Association Between Short Sleep Duration and Obesity Among South Korean Adolescents

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Abstract

Short sleep duration and obesity are common health concerns in youth. This study of South Korean adolescents explores the association between the two conditions analyzing secondary data from the 2007 Korea Youth Risk Behavior Web-Based Survey. The sample is representative of the South Korean adolescent population ($N = 73,836$). For data analysis, analysis of variance, chi-square test, and logistic regression were used. Findings indicated that (a) sleep duration is inversely associated with levels of body mass index, $F(4, 72654) = 240.07$, $p < .0001$, and risks for overweight and obesity, $\chi^2(4, 72659) = 27.41$, $p < .0001$; and (b) after controlling for obesity-related factors, reduced sleep is strongly associated with a greater risk for overweight and obesity, $OR = 0.94$, $p < .0001$. Given the important link between sleep and obesity, health professionals should consider sleep habits as a significant factor in obesity-related problems of youth.

Keywords

sleep, adolescence, obesity

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The World Health Organization has estimated that globally in 2005, there were 1.6 billion overweight individuals aged 15 years and older and 400 million obese adults. These figures are expected to increase 50% by 2015 (World Health Organization [WHO], 2006). A similar trend is also found among the South Korean population. The proportion of obese adults has increased by 6% during the past decade, and in 2007 one third of South Korean adults were corpulent (Korea Centers for Disease Control and Prevention [KCDCP], 2008b). Also, the percentages of obese teens have been continuously rising since 2005. In 2007, approximately 10% of South Korean youths were obese (KCDCP, 2008a).

In the literature, there is a well-documented link between obesity and a variety of diseases such as stroke, hypertension, heart disease, diabetes, osteo-arthritis, and cancer (Brooks-Gunn, Fink, & Paxson, 2005; WHO, 2006). Obesity is also associated with two other adverse consequences: an increase in health-related expenditures and social isolation due to distorted perceptions of obesity (Kiess et al., 2001). Considering this increasing prevalence of obesity and its detrimental consequences, obesity is one of the most significant health problems worldwide.

Obesity as a Significant Health Concern During Childhood and Adolescence

Obesity is defined as an age- and sex-adjusted BMI at or above the 95th percentile for children and adolescents of the same age and sex (Centers for Disease Control and Prevention [CDC], 2009a). Although obesity is a major public health challenge at every life stage, it warrants special attention during childhood and adolescence for the following reasons. First, obese young people are at greater risk of experiencing social stigma because of their appearance. Second, there is a higher risk for chronic diseases linked to cardiovascular, respiratory, and endocrine systems among corpulent children and youth (Kiess et al., 2001). Third, there is a higher risk for mental health disorders (e.g., social isolation, suicide, eating disorders, and distorted body image) among these individuals (Brooks-Gunn et al., 2005; Kiess et al., 2001). Fourth, obesity during these early developmental stages is highly likely to persist into adulthood (Dietz & Gortmaker, 2001; Sinha & Kling, 2009). Finally, obesity in childhood and adolescence is a strong predictor of chronic diseases in adulthood (Kiess et al., 2001). Particularly in South Korea, adolescent obesity is one of the most critical health concerns as a result of a rapid increase in the number of obese teens: Its prevalence in 2007 has doubled as compared to 10 years ago (KCDCP, 2008a; Oh et al., 2008).

Various intervention programs based on modification of the obesity-related factors have been developed to prevent obesity in childhood and adolescence or lessen its prevalence. A meta-analytic review showed that these programs have had modest results despite vigorous efforts (Stice, Shaw, & Marti, 2006). For example, most participants experienced weight gain within the 5-year period after participating in these programs (Anderson, Konz, Ferderich, & Wood, 2001). Therefore, it is critical to further understand obesity in order to develop effective intervention strategies (Taheri & Thomas, 2008).

Recently, researchers have focused on short sleep duration as a potential factor affecting obesity. For the past few decades, sleep duration has progressively decreased, and weight has steadily increased during the same period (Hart & Jelalian, 2008). Although the existing literature reveals some mixed findings, researchers generally agree on the presence of a strong link between the two conditions in childhood and adulthood (Chen, Beydoun, & Wang, 2008; Marshall, Glozier, & Grunstein, 2008; Taheri & Thomas, 2008; Van Cauter & Knutson, 2008). However, in adolescence little is known about the nature of the association between the two conditions (Chen et al., 2008). Marshall et al. (2008) suggest that the relationship between sleep duration and obesity in adolescence may differ. Thus, it is crucial to investigate the relationship between the two conditions in adolescence. Furthermore, the majority of South Korean teens get less than the recommended hours of sleep a night, which is at least 8.5 hours (National Sleep Foundation [NSF], 2000; Yang, Kim, Patel, & Lee, 2005). Also, in a study of nationally representative Korean adolescents, 74.1% of them reported that they did not get enough sleep to overcome the fatigue of the prior week (KCDCP, 2008a). Considering serious sleep deprivation in South Korean youth, the understanding of the relationship between the two conditions becomes more important.

Purpose

The purpose of this study was to explore the association between sleep duration and overweight and obesity using a sample representative of South Korean adolescents. More specifically, the average body mass index (BMI), which is related to body fat and used for determining obesity levels (CDC, 2009b), was calculated for the entire sample. Also, the proportions of obesity and levels of sleep duration were explored in the sample. Second, average BMIs were explored across five levels of sleep duration. Third, the prevalence of overweight and obesity were also examined across five levels of sleep duration. Finally, the influence of sleep duration on overweight and obesity was examined, after adjusting for potential factors affecting obesity.

These factors were chosen based on the literature. In general, the factors can be grouped into two categories, that is, endogenous and exogenous factors. The former refers to genetic factors and gender: Persons whose parents are obese and male youth are at greater risk for being obese. The latter refers to environmental and personal factors such as high socioeconomic status, fast-food consumption, depression, sedentary lifestyles, breakfast skipping, and psychosocial and family problems (Kiess et al., 2001; Rampersaud, Pereira, Girard, Adams, & Metzl, 2005). In terms of family characteristics, lack of parental supports and low parental education levels has a significant impact on teen obesity (Nowicka & Flodmark, 2008; Shrewsbury & Wardle, 2008). Thus, to examine a precise relationship between sleep duration and obesity, the influences of the aforementioned factors were controlled in analysis.

Method

Study Design and Data

For this study, data from the 2007 Korea Youth Risk Behavior Web-based Survey (KYRBWS) was cross-sectionally analyzed. The Korea Centers for Disease Control and Prevention has conducted the KYRBWS online survey every year since 2005. The purpose of this survey is (a) to understand health-related risk behaviors among youth and (b) to develop effective strategies and policies that promote adolescent health in South Korea. Currently, 3 years of data are available and the most recent survey conducted in 2007 was used for this study (KCDCP, 2009).

The sample for the 2007 KYRBWS was selected using stratified cluster sampling and was nationally representative of all of middle and high school students in South Korea. South Korea was divided into 64 strata based on administrative districts. Middle and high school clusters were systematically chosen from those strata. The number of schools selected in individual stratum was proportional to the number of students within each stratum. A total of 400 middle schools and 400 high schools were chosen. Within each selected school, a single class from each grade was chosen using systematic random sampling. The online survey was administered to these students, who understood the study aims and agreed to take part in the survey (KCDCP, 2009).

Sample

There is no standard worldwide definition of *adolescence*, because the experience of adolescents varies from region to region (Adams, 2005).

Therefore, this study defined an "adolescent" as a person aged 12 to 18 years, as recommended by South Korean Ministry for Health, Welfare and Family Affairs (2007). Of the participants in the 2007 KYRBWS, the number of subjects used for this study was 73,836.

Measures of Main Interest

Sleep duration. Subjects were asked about the number of hours slept at night on weekdays. Responses ranged from 1 (*less than 5 hours*) to 5 (*8 hours or more*). Previous studies have shown that the majority of adolescents sleep less than 8 hours per night (NSF, 2000; Seicean et al., 2007). This is similar to the finding in the current study: The majority of the participants slept 5.0 to 7.9 hours a night. As a result, "8 hours or more" was chosen as the maximum category in order to make the number of students in each group as uniform as possible.

Overweight and obesity. Self-reported weight and height were used to calculate body mass index (BMI). Because the quantity of body fat among adolescents varies by age and gender, these parameters must be taken into consideration in order to calculate obesity levels based on BMI in youth (CDC, 2009b). Thus, obesity levels were determined based on the Korean National Growth Chart for adolescents, which were adjusted for age and gender (Moon et al., 2007).

Measures to Control for Their Effects

Age. The age variable created by the Korea Centers for Disease Control and Prevention was used without modification.

Gender. Gender identity was used without modification. Males had a value of 1 and females had a value of 0.

Household economic status. Family economic level was used. Possible responses ranged from 1 (*very rich*) to 5 (*very poor*).

Father's education. Highest paternal level of education was used. Possible responses ranged from 1 (*middle school or lower*) to 3 (*college or higher*).

Mother's education. Highest maternal level of education was used. Possible responses ranged from 1 (*middle school or lower*) to 3 (*college or higher*).

Coresidence with parents. Coresidence with both parents at the time of the survey was used. Those who lived with both parents had a value of 1 and those who did not had a value of 0.

Sedentary lifestyle during weekdays. The amount of sedentary time (e.g., watching TV, playing computer games, and using the Internet) over the

prior 5 weekdays was used. Possible responses ranged from 1 (*less than 1 hour* per day) to 5 (*4 hours or more per day*).

Sedentary lifestyle during weekends. The amount of sedentary time over the prior weekend was used. Possible responses ranged from 1 (*less than 1 hour* per day) to 5 (*4 hours or more per day*).

Skipping breakfast. The frequency of having breakfast during the 7 days prior to the survey was used. From this question, the frequency of skipping breakfast per week was calculated. Possible responses ranged from 1 (*none or once*) to 4 (*7 days*).

Depression. Respondents were asked if their daily activities were ever disrupted for 2 consecutive weeks from sadness or despair within the past year. Possible responses were 1 (*yes*) or 0 (*no*).

Mental stress. Respondents were asked about their level of mental stress on a 5-point Likert-type scale. Possible responses ranged from 1 (*not at all*) to 5 (*very much*).

Frequency of muscle-strengthening exercise. Respondents were asked their frequency of muscle-strengthening exercises (e.g., weight lifting, sit-ups, and push-ups) during the 7 days prior to the survey. The CDC (2008a) recommends at least three muscle-strengthening activities per week. Based on this recommendation, subjects were divided into two groups: those who exercised at least three times per week and those who did not.

Frequency of fast food consumption. Respondents were asked the number of times they consumed fast food (e.g., pizza, hamburger, and fried chicken) during the 7 days prior to the survey. Responses were categorized into two groups: those who had consumed fast food during the prior week and those who did not.

Analysis

SAS Version 9.13 was used for the analysis. First, the factors of main interest, sleep duration and levels of obesity, were explored, calculating frequencies or means. Second, the differences in the mean BMI among five levels of sleep duration were examined using analysis of variance (ANOVA). Because of the unbalanced sample sizes among the groups, the PROC GLM procedure was used to properly manage unequal data in ANOVA. Also, the Scheffé test was performed for multiple pairwise comparisons among groups. Third, the differences in the proportions of those who were overweight or obese across the five levels of sleep duration were examined performing a chi-square test (Elliot, 1995). Finally, logistic regression analysis was conducted to see if sleep duration still had a strong relationship with overweight and obesity after adjusting for factors that may affect the outcome. Before
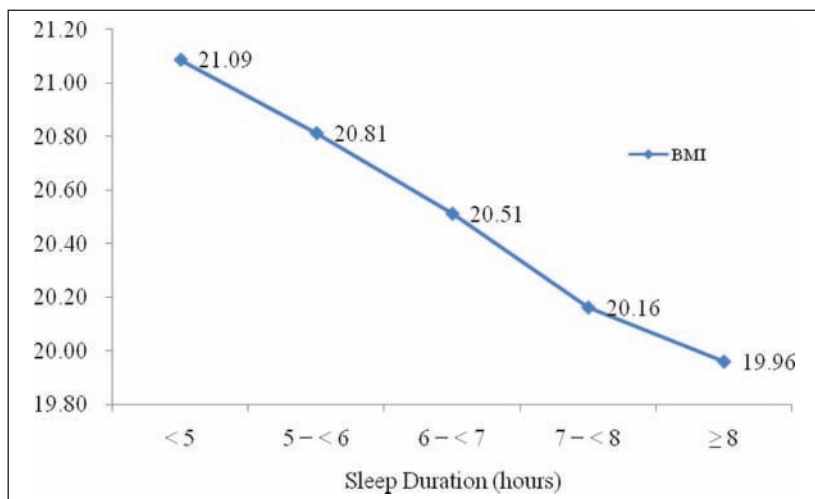
Figure 1. Association between body mass index and sleep duration

performing this analysis, multicollinearity among the independent variables was examined, and this was found not to be an issue (Allison, 1999).

Results

Demographic Characteristics of the Sample

The average age was 15 years, and about 53% of the subjects were male. Approximately 48% of the subjects rated their economic status as middle class and about 84% resided with both parents at the time of the survey. In addition, the three factors of main interest (BMI, obesity, and sleep duration) were examined. The average BMI was 20.6 kg/m^2 and about 13% of the subjects were identified as overweight (3.9%) or obese (9.1%). In terms of sleep duration, 41% of the subjects slept less than 6 hours per night and about 9% slept 8 hours or more per night.

Relationship Between BMI and Sleep Duration

There was an inverse linear relationship between BMI and sleep duration (Figure 1). The average BMI was highest among those who slept less than 5 hours per night, and lowest among those who slept 8 hours or more per night. ANOVA revealed that there was a statistically significant difference in the mean BMI across five levels of sleep duration, $F(4,72654) = 240.07$, $p < .0001$.
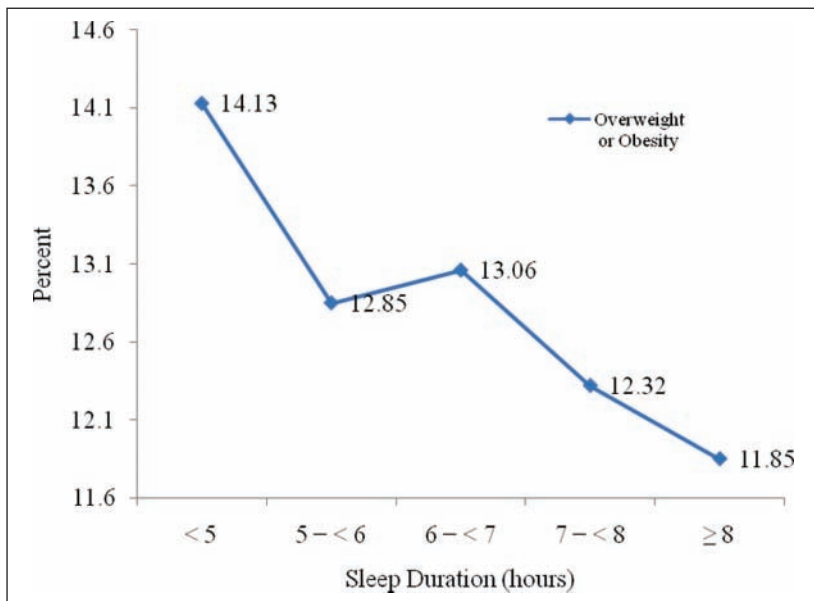
Figure 2. Percentage of overweight or obese teens by sleep duration

Moreover, Scheffé post hoc tests confirmed that all the pairwise comparisons in terms of BMI between two groups statistically differed at the .05 level. This means that there is a significant variation in BMI across the five sleep duration groups.

Association Between Sleep Duration and Being Overweight or Obese

The distribution of overweight or obese subjects across the five sleep duration groups was compared (Figure 2). The results indicated an inverse relationship between sleep duration and being overweight or obese. The percentage of overweight or obese subjects was the greatest among respondents reporting less than 5 hours of sleep (14.1%) and lowest among respondents reporting of 8 hours or more of sleep (11.9%). Furthermore, chi-square tests revealed that sleep duration was not independent of being overweight or obese, $\chi^2(4, 72659) = 27.41$, $p < .0001$. This implies that sleep duration is strongly associated with being overweight or obesity.

Table 1. Correlates of Obesity in South Korean Adolescents

Correlate	Odds Ratio	95% Confidence Interval	p-value
Age	0.995	0.979, 1.011	.5333
Gender (reference: female)	1.442	1.368, 1.520	<.0001
Household economic status	1.034	1.002, 1.066	.0352
Father's education	0.899	0.856, 0.945	<.0001
Mother's education	0.996	0.944, 1.050	.8746
Coresidence with parents	1.070	0.971, 1.181	.1727
Sedentary lifestyle during weekdays	1.053	1.029, 1.078	<.0001
Sedentary lifestyle during weekend	1.033	1.010, 1.056	.0045
Skipping breakfast	0.988	0.964, 1.012	.3203
Depression	0.964	0.913, 1.019	.1931
Mental stress	1.087	1.055, 1.120	<.0001
Frequency of muscle-strengthening exercise per week	0.825	0.772, 0.881	<.0001
Frequency of fast food consumption per week	0.879	0.746, 1.035	.1216
Sleep duration	0.935	0.913, 0.958	<.0001

Factors Linked to Overweight and Obesity

Factors significantly related to overweight and obesity in this study were gender, household economic status, paternal education level, sedentary lifestyle, mental stress, muscle-strengthening exercise, and sleep duration (Table 1). After controlling for the covariates, the risk of being overweight or obese increased by approximately (a) 44% in males as compared to females; (b) 3% per unit increase in the household economic status; (c) 5% and 3% per unit increase in sedentary lifestyles during weekdays and weekends, respectively; and (d) 9% per unit increase in mental stress. Conversely, the risk decreased by (a) 10% per unit increase in paternal education level, (b) 18% per unit increase in muscle-strengthening exercise, and (c) 7% per hour increase in sleep duration.

Discussion

Inverse Relationship Between Sleep Duration Versus BMI, Overweight, and Obesity

This study demonstrated that sleep duration had an inverse linear relationship with both BMI and obesity. Systematic reviews of previous studies indicate that the relationship is inversely linear in childhood and this signifies that a person who sleeps more has a lower risk of being overweight or obese (Marshall et al., 2008; Patel & Hu, 2008). This study is generally consistent with the inverse linear relationship found between sleep duration and being overweight or obese in childhood.

The systematic reviews conducted by Marshall et al. (2008) and Patel and Hu (2008) show that the pattern is clear in the children populations in general. However, caution is necessary for generalizing these patterns because of some inconsistencies (Taheri & Thomas, 2008), pending further empirical evidence. In addition, the underlying mechanisms of these patterns have not yet been adequately explored. One important issue to note is that researchers agree that short sleep duration is associated with an increased risk of being overweight or obese, supported by ample evidence from diverse countries such as China, Switzerland, and the United States (Hart & Jelalian, 2008; Hasler et al., 2004; Marshall et al., 2008).

Factors Linked to Overweight and Obesity

This study clearly demonstrated that shorter sleep duration was significantly associated with greater risks for being overweight or obesity, even after

adjusting for the other factors. With a 1-hour decrease in sleep duration, the likelihood of being overweight or obesity increased by 6.5%. The findings presented in the current study are in line with the existing literature, which shows an inverse relationship between the two (Seicean et al., 2007; Yu et al., 2007).

Patel and Hu (2008) propose potential mechanisms behind this connection, suggesting that short sleep duration increases hunger, opportunities to eat, and fatigue and changes thermoregulation. The first two conditions result in heightening caloric intake; the last two conditions result in lowing energy expenditure. As a consequence, risk for being obese is heightened. First, lessened sleep duration is likely to affect metabolic change and trigger hunger feelings. More specifically, the regulations of ghrelin and leptin hormones, which are linked to appetite, play critical roles: Levels of these two hormones are altered when people experience sleep deprivation (Marshall et al., 2008; Taheri & Thomas, 2008; Yu et al., 2007). With shorter sleep duration, ghrelin levels increase and leptin levels decrease. Because ghrelin increases appetite, whereas leptin reduces it, these changes lead to an increase in appetite (Jones, Johnson, & Harvey-Berino, 2008). Second, later bedtimes may provide more opportunities to eat (Taheri, 2006). A recent study shows that shortened sleep is significantly associated with increased calorie intake, especially through snack eating (Nedeltcheva et al., 2009). Third, short sleep causes tiredness and daytime drowsiness, which in turn lead people to decrease their physical activity level (Taheri, 2006; Patel and Hu, 2008). Last, some evidence shows that when people sleep less, their core body temperature drops (Landis, Savage, Lentz, & Brengelmann, 1998), and Landis et al. (1998) propose that sleep curtailment may result in making people susceptible to heat loss. This change in body temperature regulation may signify the effect of short sleep duration on altered energy expenditure (Patel & Hu, 2008).

Other factors significantly linked to being overweight or obese were gender, household economic status, paternal education level, sedentary lifestyles, mental stress, and frequency of muscle-strengthening exercise. The risk of being overweight or obese increased for those who were male, had sedentary lifestyles, experienced mental stress, and exercised less. Furthermore, increases in household economic status and lower paternal education levels also increased the risks of being overweight or obese.

These findings are consistent with what is suggested in the literature. First, males were at greater risk for being overweight or obese than their female counterparts. This gender difference was present in other studies analyzing South Korean adolescents (Park, 2009) and high school students in the United States (CDC, 2008b). The higher likelihood of being overweight or obese among male youth may be attributable to the male hormone, testosterone,

which is actively produced during this developmental stage. Wabitsch et al. (1997) explain that among male children and adolescents, testosterone strongly lessens serum leptin secretions by 62%.

Second, two indices representing socioeconomic status (SES) were connected to overweight and obesity in this study: Household economic status was positively linked to obesity, whereas paternal education level was inversely related. The influence of SES on obesity is not apparent in the literature (Brooks-Gunn et al., 2005). Recently, Shrewsbury and Wardle (2008) systematically reviewed prior studies of the relationship between SES and childhood adiposity for the 16 years from 1990 to 2005. They state that among socioeconomic indicators, parental education level is more consistently linked to obesity than income. In the majority of the studies reviewed, an inverse relationship between parental education level and obesity is present, consistent with results of this study. There are two plausible reasons why the effects of parental education levels are stronger than those of income. One reason may be that over time, parental education level is much more stable than income. The other reason may be due to different underlying mechanisms operating the link between these indicators and obesity.

Third, sedentary lifestyles (e.g., watching TV, playing computer games, and using the Internet) increased the likelihood of being overweight or obese. Obesity is a function of energy homeostasis, determined by energy intake and expenditure. Jacobs (2006) proposed a hypothesis to explain this phenomenon: Sedentary persons may lack the ability to reduce their food intake in proportion to their reduced activity levels.

Among the various components of a sedentary lifestyle, it is interesting to note that TV viewing is the single most important factor linked to being overweight or obese (Janssen et al., 2005; Rey-Lopez, Vicente-Rodrıguez, Biosca, & Morenom, 2008). In addition to changes in energy homeostasis, the strong effects of TV viewing may be attributable to both an increased exposure to TV advertisements for high-calorie foods and the consumption of them while watching TV (Brooks-Gunn et al., 2005). There is some evidence supporting this hypothesis: Those who spend more time watching TV tend to eat unhealthy foods such as sweets and soft drinks, which are frequently advertised, instead of vegetables and fruits (Utter, Scragg, & Schaaf, 2006; Vereecken, Todd, Roberts, Mulvihill, & Maes, 2006).

Fourth, mental stress levels were positively linked to risks of being overweight or obese. A substantial body of evidence supports this finding (Koch, Sepa, & Ludvigsson, 2008). Mental stress triggers the activities of the hypothalamus–pituitary–adrenal (HPA) axis, which results in increased glucocorticoid secretion (Kim & Shim, 2007; Warne, 2009). In the current

literature, glucocorticoids increase the risks for being overweight or obese in two ways. One is through its functions to induce adipose tissue accumulation. The other is that excess glucocorticoid levels are related to the deregulation of leptin function, which leads to increased appetite. Thus, people experiencing mental stress tend to exhibit food-seeking behavior (Kim & Shim, 2007). Also, they may be able to reduce mental stress by eating (Warne, 2009).

Lastly, more frequent muscle-strengthening exercise was associated with reduced risks for being overweight or obese. Exercise is a physical activity directly associated with energy expenditure. There is abundant evidence showing those with low levels of physical activity (PA) in childhood and adolescence experience a greater incidence of obesity (Kiess et al., 2001). Accordingly, physical activity has been one of the factors that researchers have attempted to increase in order to reduce the obesity epidemic. However, the effects of increased physical activity on obesity appears to differ depending on the tier of prevention, according to systematic reviews conducted by Steinbeck (2001) and Reilly and McDowell (2003).The reviews indicate that the effects of physical activity are relatively strong in tertiary prevention, that is, the treatment of obesity, although not clear in primary and secondary prevention. In addition, a recent study reveals that physical activity can affect the activities of the FTO gene, which is associated with obesity and heightened BMI. The link between the FTO gene and obesity is weak among those with high levels of physical activity (Rampersaud et al., 2008).

This study has two strengths. First, the findings are generalizable to the population of South Korean adolescents because of the use of a representative sample of South Korean teens. Second, this study adds to a growing body of literature demonstrating that the important connection between short sleep duration and being overweight or obese is pandemic in various countries. This study has two limitations. First, it was not possible to control for genetic factors because of the lack of such information in the secondary data analyzed. Second, measurement errors in some of the variables used may exist: Some variables (e.g., depression and mental stress) were measured with a single item, and sleep duration was measured using "4 hours or below" and "8 hours or above" as a group.

The following issues should be taken into consideration in future research. First, the mechanisms underlying the significant relationship between short sleep duration and obesity should be further explored. Second, multifaceted intervention strategies should be developed and implemented to curb the growing prevalence of obesity. Lastly, health professionals should consider sleep habits as a significant factor in obesity-related problems. Given that

lifestyle habits formed in childhood and adolescence significantly affect obesity, emphasis should be given to primary prevention rather than secondary and tertiary preventions (Sinha & Kling, 2009): Researchers should focus attention on assisting children and teens form these healthy habits (e.g., getting adequate sleep each night).

Declaration of Conflicting Interests

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