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Correlation between Total Sleep Time and Weekend Catch-up Sleep and Obesity based on Body Mass Index : A nationwide cohort study in Korea

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Abstract

Purpose : Obesity is a major public health burden in developed countries and a well-known risk factor for cardiovascular disease. Short sleep duration is associated with obesity, as well as diabetes, heart disease and death. In modern society, habitual sleep restrictions seem unavoidable due to social obligations and work schedules along with a tendency toward decreased sleep time. Therefore, the purpose of this study is to examine the effect of differences in sleep time between weekdays and weekends on body mass index (BMI).

Methods : This study involved 4,234 Korean adults aged 20 to 64 years based on data obtained from the 7th national health and nutrition examination survey (2016). All subjects were classified into the weekend catch-up sleep group (weekend CUS group). and the non catch-up sleep group (non-CUS group).

Results : The longer the average sleep time, the lower was the BMI, and the larger the difference in sleep time between weekdays and weekends, the lower was the BMI. Compared with those with an average sleep time of 8 hours or more, obesity was 1.6-fold higher when the average sleep time was less than 6 hours, and 1.2-fold higher in the case of sleep time of 7 hours or more and less than 8 hours. When the difference in sleep time between weekdays and weekends was 0 or less, more than 0 hours but less than 1 hour, and more than 1 hour and less than 2 hours, the risk of obesity was 1.2-fold, 1.1-fold and 1.1-fold higher, respectively, compared with the risk associated with a sleep time difference of 2 hours or greater between weekdays and weekends. However, the difference was not statistically significant.

Conclusion : Short sleep duration is positively associated with obesity. In addition, weekend catch-up sleep affects BMI.

Key Words : body mass index, obesity, sleep, sleep deprivation

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Ⅰ. Introduction

1. Research background and needs

Obesity is a major health burden for individuals, society and the economy. The prevalence of obesity worldwide has increased rapidly. In Korea, the prevalence of obesity was 32.6 % in 2009 and 36.2 % in 2016 (Nam et al., 2019). Obesity is a well-known risk factor for cardiovascular, metabolic, neurodegenerative, psychiatric, and musculoskeletal diseases and some cancers (Blüher, 2019). Therefore, preventive action is needed to reduce the prevalence of obesity and analyze the possible risk factors. Physical inactivity, westernized diet intake, socioeconomic status, behavior and lifestyle are reported as risk factors for obesity. Among them, the most recent evidence suggests that sleep pattern may affect obesity (Beccuti & Pannain, 2011). Abnormal sleep may contribute to the development of obesity (Keith et al., 2006; Mcallister et al., 2009).

Currently, the population of individuals with short sleep duration is increasing worldwide, and the analysis of 250,000 sleep-related global surveys revealed that sleep time during the week has decreased by 37 minutes over the past 10 years (Roenneberg et al., 2012). In modern society, sleep deprivation and deficiency appear inevitable due to social duty and work schedules along with decreased sleep time. Since insufficient sleep is a modifiable risk factor in obesity, its importance is being emphasized (Keith et al., 2006; Knutson et al., 2010). Individuals in modern society take a nap or increase their sleep time on weekends in the absence of work to compensate for sleep deficit on weekdays.

A previous study reported that extended weekend sleep is associated with reduced the risk of hypertension (Hwangbo et al., 2013). According to a study of middle school students in Korea, the greater the difference in sleep time between school days and non-school days, the lower is the BMI (Ryu et al., 2015). However, sleep time varies from country to country, and according to characteristics of population groups such as gender, age, and race. Short sleep duration is related to obesity in the Korean population currently (Kim et al., 2017). A study of elementary and middle school students reported that male students with a large difference in sleep time between school and non-school days were more likely to be obese (Ryu et al., 2015). However, the relationship between the difference in sleep time between weekdays and weekends and obesity in adults has not been studied until now.

2. Research purpose

The objective of the present study was to investigate the effect of the difference in sleep time between weekdays and weekends on obesity among Korean adults (20~64 years) using data from the seventh Korean national health and nutrition examination survey (KNHANES).

Ⅱ. Method

1. Study population

In this study, data from the seventh KNHANES (2016) were used. KNHANES is composed of three parts: a health interview, health examination and nutrition survey (Kweon et al., 2014). The study subjects were adults 20 to 64 years, and cases with missing study variables were excluded. Among 8,150 subjects, 4,683 cases were within the age range, and 4,234 subjects with no missing study variables were included. This is equivalent to a total of 32,256,668 individuals based on the weight calculated relative to the Korean population.

2. Study method

1) Sleep time analysis

Sleep time was calculated using mental health items in the seventh KNHANES. The average sleep time was calculated using the average daily sleep time on weekdays and weekends ((average sleep time per day 5 + average sleep time per weekend 2)/7). The average sleep time was classified into 4 groups: <6 hrs, 6~7 hrs, 7~8 hrs, and ≥ 8 hrs.

The difference in sleep time between weekdays and weekends was defined as the average sleep time per day on a weekend minus the average sleep time per day during weekdays. It was classified into 4 groups: ≤0 hr, 0~1 hr, 1~2 hrs and ≥ 2 hrs. In order to investigate the characteristics of subjects according to the difference in sleep time between weekdays and weekends, all subjects were divided into two groups. If the average daily sleep time on weekends was longer than the average daily sleep time on weekdays, the subjects were classified under the weekend catch-up sleep group (weekend CUS group). The remaining subjects were included in the non-catch-up sleep group (non-CUS group).

2) Body Mass Index (BMI) analysis

The BMI was calculated using weight and height data obtained via health examination in the seventh KNHANES using the formula, weight (㎏)/height (m)^2. Obesity is determined by the World Health Organization Regional Office for the Western Pacific obesity criteria, based on a BMI value of 25 ㎏/㎡ or higher (Consultation, 2004). A BMI less than ㎏/㎡ is considered normal.

3) Demographic, socioeconomic and health variables

The demographic, socioeconomic and health characteristics were determined according to the classification of the seventh KNHANES. The level of education was divided into elementary, middle and high school levels, high school graduates, and college graduates. Lower, middle, middle and high school categories were created based on the quartile of income. Occupational status was divided into employed and non-employed, and smoking status was divided into smokers and non-smokers. Smokers and occasional smokers were classified as smokers, while those who smoked in the past but did not smoke or have never smoked were classified as non-smokers. Drinking status was determined according to the frequency of drinking, and those who drink more than once a month were classified as drinker, and those who consumed less than once a month were classified as non-drinker. Depression was determined using the sum of the 9-item scores of the patient health questionnaire-9 (PHQ-9). Subjects with scores of 10 or more were defined as depressed. Data related to hypertension and diabetes were also obtained.

4) Statistical analysis

To identify the subject characteristics, the frequency and weighting percentages of categorical variables were presented. A Chi-square test with Rao-Scott correction was performed. The mean and standard error of continuous variables were presented, and analysis of variance (ANOVA) was performed. Logistic regression analysis was conducted to confirm the correlation of independent variables with dependent variables, and odds ratio (OR)s and 95 % confidence interval (CI)s were calculated as relative risks.

In the analysis of average sleep time per day, age, sex, education, and income levels, occupational, smoking, drinking, exercise, depression, hypertension, and diabetic status was corrected. In the analysis of the difference in sleep time between weekdays and weekends, parameters of age, average sleep time per day, gender, education level, income level, occupational status, smoking status, drinking status, exercise status, depression status, hypertension prevalence, and diabetes status were adjusted. Statistical analyses were performed using SPSS 23 to reflect the complex sampling design and sampling weights of KNHANES.

Ⅲ. Results

1. Subjects' characteristics according to average total sleep time

Among the subjects, 514 (12.2 %) had an average sleep time of less than 6 hours per day; 1,113 (26.6 %) had an average sleep time of 6 hours or more; 1,444 (34.30 %) had an average sleep time of 7 hours or more; and 1,163 (27.0 %) had an average sleep time of 8 hours or more.

The longer the average sleep time, significantly lower were the BMI and obesity rates. There was a significant difference in average sleep time between weekdays and weekends, and there was a significant difference in job status. In addition, significant differences were found in age, gender, PHQ-9 scale, education, and income levels, and in the presence of diabetes according to the average sleep time (Table 1).

Table 1. Subjects' characteristics based on average sleep duration

	Average sleep duration (hour)				Total	*p*
	<6 hrs	6~7 hrs	7~8 hrs	≥8 hrs		
Subjects' number	514 (12.2 %)	1113 (26.6 %)	1444 (34.3 %)	1163 (27.0 %)	4234 (100.0 %)	
Age (year)	44.5±.6	43.7±.5	41.8±.4	40.6±.5	42.3±.3	<.01
Body Mass Index (kg/m²)	24.5±.2	24.0±.1	24.0±.1	23.6±.1	24.0±.1	<.01
PHQ-9 score	3.3±.2	2.4±.1	2.4±.1	2.6±.1	2.6±.1	<.01
Average sleep time during weekdays (hrs)	4.9±.1	6.2±.0	7.1±.0	8.5±.0	7.0±.0	<.01
Average sleep time during weekends (hrs)	5.9±.1	7.1±.0	7.9±.0	9.0±.0	7.7±.0	<.01
Average sleep time (hrs)	5.2±.0	6.4±.0	7.4±.0	8.6±.0	7.2±.0	<.01
Gender (M/F) (%)	216/298 (50.8/49.2)	499/614 (53.4/46.6)	635/809 (52.2/47.8)	440/723 (46.0/54.0)	1790/2444 (50.7/49.3)	.01
Obesity (BMI≥(25 kg/m²) (Yes/No) (%)	205/309 (42.0/58.0)	399/714 (35.6/64.4)	491/953 (35.3/64.7)	350/813 (30.2/69.8)	1145/2789 (34.8/65.2)	<.01
Education						<.01
≤Elementary school	61 (9.5 %)	95 (7.1 %)	112 (6.8 %)	89 (6.2 %)	357 (7.0 %)	
Middle school	53 (9.1 %)	65 (5.4 %)	129 (8.1 %)	128 (10.2 %)	375 (8.1 %)	
High school	205 (41.9 %)	409 (40.0 %)	494 (36.7 %)	441 (40.2 %)	1549 (39.1 %)	
≥College	195 (39.4 %)	544 (47.6 %)	709 (48.4 %)	505 (43.4 %)	1953 (45.8 %)	
Income						<.01
1st/2nd/3rd/4th quantile (%)	59/144/151/160 (12.8/26.4/30.5/30.4)	90/240/350/433 (8.4/20.3/322.2/39.1)	103/333/486/522 (8.1/22.6/33.3/36.1)	132/287/371/373 (12.4/23.7/32.0/32.0)	384/1004/1358/1488/1004/1358/1488 (9.9/22.7/32.3/35.1)	
Job (Yes/No) (%)	339/175 (66.9/33.1)	789/324 (71.4/28.6)	1030/414 (72.4/27.6)	747/416 (4.7/35.3)	2905/1329 (69.4/30.6)	<.01

Table 1. Subjects' characteristics based on average sleep duration (Continue)

	Average sleep duration (hour)				Total	*p*
	<6 hrs	6~7 hrs	7~8 hrs	≥8 hrs		
Smoking (Yes/No) (%)	126/388 (28.0/72.0)	248/865 (26.3/73.7)	290/1154 (22.7/77.3)	248/915 (24.8/75.2)	912/3322 (24.9/75.1)	.16
Alcohol (Yes/No) (%)	300/214 (61.9/38.1)	653/460 (62.8/37.2)	896/548 (66.4/33.6)	699/464 (63.0/37.0)	2548/1686 (64.0/36.0)	.18
Exercise (Yes/No) (%)	57/457 (10.6/89.4)	111/1002 10.1/89.9)	142/1392 (10.2/89.8)	111/1052 (10.2/89.8)	421/3813 (10.2/89.8)	.99
Depressive mood (Yes/No) (%)	40/474 (7.1/92.9)	53/1060 (4.7/95.3)	67/1377 (4.6/95.4)	59/1104 (5.1/94.9)	219/4015 (5.1/94.9)	.22
Hypertension (Yes/No) (%)	89/425 (16.7/83.3)	172/941 (13.8/86.2)	178/1266 (12.2/87.8)	172/991 (13.2/86.8)	611/3623 (13.4/86.6)	.14
Diabetes mellitus (Yes/No) (%)	39/475 (7.2/92.8)	72/1041 (6.3/93.7)	56/1388 (3.8/96.2)	68/1095 (5.0/95.0)	235/3999 (5.2/94.8)	.02

p-values are from Rao-scott χ^2 test or ANOVA with the post hoc Scheffé test, categorical variable: unweighted n(weighted %), continuous variable; mean ± standard error

2. Association between average total sleep time and obesity

After adjustment for confounding factors such as age, gender, education, income, job, smoking, alcohol, exercise, depressive mood, hypertension, and diabetes mellitus, the OR for obesity among subjects who slept less than 6 hrs daily was 1.6 (95% CI = 1.2~2.1) in comparison with subjects with the average sleep time of more than 8 hrs. The ORs for obesity for those with the average sleep time of 6-7 hrs and 7~8 hrs were both 1.2 (95% CI = 1.0~1.5).

3. Subjects' characteristics according to differences in sleep time between weekdays and weekends

Among the study subjects, 2,135 (49.5 %) had less than 0 hours of sleep time difference between weekdays and weekends (the average sleep time per day on a weekend minus the average sleep time per day during weekdays), 330 (7.5 %) had more than 0 hours of sleep time difference, while 932 (21.9 %) reported more than 1 hour of sleep time difference, and 837 (21.2 %) had more than 2 hours of sleep time difference.

The longer the catch-up sleep on weekends, that is, the greater the difference in sleep time between weekends and weekdays, the lower were the BMI and the rate of obesity.

There were significant differences in average sleep time during weekdays and average sleep time during weekends according to the difference in sleep time between weekends and weekdays. Among subjects with more than two hours of sleep difference between weekdays and weekends, the occupational rate was higher than in other groups.

In addition, significant differences were found in age, gender, PHQ-9 score, education level, income level, smoking status, the presence of hypertension, and diabetes depending on the difference in sleep time between weekdays and weekends (Table 2).

Table 2. Characteristics of subjects based on weekend catch-up sleep

	Weekend catch-up sleep (hour)				Total	*p*
	≤ 0hr	0~1hr	1~2 hrs	≥2 hrs		
Subjects' number	2135 (49.5 %)	330 (7.5 %)	932 (21.9 %)	837 (21.2 %)	4234 (100.0 %)	
Age (year)	44.4±.4	41.8±.8	40.9±.5	39.0±.5	42.3±.3	<.01
Body Mass Index (kg/m^2)	24.2±.1	24.0±.3	23.7±.15	23.7±.16	24.0±.1	.01
PHQ-9 score	2.7±.11	2.3±.2	2.4±.1	2.6±.13	2.6±.1	.03
Average sleep time during weekdays (hrs)	7.3±.0	7.1±.1	6.9±.0	6.4±.1	7.0±.0	<.01
Average sleep time during weekends (hrs)	7.0±.0	7.6±.1	8.1±.0	9.1±.1	7.7±.0	<.01
Average sleep time (hrs)	7.2±.0	7.2±.1	7.2±.0	7.1±.1	7.9±.0	.51
Gender (M/F) (%)	954/1181 (53.9/46.1)	126/204 (46.9/53.1)	354/578 (45.2/54.8)	356/481 (50.1/49.9)	1790/2444 (50.7/49.3)	<.01
Obesity (BMI ≥25 kg/m^2) (Yes/No) (%)	781/1354 (37.5/62.5)	106/224 (33.6/66.4)	302/630 (323./67.7)	256/581 (31.6/68.4)	1445/2789 (34.8/65.2)	.02
Education						<.01
≤Elementary school	251 (9.7 %)	19 (4.7 %)	52 (4.9 %)	35 (3.9 %)	357 (7.0 %)	
Middle school	244 (10.8 %)	18 (5.3 %)	65 (5.9 %)	48 (4.9 %)	375 (8.1 %)	
High school	779 (39.1 %)	122 (41.0 %)	327 (38.1 %)	321 (39.6 %)	1549 (39.1 %)	
≥College	861 (40.4 %)	171 (49.0 %)	488 (51.0 %)	433 (51.6 %)	1953 (45.8 %)	
Income						<.01
1st/2nd/3rd/4th quantile (%)	239/535/690/671 (12.3/23.6/33.0/31.1)	20/63/100/147 (6.6/18.2/31.4/43.8)	61/204/300/367 (6.7/22.0/32.1/39.1)	64/202/268/303 (8.7/23.2/31.2/37.0)	384/1004/1358/1488 (9.9/22.7/32.3/35.1)	
Job (Yes/No) (%)	1393/742 (66.4/33.6)	232/98 (72.1/27.9)	660/272 (70.5/29.5)	620/217 (74.2/25.8)	2905/1329 (69.4/30.6)	<.01
Smoking (Yes/No) (%)	498/1637 (27.0/73.0)	64/266 (24.4/75.6)	157/775 (19.2/80.8)	193/644 (25.9/74.1)	912/3322 (24.9/75.1)	<.01
Alcohol (Yes/No) (%)	1243/892 (62.3/37.7)	190/140 (62.6/37.4)	578/354 (65.8/34.2)	537/300 (66.5/33.5)	2548/1676 (64.0/36.0)	.18
Exercise (Yes/No) (%)	182/1953 (9.0/91.0)	37/293 (12.7/87.3)	102/830 (11.0/89.0)	100/737 (11.5/88.5)	421/3813 (10.2/89.8)	.12
Depressive mood (Yes/No) (%)	132/2003 (6.2/93.8)	12/318 (3.7/96.3)	36/896 (3.4/96.6)	39/798 (4.6/95.4)	219/4015 (5.1/94.9)	.02
Hypertension (Yes/No) (%)	385/1750 (16.9/83.1)	36/294 (10.2/89.8)	110/822 (10.8/89.2)	80/757 (9.3/90.7)	611/3623 (13.4/86.6)	<.01
Diabetes mellitus (Yes/No) (%)	155/1980 (6.8/93.2)	14/316 (4.6/95.4)	34/898 (3.0/97.0)	32/805 (4.0/96.0)	235/3999 (5.2/94.8)	<.01

p-values are from Rao-scott χ^2 test or ANOVA with the post hoc Scheffé test; categorical variable: unweighted n(weighted %), continuous variable: mean ± standard error.

4. Characteristics of subjects in weekend CUS group and non-CUS group

The participants' general characteristics were investigated according to sleep time. The subjects' average sleep time was 7.2±.0 hrs, and the average BMI was 24.0±.1 kg/㎡, including 1,445 (34.8 %) obese subjects. There were 2,099 (50.50 %) subjects in the weekend CUS group and 2,135 (49.5 %) in the non-CUS group.

The weekday sleep time of subjects belonging to the weekend CUS group was shorter than in the non-CUS group. (6.7±.0 hrs vs. 7.3±.0 hrs) and the sleep time on weekends in the weekend CUS group was longer than in the non-CUS group (8.4±.0 hrs vs. 7.0±.0 hrs. BMI was lower in the weekend CUS group than in the non-CUS group (23.7±.1 kg/㎡ vs. 24.2±.1 kg/㎡)). Obesity was also lower in the weekend CUS group than in the non-CUS group (664 patients (32.2 %) vs. 781 patients (37.5 %).

In the weekend CUS group, the average sleep time was of 272 (12.8 %) reported <6 hrs, 631 (30.6 %) had 6~7 hrs, 733 (35.2 %) slept for 7~8 hrs, and 463 (21.3 %) for ≥8 hours.

In the non-CUS group, 242 subjects (11.5 %) slept for ≤6 hours, 482 subjects (22.4 %) reported 6-7 hrs of sleep, 711 subjects (33.3 %) 7~8 hrs, and 700 subjects (32.7 %) ≥8 hours.

In total, the most common sleep time was 7~8 hrs [1,444 subjects (34.3 %)]. In addition, statistically significant differences were found according to gender, hypertension, diabetes, depression, smoking, exercise, education level, and income level between the two groups (Table 3).

Table 3. Subjects' characteristics in the weekend catch-up sleep (CUS) group and non-CUS group (n=4,234)

	Weekend CUS group	Non CUS group	Total	*p*
Subjects' number	2099 (50.5 %)	2135 (49.5 %)	4234 (100.0 %)	
Age (year)	40.2±.4	44.4±.4	42.3±.3	<.01
Body Mass Index (kg/㎡)	23.7±.1	24.2±.1	24.0±.1	<.01
PHQ-9 score	2.5±.1	2.7±.1	2.6±.1	<.01
Average sleep time during weekdays (hrs)	6.7±.0	7.3±.0	7.0±.0	<.01
Average sleep time during weekends (hrs)	8.4±.0	7.0±.0	7.7±.0	<.01
Average sleep time (hrs)	7.2±.0	7.2±.0	7.2±.0	.9
Gender (M/F) (%)	836/1263 (47.5/52.5)	954/1181 (53.9/46.1)	1790/2444 (50.7/49.3)	<.01
Obesity (BMI ≥25kg/㎡)(Yes/No) (%)	664/1435 (32.2/67.8)	781/1354 (37.5/62.5)	1445/2789 (34.8/65.2)	<.01
Education				<.01
≤Elementary school	106 (4.50 %)	251 (9.7 %)	357 (7.0 %)	
Middle school	131 (5.4 %)	244 (10.8 %)	375 (8.1 %)	
High school	770 (39.2 %)	779 (39.1 %)	1549 (39.1 %)	
≥College	1092 (51.0 %)	861 (40.4 %)	1953 (45.8 %)	
Income				<.01

Table 3. Subjects' characteristics in the weekend catch-up sleep (CUS) group and non-CUS group (Continue) (n=4,234)

	Weekend CUS group	Non CUS group	Total	*p*
1st/2nd/3rd/4th quantile (%)	145/469/668/817 (7.5/21.9/31.6/38.9)	239/535/690/671 (12.3/23.6/33.0/31.1)	384/1004/1358/1488 (9.9/22.7/32.3/35.1)	
Job (Yes/No) (%)	1512/587 (72.3/27.7)	1393/742 (66.4/33.6)	2905/1329 (69.4/30.6)	<.01
Smoking (Yes/No) (%)	414/1685 (22.8/77.2)	498/1637 (27.0/73.0)	912/3322 (24.9/75.1)	.01
Alcohol (Yes/No) (%)	1305/794 (65.6/34.4)	1243/892 (62.3/37.7)	2548/1686 (64.0/36.0)	.06
Exercise (Yes/No) (%)	239/1860 (11.4/88.6)	182/1953 (9.0/91.0)	421/3813 (10.2/89.8)	.02
Depressive mood (Yes/No) (%)	87/2012 (4.0/96.0)	132/2003 (6.2/93.8)	219/4015(5.1/94.9)	<.01
Average sleep duration(hour) (Yes/No) (%)				<.01
< 6 hrs	272 (12.8 %)	242 (11.5 %)	514 (12.2 %)	
6~7 hrs	631 (30.6 %)	482 (22.4 %)	1113 (26.6 %)	
7~8 hrs	733 (35.2 %)	711 (33.3 %)	1444 (34.3 %)	
≥ 8hrs	463 (21.3 %)	700 (32.7 %)	1163 (27.0 %)	
Hypertension (Yes/No) (%)	226/1873 (10.1/89.9)	385/1750 (16.9/83.1)	611/3623 (13.4/86.6)	<.01
Diabetes mellitus (Yes/No) (%)	80/2019 (3.6/96.4)	155/1980 (6.8/93.2)	235/3999 (5.2/94.8)	<.01

p-values are from Rao-scott χ^2 test or ANOVA with the post hoc Scheffé test; categorical variable: unweighted n(weighted %), continuous variable: Mean ± Standard Error.

5. Association between average total sleep duration and obesity

When the difference between weekday and weekend sleep time was less, the risk of obesity was higher than when the difference in sleep time between weekdays and weekends was more than 2 hours, but it was not statistically significant. After adjustment for confounding factors such as age, sleep duration, gender, education, income, job, smoking, alcohol, exercise, depressive mood, hypertension, and diabetes mellitus, the OR for obesity among subjects with no weekend catch-up sleep was 1.2 (95 % CI = 1.0~1.4) in comparison with subjects with the weekend catch-up sleep of more than 2 hrs. The ORs for obesity for those with the weekend catch-up sleep of 0~1 hr and 1~2 hrs were 1.1 (95 % CI = 0.8~1.6) and 1.1 (95 % CI = 0.8~1.4), respectively.

Ⅳ. Discussion

The purpose of this study was to investigate the relationship between average sleep time and the difference in sleep time between weekdays and weekends and obesity among Korean adults aged 20~64 years. As a result of the study, those who slept for more than 7 hours and less than 8 hours per day had the highest rate (34.3 %), and the longer the average sleep time, the lower was the risk of obesity. Based on logistic regression analysis, obesity was significantly higher (1.6-fold) when the average sleep time

was ≤ 6 hrs, and 1.2 times higher when it was 7-8 hrs than when the average sleep time was less than 6 hours. The risk of obesity was 1.2-fold, 1.1-fold and 1.1-fold higher when the sleep time difference between weekdays and weekends is ≤ 0 hours, 0~1 hr, 1~2 hrs than when the sleep time difference between weekdays and weekends was more than 2 hrs. However, it was not statistically significant.

Various studies have shown an association between sleep duration and obesity. A 2012 Australian study found that adult men and women who slept less than 7 hours each night had an increased risk of obesity than those who slept longer. The risk of obesity was increased in men with an average sleep time of more than 9 hours, but not in women (Magee et al., 2010). A 2013 Brazilian study found that shorter average sleep duration, REM sleep, and slow wave sleep increased BMI, central adiposity, and the risk of cardiovascular disease in adult men and women (Moraes et al., 2013). A 2014 US study found that insufficient sleep time leads to overweight and obesity in adult men and women (Jean-Louis et al., 2014). Based on a 2017 Korean study, it was found that BMI decreased by 0.12 kg/m^2 with a 1 hr increase in the difference in sleep time between weekdays and weekends (Im et al., 2017). These results may differ depending on race, study design, sample size, and correction variables.

Although the mechanism underlying obesity induction by short sleep time obesity is unclear, various hypotheses have been proposed. First, short sleep duration is strongly related to appetite control and increases appetite by decreasing leptin secretion, which suppresses appetite, and increases ghrelin secretion, which increases appetite (Knutson & Van, 2008). Second, lack of sleep activates the sympathetic nervous system at night to increase cortisol and growth hormone secretion (Magee et al., 2010). This can lead to insulin resistance and impaired glycemic control. Third, short sleep duration causes excessive daytime sleepiness and affects physical activity in daily life (Atkinson & Davenne, 2007). This reduces intentional motor activity, thereby reducing overall energy expenditure. Some studies have reported that poor sleep quality is associated with a higher incidence of obesity-related metabolic syndrome (Logue et al., 2014). Therefore, controlling the average sleep duration and quality of sleep is important in lowering the risk of obesity.

In the present study, the greater the difference in sleep time between weekdays and weekends, the lower was the risk of obesity, but it was not statistically significant. According to previous studies, the larger the difference in sleep time between weekdays and weekends, the lower was the BMI. Furthermore, sleeping longer on weekends to catch up with sleep lost during weekdays may play a role in preventing weight gain due to chronic lack of sleep (Im et al., 2017). Therefore, as a result of this study, short sleep duration may be related to the risk of obesity in Korean adults, suggesting that adequate sleep is an important lifestyle intervention for obesity prevention. In addition, the effect of difference in sleep time between weekdays and weekends maybe related to BMI, emphasizing the importance of sleep duration on weekdays and weekends in addition to management of sleep disorder.

Weekend CUS is not only related with social schedules and short sleep duration during weekdays but also related with individual's chronotype, reflecting interindividual differences in daily activity patterns and sleep-wake cycles. Sleep duration and chronotype are known to be related with diet, physical activity and cardiometabolic health (Almoosawi et al., 2019). Weekend CUS might have positive impacts on obesity by counteracting the negative effects of sleep deprivation during weekdays.

Further, social jet lag was associated with chronic sleep deprivation, health-impaired behaviors (e.g., smoking, drinking alcohol, caffeine intake, etc.), elevated BMI, and risk of chronic diseases (Roenneberg et al., 2012). A study of healthy Dutch university students found that social jet lag had negative effects on endocrine, and behavioral patterns, as well as cardiovascular risk factors (Rutters et al., 2014). Therefore, there is a need for further studies to

explore the effects of sleep deprivation on diseases other than obesity.

The main factors contributing to reduced sleep time among subjects include increased working hours and leisure activities (Bin et al., 2012). Therefore, efforts to increase sleep duration by reducing excessive leisure time along with proper regulation of work hours of workers can prevent weight gain by affecting appetite and also increasing the amount of physical activity. Interventions should be directed towards maintaining adequate sleep time, both on weekdays and on weekends.

This study is the first report to analyze the relationship between sleep time differences during weekdays and weekends and obesity using the KNHANES data. The findings are applicable to general population of Korean adults due to the large sample of Koreans' surveyed. However, since the KNHANES data consists of self-report questionnaires, inaccuracies and possible loss of information and errors in recall may occur. Therefore, the possibility of a difference between actual and reported sleep time cannot be excluded. This study analyzed cross-sectional data and has limitations in determining the effects of persistent sleep deprivation on obesity. In addition, since the quality of sleep was not analyzed together with sleep time in the present study, it is necessary to perform a longitudinal study and utilize polysomnography to measure objective sleep time and sleep quality based on prospective cohort design or clinical trials. Since the average sleep time varies depending on demographic and sociological characteristics, it is necessary to analyze the comprehensive effects of sleep time on obesity according to demographic and sociological characteristics in the future study. Despite these limitations, the assessment of relationship between sleep time and the difference in sleep time between weekdays and weekends with obesity based on BMI with a large population sample validates the study findings (Kim et al., 2017).

V. Conclusion

The present study revealed that a short sleep duration is positively associated with high BMI and weekend catch-up sleep may affect BMI. Sleep deprivation may contribute to the development of obesity. To reduce the risk of obesity, preventive interventions to improve insufficient sleep time and patterns may be helpful.

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