±1.7	0.961	253.5±1.4	<0.001	145.0±0.7	<0.001	266.8±1.2	<0.001
Yes	515.0±4.6		211.5±3.7		158.3±2.2		290.1±3.6	
Eating Breakfast (more than 3 times/week)								
No	478.0±3.0	<0.001	209.7±2.3	<0.001	160.7±1.4	<0.001	287.4±2.3	<0.001
Yes	529.7±1.8		264.3±1.6		140.8±0.8		190.3±1.3	
Drinking Soft drinks (more than 3 times/week)								
No	524.8±1.8	<0.001	260.0±1.5	<0.001	140.9±0.7	<0.001	261.2±1.3	<0.001
Yes	477.2±3.4		205.4±2.6		167.8±1.6		300.9±2.7	
Eating Fast food (more than 3 times/week)								
No	517.5±1.7	<0.001	252.2±1.4	<0.001	142.5±0.7	<0.001	264.1±1.2	<0.001
Yes	499.0±4.1		227.5±3.3		169.8±2.0		300.9±3.2	
Abbreviations: SE; Standard error								

**Table 3:** Distribution of Sedentary Time (ST) for study and for leisure in female students.

The distribution of general characteristics and health behaviors between normal-weight students and students with obesity is shown in (Table 4). Moderate and vigorous physical activity significantly shifted the distribution toward normal weight in male students but not female students. One of health-related behaviors (drinking alcohol) increased the obesity rate in both male and female students, two dietary habits (eating fast foods, drinking soft drinks) decreased the obesity rate, and others (smoking and eating breakfast) had no effect.

The association between ST and obesity in male students was determined after adjusting for school level, socioeconomic status, physical activities, drinking soft drinks, and eating fast foods. STs

for leisure above the median on weekdays and weekends and for the entire week correlated significantly with an increased risk of obesity; the odds ratios (95% confidential intervals) were 1.11 (1.04-1.18) (P=0.001), 1.22 (1.15-1.30) (P<0.001), and 1.16 (1.09-1.23) (P<0.001), respectively (Table 5). The association between ST and obesity in female students was determined after adjusting for school level, socioeconomic status, drinking soft drinks, and eating fast foods. STs for leisure above the median on weekdays and weekends and for the entire week correlated significantly with an increased risk of obesity; the odds ratios (95% confidence intervals) were 1.14 (1.04-1.24) (P = 0.005), 1.26 (1.16-1.37) (P<0.001), and 1.25 (1.15-1.37) (P<0.001), respectively (Table 6).

	Male students			Female students		
n (%)	Normal weight	Obesity	P	Normal weight	Obesity	P
School Type						
Middle school	13430 (86.1)	2163 (13.9)	<0.001	13505 (93.9)	876 (6.1)	<0.001
High school	12720 (79.8)	3224 (20.2)		13672 (89.6)	1589 (10.4)	
Socio-economic Status						
Low-Lower middle	3914 (80.4)	952 (19.6)	<0.001	3881 (87.0)	578 (13.0)	<0.001
Middle	11826 (82.8)	2451 (17.2)		13775 (91.9)	1214 (8.1)	
Upper middle-upper	10410 (84.0)	1984 (16.0)		9521 (93.4)	673 (6.6)	
Moderate Physical Activity (days/week)						
0-4	20940 (82.4)	4473 (17.6)	<0.001	25226 (91.7)	2271 (8.3)	0.207
7-May	5210 (85.1)	914 (14.9)		1951 (91.0)	194 (9.0)	
High-intensity Physical Activity (days/week)						
0-2	12726 (81.7)	2854 (18.3)	<0.001	20227 (91.8)	1802 (8.2)	0.155
7-Mar	13424 (84.1)	2533 (15.9)		6950 (91.3)	663 (8.7)	
Experience of smoking						
No	23769 (82.9)	4912 (17.1)	0.514	26541 (91.7)	2394 (8.3)	0.095
Yes	2381 (83.4)	475 (16.6)		636 (90.0)	71 (10.0)	
Experience of drinking						
No	22009 (83.3)	4428 (16.7)	<0.001	24002 (92.0)	2100 (8.0)	<0.001
Yes	4141 (81.2)	959 (18.8)		3175 (89.7)	365 (10.3)	
Eating Breakfast (more than 3 times/week)						
No	7134 (82.5)	1512 (17.5)	0.24	7831 (91.3)	746 (8.7)	0.131
Yes	19016 (83.1)	3875 (16.9)		19346 (91.8)	1719 (8.2)	
Drinking Soft drinks (more than 3 times/week)						
No	17610 (82.4)	3773 (17.6)	<0.001	21410 (91.5)	1999 (8.5)	0.007
Yes	8540 (84.1)	1614 (15.9)		5767 (92.5)	466 (7.5)	
Eating Fast food (more than 3 times/week)						

No	21527 (82.5)	4559 (17.5)	<0.001	23088 (91.5)	2147 (8.5)	0.004
Yes	4623 (84.8)	828 (15.2)		4089 (92.8)	318 (7.2)	

**Table 4:** General characteristics and health behaviors about obesity based on gender.

Variables <sup>2</sup>	Obesity			
	Crude OR	P	Adjusted <sup>1</sup> OR	P
	(95% CI)		(95% CI)	
Sedentary time for study				
Weekdays				
< median (420.0)	1		1	
≥median (420.0)	1.13 (1.07-1.20)	<0.001	1.02 (0.96-1.09)	0.051
Weekends				
< median (120.0)	1		1	
≥median (120.0)	0.98 (0.92-1.04)	0.443	0.92 (0.87-0.98)	0.009
Total week				
< median (342.9)	1		1	
≥median (342.9)	1.14 (1.07-1.20)	<0.001	1.02 (0.96-1.09)	0.468
Sedentary time for leisure				
Weekdays				
< median (120.0)	1		1	
≥median (120.0)	1.08 (1.02-1.14)	0.014	1.11 (1.04-1.18)	0.001
Weekends				
< median (210.0)	1		1	
≥median (210.0)	1.20 (1.13-1.27)	<0.001	1.22 (1.15-1.30)	<0.001
Total week				
< median (137.1)	1		1	
≥median (137.1)	1.13 (1.06-1.20)	<0.001	1.16 (1.09-1.23)	<0.001
Abbreviations: OR; odd-ratios, CI; confidential interval; <sup>1</sup> Adjusted for school type, socio-economic status, moderate physical activities, high-intensity physical activities, drinking soft drinks, eating fast food; <sup>2</sup> Sedentary time median values were described by minutes per day				

**Table 5:** Odds Ratios for Risk Factors of Obesity by Sedentary Behavior in Male students.

Variables <sup>2</sup>	Obesity			
	Crude OR	P	Adjusted <sup>1</sup> OR	P
	(95% CI)		(95% CI)	
Sedentary time for study				
Weekdays				
<median (540.0)	1		1	
≥median (540.0)	1.05 (0.96-1.14)	0.027	0.92 (0.85-1.06)	0.07
Weekends				
<median (180.0)	1		1	
≥median (180.0)	0.87 (0.80-0.95)	0.001	0.81 (0.74-0.88)	<0.001



Total week				
<median (454.3)	1		1	
≥median (454.3)	1.03 (0.95-1.12)	0.519	0.90 (0.82-0.98)	0.016
Sedentary time for leisure				
Weekdays				
<median (120.0)	1		1	
≥median (120.0)	1.09 (1.00-1.19)	0.041	1.14 (1.04-1.24)	0.005
Weekends				
<median (240.0)	1		1	
≥median (240.0)	1.24 (1.15-1.35)	<0.001	1.26 (1.16-1.37)	<0.001
Total week				
<median (154.3)	1		1	
≥median (154.3)	1.21 (1.11-1.32)	<0.001	1.25 (1.15-1.37)	<0.001
Abbreviations: OR; odd-ratios, CI; confidential interval; <sup>1</sup> Adjusted for school type, socio-economic status, moderate physical activities, high-intensity physical activities, drinking soft drinks, eating fast food; <sup>2</sup> Sedentary time median values were described by minutes per day				

**Table 6:** Odds Ratios for Risk Factors of Obesity by Sedentary Behavior in Female students.

Discussion

The present study investigated the association between sedentary lifestyles and obesity in adolescents participating in the 12<sup>th</sup> KYRBS, which was conducted in 2016. Obesity in children and adolescents can be defined as a BMI above the 95<sup>th</sup> percentile based on relative body weight versus standard body weight [13]. However, in the Asian Pacific region, obesity in adolescents is commonly defined as a BMI≥25 kg/m<sup>2</sup>, independent of percentile; thus, we used this definition in our study. Obesity was more prevalent in male students than female students (2-fold increase) and in high school students than middle school students; these results are similar to those of a previous study [14]. They can be explained by the pressure on women to lose weight owing to sociocultural influences (which have less impact on men) and the emphasis of high schools on college admission preparations rather than physical activity [15,16].

Skipping breakfast has been linked to an increased risk of obesity [16,17]. In our study, however, skipping breakfast did not significantly correlate with obesity. Hence, additional studies assessing this relationship are needed. Surprisingly, we found that students with obesity ate fast food less often than those without obesity. This finding contradicts the expected association between obesity and fast food (e.g., ramen and hamburgers) consumption. Others reported that underweight or normal-weight people ate fast foods more frequently, but ate lesser total amounts of fast

foods, than did people with obesity, leaving room for controversy [18,19]. Countries throughout the world recommend limited intake of high-fat fast foods (e.g., hamburgers and pizza), as they can cause obesity in adolescents [20]. Because the group with a lower intake of fast foods had a higher obesity rate in the present study, future studies should consider the quality of the fat consumed and other relevant variables.

In our study, the obesity rate was lower in male students who performed moderate and vigorous physical activities than in those who did not. This finding is consistent with previous reports indicating that proper exercise prevents obesity [19,20]. On the other hand, the obesity rate was similar in female students who or did not perform moderate or vigorous physical activities. However, caution should be taken in interpreting these results: it is possible that the students with obesity were not particularly physically active in the past, while those without obesity were highly physically active in the past [21]. The groups without moderate or vigorous physical activities had longer study and leisure STs than those with physical activities. Sedentary behavior limits participation in physical activities and consequently reduces energy consumption. Hence, physical activity can expend the energy required for weight control [22-24]. The energy consumption ranges for sedentary versus active behaviors differ. Sedentary behaviors, such as watching TV, using a computer, or sitting in a car, generally consume 1.0-1.5 METs, whereas moderate-to-strenuous physical activities, such as bicycling, swimming, walking, and running consume 3-8 METs



[24]. Moreover, in some sedentary behaviors (e.g., watching TV), the hands are free, allowing the person to consume harmful snacks or high-calorie beverages, which can further increase the risk of obesity [25,26].

The present study examined the distribution of STs according to the type of sedentary activity and determined the obesity rates in groups with STs above the median to identify the effects of a sedentary lifestyle on obesity. As confirmed by previous studies, confounding factors such as energy intake and physical activity affect the relationship between sedentary lifestyle and BMI [23,27]. Although our analysis included some confounders, dietary factors and physical activities could not be assessed accurately owing to the limits of the self-reported questionnaire. In study, STs for leisure above the median predicted a higher risk of obesity than STs for study above the median. As an explanation, previous studies have shown that leisure activities such as watching TV consume less energy than do study activities such as writing or reading [27,28]. Australian adolescents spend most of their weekday and weekend leisure time watching TV, whereas only about 35% of Korean students spend 2 or more hours watching TV [29,30]. Although the percentage of students watching TV was not calculated in our study, we believe that watching TV accounts for a large proportion of ST.

Weekday/study STs were not associated with obesity in our study, whereas weekend/study STs inversely correlated with obesity. In additional analyses, the correlation between weekday/study ST and weekday/leisure ST was -0.074, whereas the correlation between weekend/study and weekend/leisure was -0.173. These numbers indicate that study times increased and leisure times decreased on weekends. This tendency might influence the relationship between food intake and energy consumption. This study had some limitations. First, because it was a cross-sectional study, causal relationships could not be clearly identified. Second, the questionnaire used in the KYRBS did not differentiate between an active sedentary lifestyle (e.g., playing virtual reality games) and a non-active sedentary lifestyle (e.g., watching videos). Third, it evaluated the frequency of food intake but not the actual amount of food consumed. Fourth, because it included data from only a single questionnaire, comparisons between our results and those of others (which perhaps used different measurement tools for physical activity) are difficult [8,31].

## Conclusions

A sedentary lifestyle in adolescents was associated with obesity in this study. By providing insight into the health behaviors of adolescents, our findings should aid the implementation of future obesity-management programs for adolescents. Because adolescent lifestyle habits are often carried over into adulthood, our findings may also help lower the risk of obesity in adults. Further

investigation of the relationship between sedentary lifestyle and obesity in adolescents is recommended.

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## Conflict of Interest

The Authors declare that there is no conflict of interest.

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