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The Associations of Sleep Duration and Healthy Eating Index with Body Mass Index and Waist Circumference in Korean Adults: Results from the Korean National Health and Nutrition Examination Survey 2013-2015

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ABSTRACT

This study aimed to investigate the association of sleep duration and healthy eating with measure of obesity, the body mass index (BMI) and waist circumference (WC). Data from the 2013-2015 Korea National Health and Nutrition Examination Survey, a nationwide cross-sectional survey. The association of sleep duration and the Korean Healthy Eating Index (HEI) with obesity were analyzed using multiple regression. Age, sex, household income, education level, days of physical activity, self-rated health, and year were adjusted as covariates. These covariates were included in the stepwise regression analysis. We created a combined variable (HEI × sleep duration) and examined its association with obesity. South Korea (KOR) Participants 13,349 individuals aged ≥0 years. Short sleep duration (≤ and 6 h) was associated with low total HEI score, not eating breakfast, low mixed grain intake, low total fruit intake, low total vegetable intake, and inadequate energy intake, while long sleep duration was associated with low vegetable intake. High HEI score was associated with low BMI and low WC. This study shows the association between sleep duration and overweight-obesity status with considering diet intake quality. Therefore, proper sleep duration and good diet intake quality may help prevent the risk of obesity.

1. Introduction

The association between sleep duration and the risk of obesity has been extensively studied. The proposed potential mechanisms from sleep duration to obesity can be classified into three

major pathways. Short sleep duration causes dysregulation of insulin and glucose, (Cali et al., 2009; Knutson & Van Cauter, 2008) decrease in leptin level, and increase in ghrelin level, thereby increasing hunger and appetite (Spiegel, Tasali, Penev, & Van Cauter, 2004), altered overall dietary intake and eating behaviors (Gebski et al., 2018; Patel & Hu, 2008), increased frequency of eating (Sivak, 2006), increased preference for snacks instead of meals, and low intake of fruits and vegetables (S. Kim, DeRoo, & Sandler, 2010), and high intake of potassium and calcium (Mossavar-Rahmani et al., 2015). The relationship between long sleep duration and obesity, on the other hand, may be explained by sedentary lifestyle, physical inactivity, and unhealthy eating habits (Tan, Chapman, Cedernaes, & Benedict, 2018). A number of proposed potential mechanisms for the link between sleep duration to obesity (Dashti, Scheer, Jacques, Lamon-Fava, & Ordovás, 2015; Hart, Cairns, & Jelalian, 2011; Tan et al., 2018): 1) dietary intake and eating behavior change due to metabolic profile alteration, 2) dietary intake and eating behavior change due to increased time for intake, altered time of intake, and sleepiness-related impairments in cognitive functions such as impulse control, motivation, judgment mood, and attention, 3) reduced physical activity.

Dietary intake and eating behavior are well-known risk factors of obesity (Guo, Warden, Paeratakul, & Bray, 2004; Torres & Nowson, 2007). It is important to adjust these factors in a model that identifies the relationship between sleep duration and obesity. Recent studies have reported the mediation effects of eating behaviors such as disordered eating habits (Yeh & Brown, 2014) and disinhibition of eating (Blumfield, Bei, Zimberg, & Cain, 2018). Interestingly, no significant mediation effect of eating behavior between sleep duration and BMI was found in Blumfield et al.'s study (Blumfield et al., 2018). However, Yeh and Brown's study (Yeh & Brown, 2014) reported significant mediation effects of binge-eating and night-eating on the associations between BMI and total sleep quality, including sleep duration. They found that binge-eating and night-eating partly explain the relationship between worse sleep quality and weight gain. However, few studies examined the influence of dietary intake between sleep duration and obesity, even though dietary intake regulation is a key factor to achieve weight loss (Fruh, 2017; Wolf & Woodworth, 2009).

The healthy eating index (HEI) is a useful tool to assess diet intake quality. (Krebs-Smith et al., 2018) The HEI questionnaire comprises items such as grain, vegetable, fruit, milk, meat, total fat, saturated fat, cholesterol, sodium, and food variety (Guo et al., 2004). Notably, low HEI score was associated overweight and obesity (Camhi, Whitney Evans, Hayman, Lichtenstein, & Must, 2015; Guo et al., 2004; Tande, Magel, & Strand, 2009). Moreover, short sleep duration is associated with low fruit and vegetable intake (Gebski et al., 2018), which is related to a low HEI score.

The relationship between sleep duration and the risk of obesity has been extensively studied. However, the effects of dietary intake have not been taken into consideration when examining this relationship. HEI, which is used to assess diet intake quality, may clarify the relationship. Therefore, we aim to examine the associations of sleep duration and healthy eating index with overweight-obesity status in Korean adults using data collected from the 2013-2015 Korea National Health and Nutrition Examination Survey. We hypothesize that: 1) shorter and longer sleep

duration to be associated with low diet intake quality and 2) shorter and longer sleep duration and low diet intake quality to be associated with high body mass index (BMI) and waist circumference (WC).

2. Materials and Methods

2.1 Study data

This study used the pooled data from the 2013-2015 Korea National Health and Nutrition Examination Survey (KNHANES) published by the Korea Centers for Disease Control and Prevention (Kweon et al., 2014). KNHANES collected samples using a multistage, stratified cluster-sampling design based on the National Census Registry. KNHANES is a nationally representative cross-sectional survey data in the Republic of Korea.

Only those data from 2013 to 2015 were used because the HEI was provided only in this period. The study population was 8018 in 2013, 7550 in 2014, and 7380 in 2015. From a total of 22,948 respondents, we excluded those who were below 20 years old (N = 5168), had missing HEI data (N = 1981), and/or had other independent variables, such as BMI, survey weight, sleep duration, and smoking status (N = 2450). Finally, data from 13,349 respondents were included in our study.

2.2 Study variables

The BMI and WC were included in the model as dependent variables. The independent variables were age, sex, number of household members, education, household income, smoking, occupation, monthly drinking status, days of physical activity, self-rated health, level of stress, sleep duration, and the year. Monthly drinking status was categorized into less than one glass of alcohol per month and more than one glass of alcohol per month. Data on the days of physical activity were derived from the following two questions: “During the last week, how many days did you do strength exercises such as push-ups, sit-ups, dumbbells, weights, and iron bars?” and “During the last week, how many days did you do exercises such as stretching, freehand exercises, etc.?” The value of the days of physical activity was defined as the maximum days of the two answers. Meanwhile, self-rated health was classified into poor, normal, and good. Sleep duration was divided into ≤ 5, 6, 7, 8, and ≥ 9 h.

Korean Healthy Eating Index was included as the HEI. The Korean HEI was developed according to the HEI for Korean situation (Yun & Oh, 2018). It is composed of eight adequacy, three moderation, and three balance components. Adequacy components include having breakfast; mixed grain intake; total fruit intake; fresh fruit intake; total vegetable intake; vegetable intake, excluding Kimchi and pickled vegetable intake; meat, fish, egg, and bean intake; and milk and milk product intake. The percentage of energy from saturated fatty acid, the percentage of energy from sweets and beverages, and the sodium intake constituted the three moderation components. The three balance

components were the percentage of energy from carbohydrate, the percentage of energy from fat, and energy intake. The maximum score was 100 (high diet quality), whereas the minimum was 0 (low diet quality).

To identify the combined associations of HEI and sleep duration, we categorized the HEI into quartiles (Q1 to Q4) and included one 20-category variable from the HEI category (4) × sleep duration (5).

2.3 Statistical analysis

The distribution of the HEI, BMI, and WC by independent variables was examined by t-test and ANOVA. The association between the independent variables and obesity was also investigated by multiple regression using survey reg in the SAS 9.4 Cary Inc. Survey sample weights were used in all of the analyses. All independent variables, such as age, sex, number of household member, education, household income, smoking, monthly drinking status, days of physical activity, self-rated health, and the year, were adjusted in the multiple regression model. However, the number of household members, smoking, monthly drinking status, occupation, and stress level were dropped by stepwise selection.

Multiple regression was conducted for identifying associations between sleep duration and HEI. The regression conducted separately for all 14 components and the total score of HEI. Then multiple regression was used twice for identifying association between sleep duration and HEI, and BMI and WC. Sleep duration and HEI were separately included in the model. This can identify the association of both sleep duration and HEI with obesity. Then, they were both considered as a combined variable, and its association with obesity examined using multiple regression.

3. Results

Table 1 shows the general characteristics of participants in this study. Among 13,349 respondents, the mean values for HEI, BMI, and WC were 63.5 ± 0.2, 23.8 ± 0.0, and 81.4 ± 0.1, respectively. Results of the t-test and ANOVA among the HEI, BMI, and WC were all significant. The HEI, BMI, and WC increased as the age increased. The HEI and BMI showed a slight decrease in those aged 70s compared with those aged 60s. The relationship between sleep duration and HEI exhibited an inverted U-shape. Short sleep duration ($\leq$5 h) and long sleep duration ($\geq$9 h) showed low HEI. The BMI exhibited a linear trend, and it decreased with an increased sleep duration. Meanwhile, the WC exhibited a U-shape. Short sleep duration and long sleep duration showed an increased WC.

Table 1. Participants' characteristics and their Healthy Eating Index, BMI, and waist circumference

				Healthy Eating Index		BMI		WC	
		N	Weighted %	Mean ± SD	p-value	Mean ± SD	p-value	Mean ± SD	p-value
Age	20-29	1420	17.7	57.5 ± 10.4	<.001	22.8 ± 3.1	<.001	77.3 ± 8.2	<.001
	30-39	2188	19.6	61.2 ± 11.5		23.7 ± 03.5		80.8 ± 10.0	
	40-49	2423	21.2	64.3 ± 11.7		24 ± 3.1		81.2 ± 9.0	
	50-59	2625	19.9	66.5 ± 12.1		24.2 ± 3.0		82.7 ± 8.7	
	60-69	2410	11.4	68.4 ± 15.0		24.3 ± 3.9		84.3 ± 11.3	
	≥70	2283	10.2	65.3 ± 15.5		23.9 ± 4.2		84.5 ± 12.3	
Sex	Male	5411	49.0	61.8 ± 11.6	<.001	24.4 ± 3.1	<.001	85.1 ± 8.3	<.001
	Female	7938	51.0	65.1 ± 14.2		23.2 ± 3.9		77.9 ± 10.5	
Education	≤Elementary	3269	16.3	63.8 ± 15.0	<.001	24.5 ± 4.2	<.001	84.3 ± 11.4	<.001
	Middle school	1451	9.2	64.9 ± 13.6		24.1 ± 3.5		83 ± 10.0	
	High school	4368	37.0	62.8 ± 12.6		23.7 ± 3.3		80.9 ± 9.4	
	≥College	4261	37.4	62.5 ± 12.0		23.8 ± 3.3		81.4 ± 9.6	
Household income	Q1 (low)	2633	14.8	61.7 ± 14.9	<.001	24.2 ± 4.2	<.001	83.7 ± 11.8	<.001
	Q2	3384	24.7	62.5 ± 13.0		23.8 ± 3.7		81.4 ± 10.4	
	Q3	3622	29.6	63.4 ± 12.4		23.8 ± 3.4		81.3 ± 9.6	
	Q4 (high)	3710	31.0	65.2 ± 12.5		23.6 ± 3.2		80.5 ± 9.4	
Days of physical activity (Days)	No	5528	39.2	61.7 ± 13.2	<.001	23.8 ± 3.8	0.050	81.8 ± 10.8	<.001
	1-2	2467	19.6	63.4 ± 12.5		23.8 ± 3.6		80.9 ± 10.2	
	3	1555	12.5	64.8 ± 12.9		23.7 ± 3.3		80.6 ± 9.4	
	4	3799	28.7	65.4 ± 12.9		23.9 ± 3.2		81.6 ± 9.3	
Self-rated health	Poor	2638	17.2	63.1 ± 14.0	<.001	24.1 ± 4.4	<.001	82.9 ± 12.1	<.001
	Normal	6705	50.4	63.5 ± 13.0		23.9 ± 3.5		81.7 ± 10.0	
	Good	4006	32.4	63.7 ± 12.5		23.5 ± 3.0		80.2 ± 9.0	
Year	2013	4609	33.6	63.1 ± 13.2	0.003	23.8 ± 3.6	0.002	80.5 ± 10.3	<.001
	2014	4354	32.8	63.8 ± 12.9		23.7 ± 3.4		81.1 ± 9.8	
	2015	4386	33.6	63.5 ± 13.0		23.9 ± 3.5		82.6 ± 10.1	
Sleep duration	≤5	2248	15.2	62.8 ± 14.1	<.001	24.3 ± 3.8	<.001	82.9 ± 10.6	<.001
	6	3656	27.6	63.7 ± 12.9		24.0 ± 3.5		82.0 ± 10.1	
	7	3719	29.1	64.2 ± 12.5		23.6 ± 3.2		80.7 ± 9.5	
	8	2769	21.3	63.2 ± 12.8		23.5 ± 3.5		80.8 ± 9.9	
	≥9	957	6.8	61.6 ± 13.7		23.4 ± 4.2		80.6 ± 11.3	
Korean Healthy Eating Index	Q1 (low)	3344	28.6			23.9 ± 3.6	0.036	81.8 ± 15.2	<.001
	Q2	3361	25.2			23.9 ± 3.5		81.7 ± 10.0	
	Q3	3343	24.1			23.8 ± 3.4		81.4 ± 9.6	
	Q4 (high)	3301	22.1			23.6 ± 3.6		80.7 ± 10.1	

Figure 1 is the distribution of BMI, and Figure 2 is the distribution of WC for man, Figure 3 is for woman. 32.7% of respondents were obese (BMI ≥ 25), and 25.3% of respondents were abdominal obesity (WC ≥ 90 for male, WC ≥ 85 for female) (Kanazawa et al., 2005).

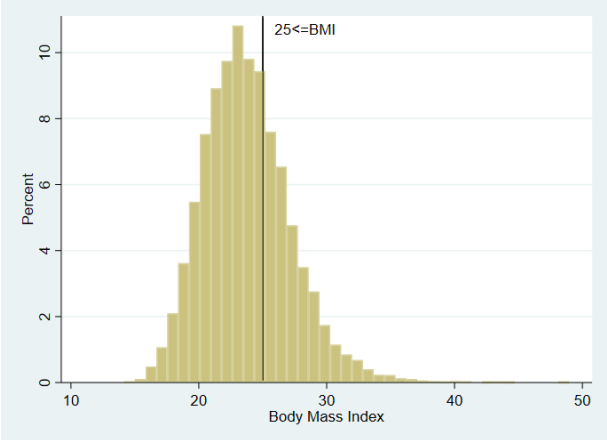

Fig. 1. The distribution of body mass index

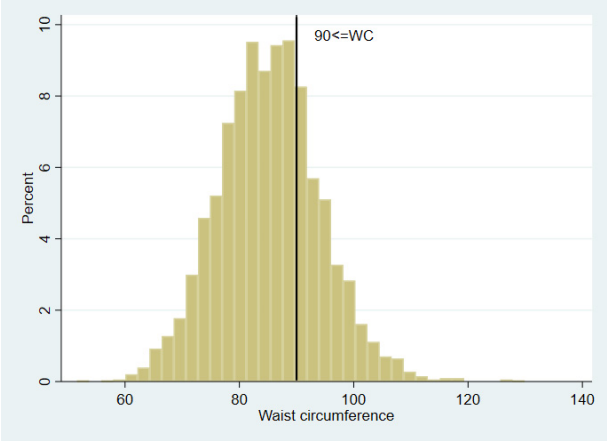

Fig. 2. The distribution of waist circumference (male)

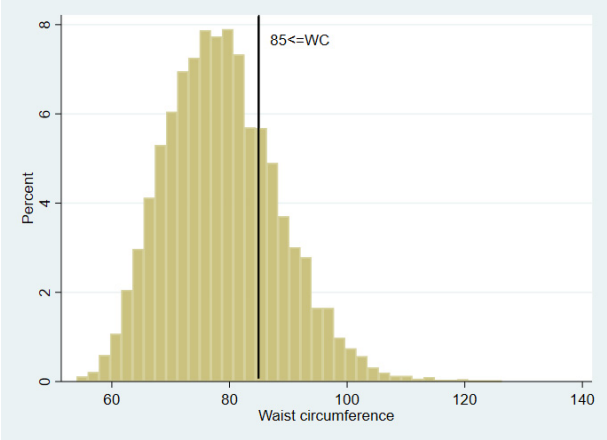

Fig. 3. The distribution of waist circumference (female)

Figure 4 and 5 present the relationship among sleep duration, HEI score, and obesity as measured by BMI and WC. In Figure 1, the BMI increased with decreasing HEI scores. A low HEI score was associated with a high BMI in all sleep duration groups. The WC increased with decreasing HEI scores in all sleep duration groups. This relationship was evident when the sleep duration was below 7 h.

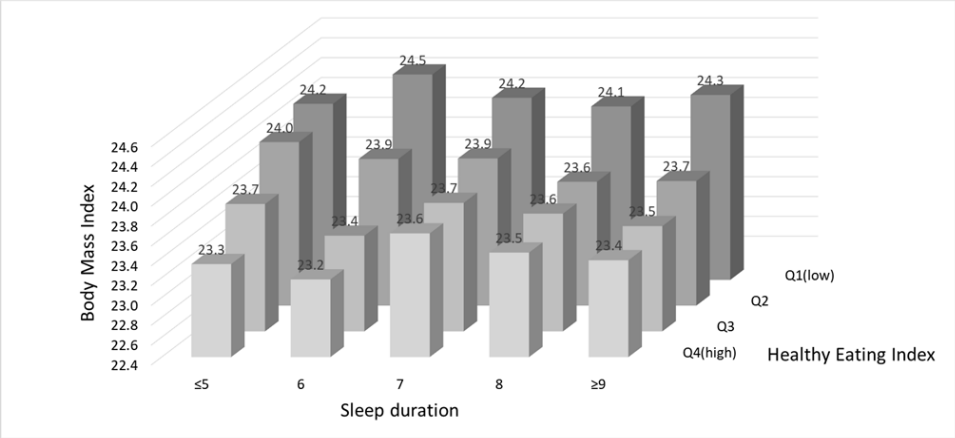

Fig. 4. Sleep duration, Healthy Eating index and BMI

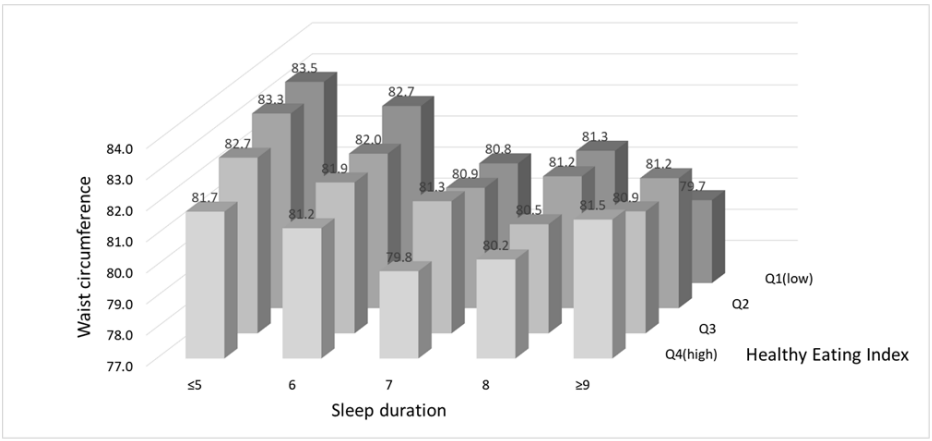

Fig. 5. Sleep duration, Healthy Eating index and Waist circumstance

Table 2 shows the association between sleep duration and HEI score and its component. After adjusting for age, sex, education, household income, days of physical activity, self-rated health, and year, the total HEI score, breakfast, mixed grain intake, total fruit intake, total vegetable intake, saturated fatty acid level, and energy intake were associated with short sleep duration. Meanwhile, vegetable intake was associated with long sleep duration.

Table 2. Results of multiple regression between sleep duration and Healthy Eating Index †

Healthy Eating Index components (Score range)	Coefficients of sleep duration (h)				
	≤5h	6h	7h ‡	8h	≥9h
Total score (0-100)	−2.09*** (−2.89-−1.29)	−0.71* (−1.34-−0.09)	ref	−0.48 (−1.19-0.22)	−0.86 (−2-0.29)
Breakfast (0-10)	−0.34** (−0.57-−0.11)	0.02 (−0.16-0.21)	ref	−0.08 (−0.3-0.14)	−0.19 (−0.5-0.13)
Mixed grain intake (0-5)	−0.19** (−0.31-−0.06)	−0.09 (−0.21-0.02)	ref	−0.12 (−0.24-0)	0.01 (−0.17-0.19)
Total fruit intake (0-5)	−0.13* (−0.26-−0.01)	0.01 (−0.09-0.12)	ref	0.01 (−0.1-0.13)	0.05 (−0.13-0.23)
Fresh fruit intake (0-5)	−0.13 (−0.28-0.01)	0.01 (−0.11-0.13)	ref	−0.02 (−0.15-0.11)	0 (−0.2-0.2)
Total vegetables intake (0-5)	−0.11* (−0.2-−0.02)	−0.04 (−0.11-0.04)	ref	−0.01 (−0.09-0.07)	−0.17* (−0.29-−0.04)
Vegetables intake excluding Kimchi and pickled vegetables intake (0-5)	−0.13* (−0.23-−0.03)	−0.07 (−0.15-0.02)	ref	−0.03 (−0.12-0.06)	−0.22** (−0.36-−0.08)
Meat, fish, eggs and beans intake (0-10)	−0.06 (−0.25-0.13)	0.14 (−0.02-0.3)	ref	0.16 (−0.02-0.33)	−0.18 (−0.47-0.11)
Milk and milk products intake (0-10)	−0.24 (−0.5-0.03)	−0.14 (−0.38-0.11)	ref	−0.19 (−0.45-0.07)	0.15 (−0.24-0.53)
Percentage of energy from saturated fatty acid (0-10)	−0.08 (−0.29-0.13)	−0.2* (−0.39-−0.01)	ref	−0.12 (−0.33-0.1)	−0.31 (−0.64-0.02)
Sodium intake (0-10)	−0.01 (−0.24-0.22)	−0.12 (−0.31-0.06)	ref	−0.06 (−0.26-0.14)	0.27 (−0.02-0.57)
Percentage of energy from sweets and beverages (0-10)	−0.16 (−0.33-0)	0.07 −0.05-0.2)	ref	0.09 (−0.05-0.24)	−0.1 (−0.36-0.16)
Percentage of energy from carbohydrate (0-5)	0.01 (−0.12-0.14)	−0.07 (−0.18-0.04)	ref	0.04 (−0.07-0.16)	0.03 (−0.14-0.21)
Percentage of energy intake from fat (0-5)	−0.09 (−0.22-0.04)	−0.11 (−0.22-0)	ref	−0.04 (−0.15-0.07)	−0.05 (−0.23-0.12)
Energy intake (0-5)	−0.43*** (−0.58-−0.28)	−0.14* (−0.26-−0.01)	ref	−0.14 (−0.27-0)	−0.15 (−0.34-0.04)

† Age, sex, education, household income, days of physical activity, self-rated health, and year were adjusted in all models. Healthy eating index is from Korean healthy eating index.
‡: Sleep duration was included in the model as a categorical variable. Sleep duration 7h was the reference group. ref, reference group
*: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$

Table 3 lists the results of multiple regression between sleep duration and HEI with obesity. The variables, namely, age, sex, education, household income, days of physical activity, self-rated health, and the year were adjusted in all models. Sleep duration of only ≤5 and 6 h were significantly associated with high BMI and WC. HEI Q4 was significantly associated with a low BMI, whereas the HEI score was significantly associated with WC in all HEI quantiles.

Table 3. Coefficients of sleep duration and Healthy Eating Index on BMI and waist circumference†

Variables		BMI				Waist circumference			
		Unstandardized beta	Standardized beta	Std Err	p-value	Unstandardized beta	Standardized beta	Std Err	p-value
Sleep duration (h)	≤5	0.53	0.15	0.11	<.001	1.44	0.41	0.29	<.001
	6	0.36	0.10	0.09	<.001	0.81	0.23	0.24	0.001
	7	Ref				Ref			
	8	−0.04	−0.01	0.10	0.709	0.21	0.06	0.25	0.376
	≥9	−0.06	−0.02	0.19	0.731	0.35	0.10	0.45	0.432
Healthy Eating Index	Q1 (low)	Ref				Ref			
	Q2	−0.08	−0.02	0.10	0.444	−0.38	−0.11	0.24	0.124
	Q3	−0.19	−0.05	0.10	0.053	−0.58	−0.17	0.25	0.022
	Q4 (high)	−0.22	−0.06	0.11	0.039	−0.82	−0.23	0.28	0.003
R-squared			0.068				0.214		

†Age, sex, education, household income, days of physical activity
Q, quartile

Table 4 shows the combined associations of sleep duration and HEI with obesity. Compared with the 7 h sleep duration group and HEI Q4, the 6 h sleep duration group showed a significantly higher BMI, except for HEI Q3. Compared with the 7 h sleep duration group and HEI Q4, the 5 h sleep duration group showed a significantly higher WC, except for HEI Q2. The ≤5 h sleep duration group showed significantly higher BMI, except the for HEI Q4 on WC. Furthermore, high HEI quantiles were associated with low WC and BMI in the 6 and <6 h sleep duration groups.

Table 4. Coefficients of combination of sleep duration and Healthy Eating Index on BMI and waist circumference compared with 7 h sleep duration and Healthy Eating Index Q4†

Dependent variable	Healthy Eating Index	Sleep duration (h)				
		≤5h	6h	7h	8h	≥9h
BMI	Q4 (high)	0.73*** (0.35-1.12)	0.47** (0.13-0.81)	ref	0.00 (−0.35-0.35)	0.11 (−0.49-0.7)
	Q3	0.67** (0.23-1.1)	0.33 (−0.01-0.67)	0.21 (−0.11-0.52)	0.06 (−0.28-0.41)	0.1 (−0.46-0.67)
	Q2	0.86*** (0.43-1.29)	0.53** (0.19-0.87)	0.17 (−0.15-0.49)	0.16 (−0.22-0.54)	0.33 (−0.3-0.97)
	Q1 (low)	0.62** (0.18-1.05)	0.77*** (0.4-1.14)	0.32 (−0.06-0.69)	0.31 (−0.08-0.7)	0.02 (−0.74-0.79)
	R-squared			0.069		
Waist circumference	Q4 (high)	0.85 (−0.29-1.98)	1.12** (0.09-2.16)	ref	0.59 (−0.49-1.66)	1.73 (−0.09-3.54)
	Q3	2.18** (0.86-3.49)	2.01*** (0.96-3.06)	1.81*** (0.84-2.78)	1.11* (0.1-2.12)	1.42 (−0.19-3.04)
	Q2	2.76*** (1.59-3.93)	2.67*** (1.65-3.68)	1.61** (0.65-2.56)	1.93** (0.83-3.03)	1.69 (−0.09-3.47)
	Q1 (low)	3.84*** (2.58-5.11)	3.99*** (2.92-5.07)	2.53*** (1.45-3.61)	2.81*** (1.68-3.93)	1.49 (−0.29-3.27)
	R-squared			0.076		

†Age, sex, education, household income, days of physical activity, self-rated health, and year were adjusted in all models. Reference group is 7 h sleep duration and Healthy Eating Index Q4.
*: p < 0.05; **: p<0.01; ***: p<0.001

4. Discussion

In this study, we identified the association between sleep duration and HEI, and the combined associations of sleep duration and HEI with measure of obesity, BMI and WC. The relationship between sleep duration and HEI exhibited an inverted U-shape. Sleep duration and HEI were associated with being obese in Korean adults, conforming to the results of numerous previous studies.

The standardized coefficients of sleep duration were higher than those of the HEI. The standardized coefficient is usually used to identify the relative importance of each independent variable to the dependent variable. Our result addressed that sleep duration is more important than HEI. The Korean HEI was developed based on the HEI from the United States and Korean data. The risk factors of obesity, abdominal obesity, and metabolic syndrome were selected as the components of the Korean HEI (Yun & Oh, 2018). Therefore, we expected that the standardized coefficients of HEI would be higher than the standardized coefficients of sleep duration, however, it was not. It represents that sleep duration is one of the important risk factors for public health in observational studies. There are numerous published studies on sleep duration related to suicide ideation, cardiovascular disease, diabetes, dyslipidemia, and quality of life (Bin, 2016; Itani, Jike, Watanabe, & Kaneita, 2017; J.-H. Kim, Park, Lee, & Yoo, 2015; J. H. Kim, Park, Yoo, & Park, 2015).

Sleep duration below 7 h was associated with increasing BMI and WC linearly. A recent study revealed that there is a causal relationship between short sleep duration and body weight (Do, 2019). However, only few studies reported the relationship between long sleep duration and BMI and WC (Chaput, McNeil, Despres, Bouchard, & Tremblay, 2013; Patterson et al., 2014; Tan et al., 2018; Theorell-Haglow, Berglund, Janson, & Lindberg, 2012). In our results, a U-shape pattern also existed for the WC, to some extent, because of the HEI. Low HEI quantiles were associated with high WC in all sleep duration group except for $\geq$9h sleep duration group. Although the coefficients of $\geq$9h sleep duration group in Table 4 were non-significant, they were on the borderline of significance ($p<0.010$) and the direction of association was same to other sleep duration groups. Taheri and Thomas reported (Taheri & Thomas, 2008) that healthy eating behavior is a confounding variable between sleep duration and WC. Thus, we proposed that the association between long sleep duration and obesity was mediated or moderated by dietary intake.

Mossavar-Rahmani et al.'s study reported that the Alternate Healthy Eating Index (AHEI) score was not significantly associated with sleep duration. However, AHEI components were associated with sleep duration; short sleepers had lower intake of potassium, fiber, and calcium, whereas long sleepers had lower intake of caffeine (Mossavar-Rahmani et al., 2015). Our data revealed that the total HEI score, breakfast, mixed grain intake, total fruit intake, total vegetable intake, saturated fatty acid level, and energy intake were significantly associated with sleep duration. Among them, a U-shape of fiber intake in sleep duration from short to long was identified. Low vegetable intake was observed in short sleep duration ($\leq$5 h) and long sleep duration ($\geq$9 h). Association and causality between fiber intake and obesity were well-described by a systematic review of randomized controlled trials (Thompson, Hannon, An, & Holscher, 2017).

Intake of sweets and protein was individually associated with short sleep duration (Dashti et al., 2015; S. Kim et al., 2010; Prather et al., 2016). Unexpectedly, we did not observe a significant

association between sweets and beverages and sleep duration, with marginal significance for the <5 h short sleep duration group ($p = 0.051$). In addition, protein intake was not associated with sleep duration. According to a systematic review (Dashti et al., 2015), the association between short sleep duration and protein intake was controversial. Absolute intake of protein was increased by short sleep duration, but the relative intake of protein compared with energy was decreased by short sleep duration (Dashti et al., 2015). This insight will be a future study thesis.

Breakfast was associated with the ≤5 h short sleep duration. Although short sleep duration induces more time and opportunities for eating (Chaput, 2014), respondents who slept a short time were used to not eating breakfast. Gwin et al. (Gwin & Leidy, 2018) suggested that breakfast consumption improved the perceived sleep quality and onset. Tambalis et al. (Tambalis, Panagiotakos, Psarra, & Sidossis, 2019) reported that skipping breakfast was related to an unhealthy lifestyle. Our results were consistent with those of previous studies (Chaput, 2014; Gwin & Leidy, 2018; Tambalis et al., 2019). It is important to recommend for a short sleeper to have breakfast. Breakfast is the most important meal of the day because the longer the fasting time, the higher the ghrelin levels and the lower the insulin levels (Mekary, Giovannucci, Willett, van Dam, & Hu, 2012). Data from the National Weight Control Registry recommended eating breakfast every day to achieve and maintain weight loss (Fruh, 2017). The association of breakfast with obesity and a reduced risk of chronic diseases, such as type 2 diabetes and metabolic syndrome, was previously reported (Bi et al., 2015; P. Deshmukh-Taskar, Nicklas, Radcliffe, O'Neil, & Liu, 2013; P. R. Deshmukh-Taskar et al., 2010; Yoo et al., 2014). The relationship between sleep duration, breakfast, and obesity should be further studied. Breakfast patterns and consumption should be examined in further studies. A previous study reported breakfast patterns, such as traditional Korean pattern, dairy-cereal pattern (Yoo et al., 2014), breakfast consumption habit (Mansouri et al., 2018), and breakfast omission with considering prudent dietary pattern and Western dietary pattern (Mekary et al., 2012). They were associated with health risks. Similar to the Mediterranean dietary pattern in the Western countries (Estruch et al., 2018), it is important to practice proper dietary patterns to prevent the risk of disease among short sleepers.

The strength of our study is as follows. This study used data from a nationally representative survey. To our knowledge, this study is the first to investigate a combined association between sleep duration and HEI using various socioeconomic variables. We anticipated that occupation, the number of household members, and drinking were confounding variables between sleep duration and obesity. However, they were dropped during stepwise selection. Even though they were included in the model, they were non-significant, and the results were consistent with the current results. Furthermore, we considered each component of Korean HEI in sleep duration. The limitations of this study are as follows. Given that the KNHANES is a cross-sectional survey, we reported associations between variables and cannot confirm the causal effects, or reverse causation. For example, a low BMI indicates an undesirable health condition in some particular cases (Jee et al., 2006), and low sleep duration is caused by unfavorable or good health condition. Although we adjusted the self-rated health, this insight needs further study. Tan et al. (Tan et al., 2018) described the possible mechanisms that long sleep duration increased the risk of obesity and unhealthy dietary choices was one of pathways between long sleep duration and obesity. Other pathways are sleep quality, sedentary

lifestyle, and habitual long sleep duration. However, these factors were not investigated in our study and need to be analyzed in a further study.

5. Conclusion

This study shows the relationship between sleep duration and overweight-obesity status with considering diet intake quality. Therefore, proper sleep duration and good diet intake quality may help prevent the risk of obesity.

Conflicts of interest

No author has any financial or other conflict of interest to declare.

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