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Physical Activity and Sedentary Behavior Are Independently Associated with Weight in Korean Adolescents

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Background: This study examines the relationship between physical activity (PA), sedentary behavior (SB) and body weight in Korean adolescents.

Methods: This study used a nationally representative sample of 72,368 South Korean adolescents, aged 13 to 18 years. The study sample was categorized according to BMI as follows: underweight, body mass index (BMI) <18.5; normal weight, $18.5 \leq$ BMI < 23.0; overweight, $23.0 \leq$ BMI < 25.0; and obese, $25.0 \leq$ BMI. An analysis was then performed to determine if meeting the recommended guidelines for PA frequency (5 times/week $\leq$) and amount of SB (<2 hours/day) was associated with weight category.

Results: The percentage of normal weight adolescents was 54.3% while the percentages of underweight, overweight, and obese adolescents were 27.4%, 10.2%, and 8.1%, respectively. Significantly fewer underweight and obese adolescents met PA guidelines compared to normal weight adolescents. In addition, underweight, overweight, and obese adolescents had significantly higher SB scores.

Conclusion: The present study indicates that in Korean adolescents, physical activity and sedentary behavior are independently associated with weight status. Overweight, obese and underweight Korean adolescents should all be independently monitored for management of health-related behaviors.

Key Words: Korean adolescent, Physical activity, Sedentary behavior, Weight status

INTRODUCTION

Over the past few decades, there has been a dramatic increase in the prevalence of obesity in many countries. The World Health Organization (WHO) estimates that more than 1.4 billion adults age 20 years and older are already overweight, and more than 200 million men and nearly 300 million women are obese [1]. According to the Korean National Health and Nutrition Examination Survey (KNHANES), the proportion of obese adults has increased continuously in Korea from 29.0% in 1998 to 31.7% in 2007, while the proportion of obese adolescents has also increased approximately four-fold, from 2.3% to 9.6% during the same period [2]. This demonstrates that the problem of adolescent obesity has become as serious as adult obesity in South Korea.

Physical activity (PA) is one of the most important factors in a long-term weight loss program. The reduction of energy expenditure resulting from a sedentary lifestyle has

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contributed to an increased prevalence of overweight and obese individuals [3-6]. Hamilton et al. [6] reported that sitting for prolonged periods can cause a loss of opportunity for cumulative energy expenditures that result from thousands of intermittent muscular contractions. Interactions between PA and sedentary behaviors (SB) such as watching television, playing video games, and using cell phones, computers, and other electronic devices, are thought to be caused by a complex mix of genetic and environmental factors which lead to an imbalance among expenditure factors [7]. The establishment of a relationship between increased PA and reduced SB during adolescence is important because health-related behavior during adolescence influences health-related behavior in adulthood [5,7,8].

In Korea, current economic growth and improvements in the standard of living have led to a decrease in various infectious diseases, but have resulted in large increases in chronic disease due to lack of PA and excessive SB [2,4,5]. Moreover, most Korean adolescents undergo psychological stress due to high expectations of academic performance and frequent exams in middle and high school [8]. Many studies have shown that increasing PA and decreasing SB are associated with an increase in obesity [9-13]. However, Korean adolescents attempt to balance energy expenditure without understanding the relationship between PA and SB according to weight. To the best of our knowledge, no studies have examined PA and SB according to the body weight in a nationally representative sample of Korean adolescents. Therefore, this study aims to examine the association between PA and SB according to body weight using national data from the 2010 Korean Youth Risk Behavior Web-based Survey (KYRBWS) in South Korean adolescents.

MATERIALS AND METHODS

1. Participants

Raw cross-sectional data from the sixth Korea Youth Risk Behavior Web-Based Survey (KYRBWS-VI) in 2010 were used for this study. These data were the basis for understanding the current level of health-related risk behaviors in Korean adolescents and were used to calculate an adolescent health index for the purposes of a health promotion project plan and evaluation. The KYRBWS-VI is an anonymous, internet-based, self-administered structured questionnaire intended to investigate health-risk behaviors and has been conducted by the Korea Center for Disease and Prevention (KCDP) [14]. Details of the data-collection procedure are described by the KCDP, and this survey has been shown to be valid and reliable [15].

The target population of this study was Korean middle and high school students. A representative sample of students from grades 7-12, aged 13-18 years, was selected; this sample consisted of 74,980 students from 400 middle schools and 400 high schools. The response rate was 97.7% (n = 73,238). Students who were absent for long periods of time, and students with dyslexia or dysgraphia were excluded from this study. After the aforementioned exclusions, a total of 72,368 students (38,139 boys and 34,229 girls) were included in this study. Subject characteristics are shown in Table 1.

2. Body weight status

Participants were asked to self-record their height and weight, and body mass index (BMI (kg/m^2)) was calculated for each participant. In accordance with the WHO Asia-Pacific standard of obesity, individuals were classified as underweight, normal, overweight, or obese based on BMIs of <18.5, 18.5-22.9, 23.0-24.9, and ≥ 25.0, respectively [16].

3. Physical activity

Respondents indicated the number of days they did PA for at least 60 min/day, ranging from never to 7 days per week, and were then classified as PA $<$ 5 times/week or PA $\geq$ 5 times/week. The American College of Sports Medicine (ACSM) recommends 60 minutes of PA $\geq$ 5 times/week for adolescents [17].

4. Sedentary behavior

Respondents indicated the number of hours during the past week they spent doing sedentary activity, including watching television, playing video games, or using cell phones, computers, or other electronic devices, and excluding time spent studying or doing homework. Responses ranged from <1 hour/day to ≥ 4 hours/day. These variables

Table 1. Subject demographics

Characteristics	Boys (n = 38,139)	Girls (n = 34,229)	Total (n = 72,368)
Age (years)	15.1 (1.7)	15.2 (1.8)	15.1 (1.8)
Height (cm), Mean (SD)	169.6 (8.2)	160.1 (5.4)	165.1 (8.2)
Weight (kg), Mean (SD)	60.1 (11.7)	51.5 (7.7)	56.0 (11.0)
BMI (kg/m^2), Mean (SD)	20.8 (3.2)	20.1 (2.6)	20.5 (3.0)
Weight category, n (%)			
Underweight (BMI < 18.5)	9,771 (25.6)	10,023 (29.3)	19,794 (27.4)
Normal weight (18.5 ≤ BMI < 23.0)	19,633 (51.5)	19,651 (57.4)	39,284 (54.3)
Overweight (23.0 ≤ BMI < 25.0)	4,385 (11.5)	2,961 (8.7)	7,346 (10.2)
Obese (25.0 ≤ BMI)	4,350 (11.4)	1,594 (4.6)	5,944 (8.1)
Family economic state, n (%)			
High	2,691 (7.1)	1,336 (3.9)	4,027 (5.6)
Middle high	8,766 (23.0)	6,715 (19.6)	15,481 (21.4)
Average	17,223 (45.2)	17,254 (50.4)	34,477 (47.6)
Middle low	6,885 (18.1)	6,819 (19.9)	13,704 (18.9)
Low	2,574 (6.7)	2,105 (6.2)	4,679 (6.5)
Gradelevel in school, n (%)			
7-8	13,424 (35.2)	11,339 (33.1)	24,763 (34.2)
9-10	13,341 (35.1)	10,975 (32.1)	24,316 (33.7)
11-12	11,325 (29.7)	11,915 (34.8)	23,224 (32.1)
PA* frequency, n (%)			
PA < 5 times/week	29,806 (78.2)	31,648 (92.4)	61,454 (84.9)
PA ≥ 5 times/week	8,333 (21.8)	2,599 (7.6)	10,932 (15.1)
Sedentary time, n (%)			
Sedentary < 2 hours/day	18,686 (49.0)	16,737 (48.9)	35,423 (48.9)
Sedentary ≥ 2 hours/day	19,453 (51.0)	17,492 (51.1)	36,945 (51.1)

*PA: 60 minutes physical activity.

were then classified as SB <2 hours/day or ≥2 hours/day. The Youth Risk Behavior Survey (YRBS) recommends SB <2 hours/day for adolescents [18].

5. Socio-demographic and family economic status information

Socio-demographic variables were determined according to grade level in school. Grade level in school was considered a proxy for age, with grades 7 and 12 corresponding to 13 and 18 years of age, respectively. Family economic status was assessed, with possible responses including one (high), two (middle high), three (average), four (middle low), and five (low).

6. Statistical analyses

The statistical software SPSS version 18.0 was used for all the analyses. All study results are presented as means +/- standard deviation. A Pearson chi-squared test and one-way ANOVA followed by Scheffe test were used to compare the normal weight group with other weight groups. In addition, multiple logistic regression analysis was used to assess associations between the normal group and the other groups in terms of PA and SB. Adjustments were successively made for family economic state and grade level in school (model 1); and family economic state, grade level in school, and number of physical education classes per a week (model 2). $p < 0.05$ was considered statistically significant.

RESULTS

1. Meeting guidelines for physical activity and sedentary behavior

The distribution of girls and boys meeting the PA and SB guidelines is presented in Table 2. Overall, 72,368 adolescents from the original sample were included in our analysis. The percentage of underweight Korean adolescents was 27.4% (boys: 25.6%; girls: 29.3%), while the percen-

Table 2. Number of Korean adolescents that meet the guidelines for physical activity and sedentary behavior, according to gender and weight

Meeting guidelines	Boys, n (%)						Girls, n (%)					
	Underweight	Normal weight	Overweight	Obese	Total	p-value[1]	Underweight	Normal weight	Overweight	Obese	Total	p-value[1]
Number of subjects in each weight group	9,771 (25.6)***	19,633 (51.5)	4,385 (11.5)***	4,350 (11.4)***	38,139 (100.0)	<0.001	10,023 (29.3)***	19,651 (57.4)	2,961 (8.7)***	1,594 (4.6)***	34,229 (100.0)	<0.001
Physical Activity[2]												
Yes	2,052 (21.1)*	4,460 (22.7)	932 (21.3)	882 (20.3)**	8,333 (21.8)	<0.001	718 (7.2)*	1,479 (9.7)	247 (8.3)	154 (7.5)*	2,599 (7.6)	0.002
No	7,712 (78.9)	15,173 (77.3)	3,453 (78.7)	3,468 (79.7)	29,806 (78.2)		9,305 (92.8)	18,172 (92.5)	2,714 (91.7)	1,440 (90.3)	31,648 (92.4)	
Sedentary Behavior[3]												
Yes	4,606 (47.1)***	9,897 (50.4)	2,190 (49.9)	1,993 (45.8)***	18,686 (49.0)	<0.001	4,965 (49.5)	9,664 (49.2)	1,387 (46.8)	721 (45.2)*	16,737 (48.9)	0.001
No	5,165 (52.9)	9,736 (49.6)	2,195 (50.1)	2,357 (54.2)	19,453 (51.0)		5,058 (50.5)	9,987 (50.8)	1,574 (53.2)	873 (54.8)	17,492 (51.1)	
Number of guidelines met[4]												
2	1,049 (10.7)	2,313 (11.8)	466 (10.6)	419 (9.6)	4,247 (11.1)	<0.001	380 (3.8)	782 (4.7)	118 (4.0)	75 (4.0)	1,355 (4.0)	0.077
1	4,567 (46.7)	9,731 (49.6)	2,190 (49.9)	2,037 (46.8)	18,525 (48.6)		4,923 (48.9)	9,579 (48.2)	1,398 (47.2)	725 (46.2)	16,625 (48.6)	
0	4,155 (42.5)	7,589 (38.7)	1,729 (39.4)	1,894 (43.5)	15,367 (40.3)		4,720 (47.3)	9,290 (47.1)	1,445 (48.8)	794 (49.8)	16,249 (47.4)	

1) *, **, and *** denote $p < 0.05$, $p < 0.01$ and $p < 0.001$, respectively, compared to the normal weight group.
2) 60 minutes physical activity $\geq$ 5 times/week.
3) Sedentary $<$ 2 hours/day.
4) Numbers of guidelines met (none: 0; physical activity or sedentary behavior: 1; both: 2).

tages of normal, overweight, and obese adolescents were 54.3% (boys: 51.5% and girls: 57.4%), 10.2% (boys: 11.5%; girls: 8.7%). and 8.1% (boys: 11.4% and girls: 4.6%), respectively. The percentage of boys and girls who met PA guidelines in the underweight group (boys: 21.1%; girls: 7.2%) and obese group (boys; 20.3% vs. girls; 7.5%) was significantly lower than in the normal weight groups (boys; 22.7% vs. girls; 9.7%). In addition, the number of boys and girls who met SB guidelines in the underweight (boys; 47.1%) and obese group (boys; 45.8% vs. girls; 45.2%) was significantly lower than in the normal weight group (boys; 50.4% vs. girls; 49.2%). Only 9.6% of obese boys and 4.0% of obese girls met the guidelines for both PA and SB. On the other hand, 11.8% of normal weight boys and 4.7% of normal weight girls met both guidelines. Among all of the body weight categories, the prevalence of adolescents who met both PA and SB guidelines was highest in normal weight boys and girls, while the prevalence of individuals who met both guidelines was lowest in obese boys (9.6%) and underweight girls (3.8%). In addition, the prevalence of not meeting either of the guidelines was highest in obese (43.5%) and underweight boys (42.5%) and lowest in normal weight boys (38.7%).

2. Multiple logistic regression models of physical activity and sedentary behavior

Table 3 summarizes the results of the multiple logistic regression analysis. Model 1 shows that after adjusting for family economic state and grade level in school, underweight (boys; OR 0.82, 95% CI 0.77-0.87, girls; OR 0.62, 95% CI 0.51-0.75) and obese (boys; OR 0.88, 95% CI 0.81-0.96, girls; OR 0.73, 95% CI 0.61-0.87) adolescents differed significantly from the normal weight group in that the underweight and obese groups did not perform PA for 5 days or more per week. In addition, underweight (OR 1.18, 95% CI 1.06-1.31) and obese girls (OR 1.16, 95% CI 1.05-1.29) did not meet SB guidelines, while normal weight girls did. Model 2 shows that after adjusting for family so-

Table 3. Adjusted multiple logistic regression models of physical activity and sedentary behavior among Korean adolescents reported as ORs and 95% CI[1)]

	Boys, OR (95% CI)		Girls, OR (95% CI)		Total, OR (95% CI)[4)]	
	Physical Activity[2)]	Sedentary Behavior[3)]	Physical Activity	Sedentary Behavior	Physical Activity	Sedentary Behavior
Model 1[5)]						
Normal weight	Reference	Reference	Reference	Reference	Reference	Reference
Underweight	0.82***	0.92	0.62***	1.18**	0.88**	1.14***
	(0.77-0.87)	(0.87-1.01)	(0.51-0.75)	(1.06-1.31)	(0.81-0.95)	(1.08-1.21)
Overweight	0.92	0.96	0.84	1.06	1.05	1.18**
	(0.85-1.00)	(0.90-1.02)	(0.68-1.04)	(0.93-1.19)	(0.98-1.13)	(1.12-1.25)
Obese	0.88**	0.92	0.73***	1.16**	0.83**	1.11**
	(0.81-0.96)	(0.84-1.00)	(0.61-0.87)	(1.05-1.29)	(0.74-0.93)	(1.04-1.19)
Model 2[6)]						
Normal weight	Reference	Reference	Reference	Reference	Reference	Reference
Underweight	0.83***	1.04	0.62***	1.17**	0.86***	1.07
	(0.86-0.89)	(0.97-1.11)	(0.52-0.75)	(1.05-1.31)	(0.79-0.93)	(0.98-1.16)
Overweight	0.92	0.98	0.83	1.03	1.01	1.02
	(0.85-1.00)	(0.89-1.07)	(0.67-1.03)	(0.92-1.14)	(0.92-1.11)	(0.92-1.12)
Obese	0.92	0.97	0.73**	0.93	1.03	1.03
	(0.85-1.00)	(0.88-1.06)	(0.61-0.88)	(0.81-1.01)	(0.95-1.12)	(0.95-1.12)

1) OR and 95% CI were determined by logistic regression analysis, *, **, and *** denote $p < 0.05$, $p < 0.01$ and $p < 0.001$.
2) 60 minutes physical activity $\geq$ 5 times/week.
3) Sedentary time > 2 hours/day.
4) Adjusted for gender.
5) Model 1: adjusted for family socio- economic status and grade level in school.
6) Model 2: adjusted for family socio-economic status, grade level in school, and number of physical education classes per week.

cio-economic status, grade level in school, and number of physical education classes per week, underweight boys (OR 0.83, 95% CI 0.86-0.89), underweight girls (OR 0.62, 95% CI 0.52-0.75), and obese girls (OR 0.73, 95% CI 0.61-0.88) did not perform PA 5 times per week, whereas the normal weight subjects did. Underweight girls (OR 1.17, 95% CI 1.05-1.31) did not meet SB guidelines, which was significantly different from normal weight girls, who did meet SB guidelines. After adjusting for gender, family economic state, and grade level in school, Model 1 shows that all members of the underweight and obese groups had a significantly higher risk in terms of PA and SB. However, after adjusting for gender, family economic state, grade level in school, and number of physical education classes per week, Model 2 found that only the underweight group had a significant risk status in terms of PA (OR 0.86, 95% CI 0.79-0.93).

DISCUSSION

Most studies on weight have focused on obesity, and there is a lack of information about underweight adolescents [19]. However, in the last two decades some Asian countries have started to notice an increasing trend in both obese and underweight adolescents [20]. In East Asian countries, less than 10% of adolescents tend to be underweight, except in South Korea and Hong Kong [19]. In South Korea, according to the KNHANES, the prevalence of obese adolescents increased approximately four-fold from 2.3% in 1998 to 9.6% in 2007, while the prevalence of underweight girls was 12.1% in 2002 and 28.2% in 2008 [14]. In this study, the percentage of underweight adolescents was 27.4%, while the percentages of normal, overweight, and obese Korean adolescents were 54.3%, 10.2%, and 8.1%, respectively. This indicates that we need to pay attention not only to obese adolescents, but also to underweight adolescents. Thus, this cross-sectional study classified 72,368 Korean adolescents into four groups according to their BMI category (underweight, normal, overweight, or obese) in order to understand health-risk behaviors according to body weight status. Average BMI was 20.8 kg/m^2 in boys and 20.1 kg/m^2 in girls. The normal range of BMI according to the WHO Asia-Pacific standard [16] is 18.5-22.9 kg/m^2 for Korean adolescents, indicating that the Korean adolescents in this study were relatively healthy.

This study shows that 21.8% of boys and 7.6% of girls met the guidelines for PA. Moreover, a greater percentage of adolescents in the normal weight category meet PA guidelines compared to other groups. Interestingly, the rate of PA participation in girls was significantly lower than for boys, which is similar to findings in other studies [2,8,21,22]. These results suggest that it is important to develop programs that promote the participation of Korean girls in PA. Previous studies have shown that screen time, including watching TV, DVDs, videos and other media sources, contributes to obesity by reducing energy expenditure and decreasing metabolic rate [23-26]. In this study, the percentage of adolescents in the normal weight category who meet SB guidelines is higher than the percentage of underweight, overweight, and obese adolescents who meet SB guidelines. These findings indicate that Korean adolescents who are not normal weight tend to spend more time sedentary. The majority of research studies investigating health-related behaviors in Korean adolescents have focused on overweight and obese populations [2,4,5]. However, the results of our study suggest that the health-related behaviors of underweight adolescents need to be monitored and managed as well.

Nearly 43.9% of the adolescents in this study (40.3% boys and 49.9% girls) had multiple PA and SB risk behaviors, and 48.6% (48.6% of both boys and girls) had at least one risk behavior. On the other hand, only an average of 7.5% of adolescents (11.1% of boys and 4.0% of girls) met all of the recommended guidelines for both health-related behaviors. These findings clearly demonstrate the need for effective PA intervention, with the goal of improving weight status in Korean adolescents, especially in Korean girls. Previous studies report that Korean girls showed a high interest in appearance but did not participate in physical activity [2,4]. According to a study by Cho et al., [2] obesity may be prevented and health can be improved when South Korean girls are more interested in exercise rather than total caloric consumption. Therefore, participation in PA and education concerning SB habits is recommended to improve overall health and to reduce or prevent obesity and overweight status in Korean adolescents.

Compared to the normal group, PA behavior in the underweight and obese groups was associated with a significantly higher risk status. In addition, compared to girls in the normal weight group, girls in the underweight and obese groups spent more time on SB such as watching television, videos, or DVDs, and playing video or computer games. This study indicates that modifications in PA may be achieved through reduction of SB. Cross-sectional studies support a significant correlation between body weight and time spent watching television or playing video games [27-30]. Before adjusting for physical education, all Korean adolescents in the underweight group had a significantly higher risk status in terms of PA and SB. After adjusting for gender, family economic state, grade level in school, and number of physical education classes per week, only the underweight group had a significant risk status for PA. This result demonstrates that time spent on physical education has a positive effect on SB in South Korean adolescents. As mentioned above, underweight and obese adolescents tend to spend more time sedentary, and obesity may be prevented when adolescents are more interested in exercise. Therefore, participating in physical education could improve the overall health of South Korean adolescents and reduce or prevent obesity. Issues associated with being underweight appear to be more serious than issues associated with other weight groups in this study. This finding shows that even underweight adolescents have health risk behaviors. This indicates that underweight South Korean adolescents, in addition to overweight and obese South Korean adolescents, should be independently monitored for management of health-related behaviors.

The strengths of this study include the large nationwide representative sample of Korean adolescents and the use of an assessment tool with high validity and reliability for evaluating health-related behaviors. However, there are several limitations, including the use of a web-based self-reported survey, and a relatively narrow behavior range. The 2010 KYRBWS was conducted during regular classes at school. As a result, peer groups may have influenced students' responses to some sensitive questions. In addition, it is difficult to compare our results to other studies because many studies of Korean adolescents are focused on obesity but do not include underweight adolescents, and no studies have examined health-risk behaviors according to body weight in a nationally representative sample of Korean adolescents.

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