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Sleep duration and quality is associated with food consumption in adolescents

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ABSTRACT

Objective: This study examined the relationship between sleep duration and quality and food consumption among adolescents.

Design: Cross-sectional study.

Setting: Data from the 2014 and 2015 Korea Youth Risk Behavior Web-based Survey were used.

Participants: Participants of 12-18 years old (n = 118,462 (59,431 males, 59,031 females)) were selected.

Primary and secondary outcome measures: Sleep duration, sleep quality and the frequencies of fruits, soda, soft drinks, fast food, instant noodle, confectionaries, vegetables, and milk consumption.

Results: Short sleep durations (< 6 h) were associated with higher soft drinks and confectionaries intake than longer sleep durations (adjusted odds ratios (AORs) [95% confidence intervals (CIs)] for ≥ 5 times a week for soft drinks, 1.73 [1.57-1.91] and confectionaries, 1.32 [1.20-1.46]; P < 0.001). Poor sleep quality, with 7-8 h of sleep, was associated with a lower intake of fruits, vegetables and milk (AORs [95% CIs] for ≥ 5 times a week for fruits, 0.71 [0.65-0.77]; vegetables, 0.66 [0.58-0.75]; and milk, 0.80 [0.74-0.86]; each P < 0.001), and higher intake of soda, soft drinks, fast food, instant noodle and confectionaries (AORs [95% CIs] for ≥ 5 times a week for soda, 1.55 [1.40-1.70]; soft drinks, 1.58 [1.43-1.73]; fast food, 1.97 [1.65-2.35]; instant noodle, 1.55 [1.37-1.76]; and confectionaries, 1.30 [1.18-1.43]; each P < 0.001) than was good sleep quality of the same duration.

Conclusion: Short sleep durations and poor sleep quality might be associated with higher consumption of unhealthier foods, such as sugar-sweetened beverages, fast food, instant noodle and confectionaries, and associated with lower consumption of fruits, vegetables and milk.

Key words: sleep duration, sleep quality, food consumption, food frequency, sugar-sweetened beverages, fast food, fruits, vegetables, adolescents, Korean

STRENGHTS AND LIMITATIONS OF THIS STUDY

- Our study was conducted on a representative population of Korean adolescents.
- We considered numerous socio-economic status variables as confounding factors to investigate the independent relationship between sleep status and food consumption.
- We considered not only sleep duration but also sleep quality in explaining sleep status.
- Our study was based on secondary data and it has some limitations in providing specific information.
- Because the data were collected based on a self-reported questionnaire, the precision of the information may be low.

INTRODUCTION

Sufficient sleep in adolescents is important to maintain good health status and school performance. According to the National Sleep Foundation [1], approximately 8 to 10 hours of sleep a night is best for adolescents. However, sleep durations for adolescents have been declining. [2] The reasons for decreasing sleep durations and reduced sleep quality among adolescents have been suggested to be associated with increased use of the internet and social media, and earlier school start times. [3 4] Inadequate sleep durations or quality could lead to poor school performance, physical health problems such as atopic conditions, headaches, mental health problems, and unhealthy behaviors. [4-7]

One of the outcomes of sleep deprivation among adolescents is obesity [8], which has become a serious public health problem worldwide. [9] The fundamental factor leading to obesity is an energy imbalance between the calories consumed and the calories expended [10]; therefore, dietary factors are closely related to the prevalence of obesity [11 12] and are considered as a potential link between sleep deprivation and obesity in adolescents. According to previous studies, the intake of fruits, vegetables and milk have a positive association, and the intake of sweets, snacks and fast food a negative association with sleep duration. [13-15] In short, adolescents who get less sleep may be more likely to consume more calories in the form of fast foods, sweets and snacks, and fewer micronutrients than adolescents who get more sleep. Previous studies demonstrated that one of the possible reasons for sleep deprivation in association with the consumption of higher energy foods might be changes in hormones such as decreased leptin and increased ghrelin levels, which can lead to an increase in appetite. [16 17] In summary, sleep deprivation in adolescents might affect dietary habits as a factor of health problems including obesity.

In Korea, the prevalence of childhood obesity in males and females was 15.3% and 11.1% in 2016, respectively and it increased steadily since 2010. [18] Lee, who performed a study using the Korea Youth Risk Behavior Web-based Survey (KYRBWS), reported that < 7 h of sleep per night in high school students was associated with increased cracker consumption. [19]

Meanwhile, studies of sleep deprivation should consider not only sleep duration but also sleep quality. However, few studies have investigated the relationship between sleep duration, along with sleep quality, and the intake of various foods while also adjusting for the numerous confounding factors among adolescents in population-based datasets. Lee utilized KYRBWS data which is population-based datasets with containing numerous variables, she did not consider the sleep quality. [19] The aim of our study was to identify the associations between sleep duration and quality and food intake among adolescents by using KYRBWS datasets. We utilized the data of the participants' level of recovery from fatigue after sleeping as sleep quality. We obtained reliable results for assessing the associations between sleep duration and quality, and the consumption of each of food type.

MATERIALS AND METHODS

Data collection

The Institutional Review Board (IRB) of the Centers for Disease Control and Prevention of Korea (KCDC) approved this study (2014-06EXP-02-P-A). Written, informed consent was obtained from each participant prior to the survey. Because this web-based survey was performed at schools and included a large number of participants, informed consent from their parents was exempted. This consent procedure was approved by the IRB of KCDC.

This was a cross-sectional study using data from the KYRBWS, covering only Korea and using statistical methods based on a designed sampling method and adjusted, weighted values. The results from the KYRBWS conducted in 2014 and 2015 were analyzed. The data were collected by the KCDC.

Public Involvement

The survey consists of 125 questions assessing demographic characteristics and health-related behaviors. Korean adolescents from the 7th through 12th grade completed the self-administered questionnaire voluntarily and anonymously. Using 43 regions (considering administrative districts, geographic accessibility, the number of schools, and population size) and the school participants attended, the mother population was stratified into 129 levels to identify the sample distribution. Groups were then selected using stratified, two-stage (schools and classes) clustered sampling based on data from the Education Ministry. Sampling was weighted by statisticians, who performed a post-stratification step and considered non-response rates and extreme values. Detailed methods are described at the KYRBWS website (https://yhs.cdc.go.kr/new/pages/main.asp).

Of a total of 140,103 participants, we excluded the following participants from analysis in this study; participants who slept less than 3 h or more than 12 h per night or who had no sleep records (18,594 participants); participants who did not give their age (403 participants); and participants without height or weight data (2,644 participants). Finally, 118,462 participants (59,431 males; 59,031 females; 12 to 18 years old) were included in this study (Figure 1).

Sleep duration and quality

The times at which participants fall asleep and wake up were recorded to within 10 min. The participants were asked the time they fall asleep and the time they wake up for the 7 most recent days classified into weekdays and weekends. Sleep duration was calculated by subtracting the time they fall asleep from the time they wake up. The mean daily sleep duration was calculated by adding weekday and weekend sleep durations with weights of 5/7 and 2/7, respectively. Sleep duration was divided into five groups: < 6 h (6(-) h), ≥ 6 h and < 7 h (6 h), ≥ 7 h and < 8 h (7 h), ≥ 8 h and < 9 h (8 h), and ≥ 9 h (9+ h). The participants were asked about their recovery from fatigue after sleeping for the 7 most recent days (quality of sleep). The answer options were very good, good, moderate, poor, and very poor. We regrouped answers into three groups of sleep quality to simplify the categories: good (very good and good), moderate, and poor (poor and very poor). We analyzed the association between sleep quality and food consumption only in the 7 h and 8 h groups as sleep duration was closely related to its quality (S1 Table).

Food intake frequency

The KCDC collected the participants' certain food intake frequencies in the 7 most recent days. The foods were fruits (not fruit juice), soda, soft drinks (including sports drinks, coffee-based beverages, and fruit drinks; excluding soda), fast food (such as pizza, hamburgers, or chicken), instant noodle, confectionaries, vegetables and milk. The data were divided into 4 groups: ≥ 5 times a week, 3-4 times a week, 1-2 times a week, and 0 time a week.

Health examination and socio-economic status

The participants were asked their weight (kg) and height (cm). Obesity levels were categorized into 4 groups according to the Centers for Disease Control and Prevention guidelines regarding body mass index (BMI, kg/m^2) for children and teens [20] as follows: obese, $\geq 95^{th}$ percentile; overweight, $\geq 85^{th}$ percentile and $< 95^{th}$ percentile; healthy weight, $\geq 5^{th}$ percentile and $< 85^{th}$ percentile; and underweight, $< 5^{th}$ percentile. The region of residence was divided into 3 groups by administrative district: large city, small city, and rural area. Subjective self-assessments of health were divided into 5 groups, from very good to very bad. The stress level of participants was divided into 5 groups: severe, moderate, mild, a little, and no stress. Self-reported economic level was grouped into 5 levels, from the highest to lowest. Parent educational level was divided into 4 groups: graduated college or higher, graduated high school, graduated middle school or below, unknown, and no parents. The participants who did not know the educational level of their parents or who had no parents were not excluded as this could have increased the number missing values for participants of relatively lower economic levels.

Statistical Analysis

Differences in the general characteristics according to sleep duration were calculated using linear regression analysis with complex sampling for age. The rate differences in relation to sex, region of residence, economic level, educational level of parents, stress level, food consumption, and quality of sleep were compared using chi-square tests with Rao-Scott

corrections.

Adjusted odd ratios (AORs) for sleep duration in relation to food consumption were calculated using multinomial logistic regression analysis with complex sampling for adjusted covariates (age, sex, obesity, region of residence, stress level, economic level, and educational level of parents).

AORs for sleep quality in relation to food consumption were calculated using multinomial logistic regression analysis with complex sampling for adjusted covariates in the 7 h and 8 h groups.

Two-tailed analyses were conducted. P-values lower than 0.05 were considered to indicate significance, and 95% confidence intervals (CIs) were calculated. The weighted values recommended by the KYRBWS were applied, and all results are presented as weighted values. The results were analyzed using SPSS ver. 21.0 (IBM, Armonk, NY, USA).

RESULTS

Analysis of the general characteristics of the study participants shows that an older age, being female, reporting being healthy, living in a large city, feeling severe or moderate stress, being at a lower economic level, and having higher parental educational levels were associated with shorter sleep durations (all P values < 0.001, Table 1).

Table 1. General characteristics of participants according to sleep duration.

Factors	Total	Sleep duration	P-value

		6(-) h	6 h	7 h	8 h	9+ h	
Number							
n	118,462	27,409	29,773	30,254	20,743	10,283	
%	100	23.1	25.1	25.5	17.5	8.7	
Mean Age (year, SD)	15.0 (1.7)	16.1 (1.5)	15.5 (1.6)	14.7 (1.6)	13.9 (1.5)	14.0 (1.6)	<0.001*
Sex (%)							<0.001†
Male	50.2	41.8	47.7	52.3	57.1	59.5	
Female	49.8	58.2	52.3	47.7	42.9	40.5	
Obesity (%)							<0.001†
Underweight	6.1	5.9	6.2	6.0	6.2	6.9	
Healthy	78.8	80.3	79.5	78.1	77.8	76.5	
Overweight	11.3	10.8	10.8	11.8	11.8	11.8	
Obese	3.8	3.0	3.5	4.1	4.2	4.8	
Region (%)							<0.001†
Large City	44.7	49.4	46.6	43.3	40.6	39.0	
Small City	47.3	44.5	46.4	48.1	49.8	50.1	
Rural Area	8.0	6.1	7.1	8.6	9.6	10.9	
Stress (%)							<0.001†
Severe	8.9	13.7	9.3	7.1	5.7	7.1	
Moderate	27.3	34.4	29.1	25.0	21.4	21.7	
Mild	43.8	39.9	45.1	45.8	44.8	42.8	

A little	16.6	10.1	14.3	18.8	23.0	21.9	
No	3.3	1.9	2.3	3.3	5.2	6.6	
Economic Level (%)							<0.001†
Highest	8.1	7.3	6.9	7.9	9.5	11.1	
Middle High	26.5	26.7	25.5	25.7	28.1	27.7	
Middle	48.3	46.9	48.9	49.5	48.3	46.3	
Middle Low	14.0	15.2	15.2	13.9	11.8	11.9	
Lowest	3.2	3.9	3.5	3.0	2.3	3.0	
Educational level, Father (%)							<0.001†
Unknown	19.7	12.8	16.0	21.9	26.6	28.5	
Middle School	2.7	2.6	2.8	2.8	2.4	2.6	
High School	29.2	28.8	30.5	30.3	27.5	26.9	
College, or over	48.4	55.8	50.8	45.0	43.6	42.0	
Educational level, Mother (%)							<0.001†
Unknown	18.9	12.0	15.2	21.0	25.8	28.1	
Middle School	2.3	2.3	2.5	2.3	2.0	2.2	
High School	37.1	39.1	39.3	37.1	33.7	31.8	
College, or over	41.7	46.7	43.0	39.6	38.5	37.9	

* Linear regression analysis with complex sampling, Significance at $P < 0.05$

† Chi-square test with Rao-Scott correction, Significance at $P < 0.05$

Higher frequencies of instant noodle, fruits, vegetables, and milk intake were associated with longer sleep durations, while higher frequencies of soda, soft drinks, fast food, and confectionaries intake were associated with shorter sleep durations (all P values < 0.001, Table 2).

Table 2. Food consumption of participants according to sleep duration.

Factors		Sleep duration					P-value
	Total	6(-) h	6 h	7 h	8 h	9+ h	
Fruits (%)							<0.001*
≥5 times a week	33.4	33.4	31.9	32.5	35.6	35.8	
3-4 times a week	28.9	28.2	29.0	29.2	29.4	28.0	
1-2 times a week	29.5	30.1	30.8	29.9	27.0	27.9	
0 time a week	8.3	8.3	8.3	8.4	8.0	8.7	
Soda (%)							<0.001*
≥5 times a week	8.0	8.3	8.1	8.0	7.7	8.0	
3-4 times a week	18.2	17.2	18.8	18.8	18.2	17.4	
1-2 times a week	48.9	48.0	49.0	49.8	49.0	48.0	
0 time a week	24.9	26.5	24.2	23.4	25.1	26.6	
Soft drinks (%)							<0.001*
≥5 times a week	13.9	16.3	14.5	13.1	12.0	11.6	
3-4 times a week	25.9	26.7	26.5	26.0	24.7	24.0	
1-2 times a week	44.1	42.2	43.9	44.8	45.6	44.6	
0 time a week	16.1	14.7	15.0	16.1	17.7	19.8	

Fast food (%)							<0.001*
≥5 times a week	2.5	2.8	2.6	2.2	2.2	2.7	
3-4 times a week	11.9	12.6	12.8	11.7	10.6	10.7	
1-2 times a week	59.8	60.0	60.7	60.5	58.8	56.2	
0 time a week	25.8	24.6	23.8	25.5	28.3	30.3	
Instant noodle (%)							<0.001*
≥5 times a week	4.6	4.4	4.3	4.8	4.8	5.4	
3-4 times a week	17.6	15.0	16.9	18.6	19.7	18.6	
1-2 times a week	51.6	49.8	51.9	52.4	52.6	51.3	
0 time a week	26.2	30.8	26.9	24.2	22.9	24.6	
Confectionaries (%)							<0.001*
≥5 times a week	10.7	12.2	11.1	9.9	9.7	9.7	
3-4 times a week	26.4	27.1	26.9	26.4	25.5	24.4	
1-2 times a week	45.4	44.3	45.6	45.9	45.9	45.6	
0 time a week	17.6	16.5	16.5	17.8	18.9	20.3	
Vegetables (%)							<0.001*
≥5 times a week	56.6	57.3	55.4	55.4	57.8	58.7	
3-4 times a week	24.1	23.8	24.5	25.1	23.2	22.6	
1-2 times a week	15.7	15.0	16.4	16.1	15.6	14.9	
0 time a week	3.6	4.0	3.7	3.4	3.4	3.8	
Milk (%)							<0.001*
≥5 times a week	41.9	36.7	38.4	42.9	48.4	50.4	
3-4 times a week	20.0	20.3	20.4	20.2	19.6	18.2	

1-2 times a week	22.4	24.3	24.0	22.2	19.4	18.6	
0 time a week	15.7	18.7	17.3	14.8	12.5	12.8	

* Chi-square test with Rao-Scott correction, Significance at $P < 0.05$

Short sleep durations (< 6 h) were associated with a higher intake of soft drinks (AOR [95% CI] for ≥ 5 times a week, 1.73 [1.57-1.91]; $P < 0.001$) and with a higher intake of confectionaries (AOR [95% CI] for ≥ 5 times a week, 1.32 [1.20-1.46]; $P < 0.001$). Soda and fast food intake showed an increasing trend in the group getting < 6 h of sleep. However, it was not definite. Fruits, instant noodle, vegetables, and milk intake did not show an evident association with getting < 6 h of sleep per night despite the significant association with sleep duration overall (Table 3). Unadjusted model was also analyzed (S2 Table).

Table 3. Adjusted odd ratios of sleep duration for food consumption using multiple logistic regression analysis with complex sampling (Reference of food frequency = 0 time a week).

Factors	AOR (95% Confidence interval) of sleep duration					P-value
	6(-) h	6 h	7 h	8 h	9+ h	
Fruits (%)						<0.001*
≥5 times a week	1.07 (0.97-1.18)	0.97 (0.89-1.06)	0.95 (0.87-1.04)	1.03 (0.94-1.12)	1	
3-4 times a week	1.04 (0.94-1.15)	1.05 (0.96-1.16)	1.05 (0.95-1.15)	1.11 (1.00-1.22)	1	
1-2 times a week	0.98 (0.89-1.08)	1.02 (0.92-1.12)	1.03 (0.94-1.13)	1.02 (0.92-1.12)	1	
Soda (%)						<0.001*
≥5 times a week	1.27 (1.14-1.41)	1.29 (1.17-1.42)	1.27 (1.16-1.40)	1.08 (0.97-1.19)	1	
3-4 times a week	1.08 (1.00-1.17)	1.25 (1.17-1.34)	1.29 (1.21-1.38)	1.13 (1.05-1.22)	1	
1-2 times a week	1.00 (0.94-1.07)	1.12 (1.06-1.18)	1.20 (1.14-1.27)	1.09 (1.03-1.16_	1	
Soft drinks (%)						<0.001*
≥5 times a week	1.73 (1.57-1.91)	1.57 (1.44-1.71)	1.38 (1.26-1.50)	1.16 (1.06-1.28)	1	

3-4 times a week	1.36 (1.25-1.47)	1.36 (1.37-1.46)	1.28 (1.19-1.38)	1.15 (1.07-1.24)	1	
1-2 times a week	1.16 (1.09-1.25)	1.22 (1.15-1.30)	1.18 (1.11-1.26)	1.14 (1.07-1.22)	1	
Fast food (%)						<0.001*
≥5 times a week	1.12 (0.95-1.32)	1.15 (0.99-1.34)	0.95 (0.82-1.11)	0.86 (0.74-1.00)	1	
3-4 times a week	1.18 (1.08-1.29)	1.31 (1.20-1.28)	1.22 (1.12-1.32)	1.07 (0.99-1.17)	1	
1-2 times a week	1.12 (1.05-1.19)	1.22 (1.15-1.28)	1.22 (1.15-1.28)	1.13 (1.07-1.19)	1	
Instant noodle (%)						<0.001*
≥5 times a week	1.09 (0.96-1.24)	1.03 (0.91-1.17)	1.07 (0.95-1.20)	0.98 (0.87-1.11)	1	
3-4 times a week	0.93 (0.86-1.01)	1.06 (0.98-1.14)	1.15 (1.07-1.23)	1.17 (1.08-1.26)	1	
1-2 times a week	0.92 (0.86-0.98)	1.04 (0.98-1.10)	1.09 (1.03-1.16)	1.11 (1.04-1.18)	1	
Confectionaries (%)						<0.001*
≥5 times a week	1.32 (1.20-1.46)	1.28 (1.17-1.41)	1.10 (1.00-1.20)	1.06 (0.97-1.17)	1	
3-4 times a week	1.20 (1.11-1.29)	1.22 (1.13-1.31)	1.16 (1.08-1.24)	1.10 (1.02-1.18)	1	
1-2 times a week	1.09 (1.12-1.17)	1.15 (1.07-1.23)	1.11 (1.04-1.18)	1.08 (1.01-1.16)	1	

Vegetables (%)						<0.001*
≥5 times a week	0.96 (0.85-1.10)	0.95 (0.83-1.07)	1.04 (0.92-1.17)	1.07 (0.94-1.22)	1	
3-4 times a week	0.92 (0.80-1.05)	0.98 (0.86-1.12)	1.15 (1.02-1.30)	1.10 (0.96-1.25)	1	
1-2 times a week	0.91 (0.79-1.05)	1.02 (0.90-1.17)	1.17 (1.03-1.33)	1.15 (1.01-1.33)	1	
Milk (%)						<0.001*
≥5 times a week	0.99 (0.91-1.07)	0.91 (0.85-0.98)	0.92 (0.85-0.99)	0.97 (0.89-1.04)	1	
3-4 times a week	1.06 (0.97-1.15)	1.04 (0.96-1.13)	1.09 (1.00-1.18)	1.09 (1.00-1.19)	1	
1-2 times a week	1.01 (0.93-1.09)	1.05 (0.97-1.14)	1.06 (0.98-1.14)	1.03 (0.95-1.12)	1	

* Significance at P < 0.05

Sleep quality was also associated with the frequency of food intake. Poor quality of sleep was associated with a lower intake of fruits, vegetables, and milk (AOR [95% CI] for ≥ 5 times a week for fruits, 0.71 [0.65-0.77]; vegetables, 0.66 [0.58-0.75]; and milk, 0.80 [0.74-0.86]; each P < 0.001). Poor sleep quality was also related with a higher intake of soda, soft drinks, fast food, instant noodle, and confectionaries (AOR [95% CI] for ≥ 5 times a week for soda, 1.55 [1.40-1.70]; soft drinks, 1.58 [1.43-1.73]; fast food, 1.97 [1.65-2.35]; instant noodle, 1.55 [1.37-1.76]; and confectionaries, 1.30 [1.18-1.43]; each P < 0.001, Table 4).

Table 4. Adjusted odd ratios of quality of sleep for food consumption using multiple logistic regression analysis with complex sampling (Reference of food frequency = 0 time a week) in 7 h and 8 h groups.

Factors	Quality of sleep			P-value
	Good	Moderate	Poor	
Fruits (%)				<0.001*
≥5 times a week	1	0.81 (0.74-0.89)	0.71 (0.65-0.77)	
3-4 times a week	1	0.93 (0.85-1.01)	0.79 (0.72-0.87)	
1-2 times a week	1	1.00 (0.92-1.09)	0.90 (0.82-0.99)	
Soda (%)				<0.001*
≥5 times a week	1	1.27 (1.16-1.40)	1.55 (1.40-1.70)	
3-4 times a week	1	1.25 (1.16-1.33)	1.35 (1.25-1.45)	
1-2 times a week	1	1.14 (1.08-1.20)	1.15 (1.08-1.22)	
Soft drinks (%)				<0.001*

≥5 times a week	1	1.24 (1.15-1.35)	1.58 (1.43-1.73)	
3-4 times a week	1	1.21 (1.13-1.29)	1.36 (1.26-1.46)	
1-2 times a week	1	1.09 (1.03-1.16)	1.10 (1.03-1.18)	
Fast food (%)				<0.001*
≥5 times a week	1	1.26 (1.07-1.49)	1.97 (1.65-2.35)	
3-4 times a week	1	1.28 (1.19-1.38)	1.49 (1.37-1.62)	
1-2 times a week	1	1.11 (1.06-1.17)	1.18 (1.11-1.25)	
Instant noodle (%)				<0.001*
≥5 times a week	1	1.29 (1.14-1.45)	1.55 (1.37-1.76)	
3-4 times a week	1	1.27 (1.19-1.36)	1.31 (1.22-1.42)	
1-2 times a week	1	1.14 (1.09-1.20)	1.11 (1.05-1.18)	
Confectionaries (%)				<0.001*
≥5 times a week	1	1.13 (1.03-1.23)	1.30 (1.18-1.43)	
3-4 times a week	1	1.12 (1.04-1.19)	1.08 (1.01-1.17)	
1-2 times a week	1	1.05 (0.99-1.12)	1.00 (0.93-1.07)	
Vegetables (%)				<0.001*
≥5 times a week	1	0.97 (0.86-1.10)	0.66 (0.58-0.75)	
3-4 times a week	1	1.14 (1.00-1.30)	0.78 (0.68-0.89)	
1-2 times a week	1	1.30 (1.14-1.49)	0.98 (0.85-1.12)	
Milk (%)				<0.001*
≥5 times a week	1	0.89 (0.83-0.95)	0.80 (0.74-0.86)	
3-4 times a week	1	1.01 (0.941.09)	0.86 (0.79-0.93)	
1-2 times a week	1	0.99 (0.92-1.06)	0.91 (0.84-0.99)	

* Significance at $P < 0.05$

DISCUSSION

We found that shorter sleep durations were associated with higher frequencies of consuming soft drinks and confectionaries than were longer sleep durations. Additionally, poor sleep quality, with 7 to 8 h of sleep per night, was associated with a lower frequency of fruits, vegetables and milk intake, and a higher frequency of soda, soft drinks, fast food, instant noodle and confectionaries intake. Unlike in previous studies, we found an association between not only sleep duration but also between sleep quality and the intake of various foods.

According to these outcomes, sleep duration in association with sleep quality might affect one's appetite and even be related to health problems. According to previous studies, a short sleep duration or poor sleep quality is associated with appetite-related hormonal changes such as lower leptin and higher ghrelin levels. These results were also associated with greater energy intake and a higher BMI. [16 17] According to a study by Baron et al., people who fall asleep later sleep less and consume more calories than people who fall asleep earlier. Moreover, consuming calories after 8 pm was associated with a higher BMI. [21] Rudnicka et al. reported that shorter sleep durations in children were associated with a higher prevalence of risk factors for type 2 diabetes, such as increases in the fat mass index, insulin resistance and fasting glucose level. [22] Meanwhile, Doo et al. reported that participants with shorter sleep durations and a higher consumption of dietary antioxidant vitamins had a lower risk of obesity than those with a lower consumption of dietary antioxidant vitamins. [23] In summary, a short sleep duration in association with poor sleep quality could affect dietary

habits and appetite, which could result in health problems. Nevertheless, people who sleep for shorter durations can reduce the risks of health problems by consuming foods rich in micronutrients such as vitamins. Although nutrient profiles were not available in our study, sugar-sweetened beverages such as soda and soft drinks, confectionaries, fast food, and instant noodle have higher energy levels but less micronutrients than fruits, vegetables, and milk. Sugar-sweetened beverages contain mainly liquid calories provided by sugars and have very few of other nutrients. A potential biological mechanism for sugar-sweetened beverages leading to obesity is that liquid calories may result in decreased satiety, leading to the consumption of more sugar-sweetened beverages with subsequent weight gain. [24] Fast food, confectionaries, and instant noodle contain high energy densities, with calories derived from carbohydrates and fats and with minimal amounts of other nutrients. Nevertheless, humans have a weak innate ability to recognize energy density, so humans fail to down-regulation the consumption of most of these foods accordingly. [25] Obesity is one of the risk factors of type 2 diabetes because it is related to an increase in insulin resistance. [26] In fact, previous studies reported that sugar-sweetened beverage and fast food consumption were associated with not only changes in bodyweight but also increased insulin resistance.[24 27] Hence, consumption of these foods could be a potential mechanistic link between sleep duration in association with quality and health problems, including obesity and type 2 diabetes in adolescents.

On the other hand, food intake might affect sleep duration in association with quality. Fruits, vegetables, and milk are sources of vitamins and minerals. Grandner et al. reported that sleep symptoms such as difficulty falling asleep, difficulty maintaining sleep, non-restorative sleep, and daytime sleepiness was associated with a lower intake of calcium, potassium, selenium, vitamin C, vitamin D, alpha-carotene, and lycopene. [28] Although

mechanistic links between vitamin intake and sleep quality are unclear, previous studies have verified the relationship between sleep duration and vitamin intake. [29 30] In addition, Grandner et al. reported that sleep symptoms associated with poor sleep quality were associated with a higher intake of salt [28], and fast food and instant noodle intake are associated with salt intake. According to the Korean food composition table, the sodium content of cooked hamburger is 498 mg/100 g, and that of cheese pizza is 447 mg/100 g. Instant noodle seasoning contains 2,225 mg of sodium in one portion (10.5 g). [31] Excessive salt (and therefore sodium) intake leads to elevated blood pressure, whereas calcium and potassium lower blood pressure. [32] According to the intervention study by Fereidoun et al., providing 0.05 g/kg of salt to participants resulted in poor sleep quality. [33] According to a study by Javaheri et al., poor sleep quality in adolescents was associated with prehypertension. [34] The findings of previous studies and those of our study show that consuming foods with high levels of salt and low levels of other micronutrients might result in reduced sleep durations and poor sleep quality.

The limitations of our study are as follows. First, our study was based on data collected by the KYRBWS, and as secondary data, it has some limitations in providing specific information. For example, the dataset did not have information on nutrient contents or the quantity of food consumed to go along with intake frequency data. In addition, data on other confounding factors such as school examination periods or the time of eating before bed were not present. Second, because the data were collected based on a self-reported questionnaire including weight and height, the precision of the information may be low such as BMI have possibility of underestimation. [35] Third, the questionnaire for sleep duration and food intake frequency was limited to asking about the previous 7 days. Hence, the responses on the questionnaire may not represent the usual sleep duration, sleep quality or food intake

frequency of each participant. To collect usual sleep duration and food intake data, the validity and reliability of the questionnaire should be evaluated in a further study. Finally, because of the cross-sectional design, the causal relationship between sleep duration and quality and food intake frequency is unclear. Longitudinal, randomized, controlled studies should be conducted to determine the causal relationship. Despite of these limitations, our findings provide valuable information for the following reasons. First, our study was conducted on a representative population of Korean adolescents. Second, we considered numerous socio-economic status variables as confounding factors to investigate the independent relationship between sleep status and food consumption. Third, we considered not only sleep duration but also sleep quality in explaining sleep status. Finally, we investigated the intake frequency of various foods to show the relationship between sleep status and food consumption.

CONCLUSION

In our study, a short sleep duration was related to a higher frequency of soft drinks and confectionaries intake. Additionally, poor sleep quality with a normal sleep duration was related to a lower frequency of fruits, vegetables and milk intake, and a higher frequency of soda, soft drinks, fast food, instant noodle and confectionaries intake in adolescents. Hence, we demonstrate that short sleep durations and poor sleep quality might be associated with unhealthy food consumption, such as consuming more sugar-sweetened beverages, fast food, instant noodle and confectionaries, and fewer fruits, vegetables and milk. Further studies with a longitudinal, randomized, controlled design are needed to elucidate the specific causal relationship between sleep status and food consumption in adolescents.

ACKNOWLEDGMENTS

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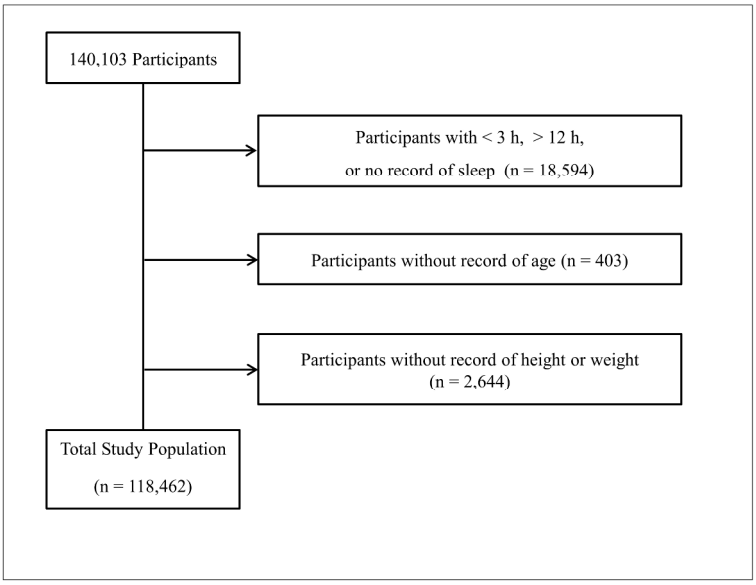
FIGURE

Figure 1. A schematic illustration of the participant selection. From a total of 140,103 participants, those getting < 3 h or > 12 h of sleep per night or with no sleep records (n = 18,594), without a record of their age (403) or without height or weight data (2,644) were excluded. The data for the 118,462 participants from whom complete records were obtained were analyzed.

SUPPLEMETARY FILES

S1 Table. Quality of sleep rates of participants according to sleep duration. * Chi-square test with Rao-Scott correction, Significance at $P < 0.05$

S2 Table. Unadjusted odd ratios of sleep duration for food consumption using multiple logistic regression analysis with complex sampling (Reference of food frequency = 0 time a week). * Significance at $P < 0.05$



Among a total of 140,103 participants, the participants Participants with < 3 h, > 12 h, or no record of sleep (n = 18,594) or without record of age (403) and height or weight records (2,644) were excluded. The data for the 118,462 participants from whom complete data were obtained were analyzed.

254x190mm (300 x 300 DPI)

S1 Table. Quality of sleep rates of participants according to sleep duration.

Factors	Total	Sleep time					P-value
		6(-) h	6 h	7 h	8 h	9+ h	
Quality of sleep (%)							<0.001*
Good	26.6	10.1	17.9	29.8	45.4	48.3	
Moderate	32.9	25.7	35.0	37.8	33.9	29.9	
Poor	40.5	64.2	47.0	32.4	20.7	21.8	

* Chi-square test with Rao-Scott correction, Significance at $P < 0.05$

S2 Table. Unadjusted odd ratios of sleep duration for food consumption using multiple logistic regression analysis with complex sampling (Reference of food frequency = 0 time a week).

Factors	AOR (95% Confidence interval) of Sleep time					P-value
	6(-) h	6 h	7 h	8 h	9+ h	
Fruits (%)						<0.001*
≥5 times a week	0.95 (0.87-1.04)	0.89 (0.82-0.97)	0.92 (0.84-1.00)	1.06 (0.97-1.16)	1	
3-6 times a week	1,06 (0.97-1.16)	1.09 (0.99-1.19)	1.07 (0.98-1.18)	1.15 (1.04-1.26)	1	
1-2 times a week	1.13 (1.03-1.24)	1.14 (1.05-.125)	1.11 (1.01-1.21)	1.04 (0.95-1.14)	1	
Soda (%)						<0.001*
≥5 times a week	1.07 (0.96-1.20)	1.12 (1.02-1.24)	1.14 (1.04-1.26)	1.01 (0.92-1.12)	1	
3-6 times a week	1.02 (0.94-1.10)	1.20 (1.12-1.29)	1.25 (1.17-1.33)	1.10 (1.02-1.18)	1	
1-2 times a week	1.02 (0.96-1.08)	1.14 (1.08-1.21)	1.21 (1.14-1.28)	1.08 (1.02-1.15)	1	
Soft drinks (%)						<0.001*
≥5 times a week	1.90 (1.73-2.09)	1.66 (1.52-1.81)	1.39 (1.28-1.52)	1.14 (1.04-1.25)	1	
3-6 times a week	1.52 (1.41-1.64)	1.49 (1.39-1.60)	1.35 (1.25-1.45)	1.15 (1.07-1.24)	1	

1-2 times a week	1.28 (1.20-1.36)	1.32 (1.25-1.41)	1.24 (1.17-1.32)	1.15 (1.08-1.23)	1	
Fast food (%)						<0.001*
≥5 times a week	1.26 (.09-1.46)	1.21 (1.05-1.39)	0.94 (0.81-1.09)	0.81 (0.70-0.94)	1	
3-6 times a week	1.45 (1.33-1.58	1.51 (1.39-1.64)	1.29 (1.19-1.40)	1.06 (0.98-1.16)	1	
1-2 times a week	1.33 (1.26-1.41)	1.38 (1.31-1.46)	1.30 (1.23-1.37)	1.13 (1.07-1.19)	1	
Instant noodle (%)						<0.001*
≥5 times a week	0.66 (0.59-0.75)	0.71 (0.63-0.80)	0.87 (0.78-0.97)	0.93 (0.83-1.05)	1	
3-6 times a week	0.67 (0.62-0.73)	0.85 (0.79-0.91)	1.03 (0.95-1.10)	1.15 (1.07-1.24)	1	
1-2 times a week	0.79 (0.75-0.84)	0.95 (0.89-1.00)	1.05 (0.99-1.11)	1.11 (1.05-1.18)	1	
Confectionaries (%)						<0.001*
≥5 times a week	1.53 (1.39-1.67)	1.40 (1.28-1.53)	1.14 (1.04-1.24)	1.07 (0.97-1.17)	1	
3-6 times a week	1.39 (1.29-1.49)	1.36 (1.27-1.46)	1.24 (1.16-1.32)	1.13 (1.05-1.21)	1	
1-2 times a week	1.23 (1.15-1.31)	1.26 (1.18-1.35)	1.17 (1.10-1.25)	1.10 (1.03-1.18)	1	
Vegetables (%)						<0.001*
≥5 times a week	0.94 (0.84-1.06)	0.96 (0.85-1.08)	1.07 (0.95-1.20)	1.11 (0.98-1.26)	1	
3-6 times a week	1.00 (0.89-1.13)	1.10 (0.97-1.24)	1.25 (1.11-1.41)	1.14 (1.00-1.31)	1	

1-2 times a week	0.98 (0.87-1.11)	1.12 (0.99-1.28)	1.25 (1.10-1.43)	1.19 (1.04-1.37)	1	
Milk (%)						<0.001*
≥5 times a week	0.51 (0.47-0.55)	0.57 (0.53-0.62)	0.73 (0.68-0.79)	0.97 (0.90-1.04)	1	
3-6 times a week	0.79 (0.73-0.86)	0.86 (0.79-0.93)	1.00 (0.92-1.08)	1.11 (1.02-1.21)	1	
1-2 times a week	0.91 (084-0.98)	0.98 (0.91-1.06)	1.03 (0.96-1.12)	1.05 (0.96-1.14)	1	

* Significance at P < 0.05

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectional reporting guidelines, and cite them as:

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		Reporting Item	Page Number
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	3-4
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	6-7
Objectives	#3	State specific objectives, including any prespecified hypotheses	7
Study design	#4	Present key elements of study design early in the paper	8
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	8

	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-10
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	8-10
Bias	#9	Describe any efforts to address potential sources of bias	9-10
Study size	#10	Explain how the study size was arrived at	8
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	8
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	10-11
	#12b	Describe any methods used to examine subgroups and interactions	8-10
	#12c	Explain how missing data were addressed	8
	#12d	If applicable, describe analytical methods taking account of sampling strategy	8
	#12e	Describe any sensitivity analyses	10-11
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	11-12
	#13b	Give reasons for non-participation at each stage	8
	#13c	Consider use of a flow diagram	8
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	11-15

	#14b	Indicate number of participants with missing data for each variable of interest	11-15
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	11-13
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	20-22
	#16b	Report category boundaries when continuous variables were categorized	20-22
	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	20-22
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	16-19
Key results	#18	Summarise key results with reference to study objectives	22
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	24-25
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	22-24
Generalisability	#21	Discuss the generalisability (external validity) of the study results	25
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	26

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The association between sleep duration, quality and food consumption in adolescent: A cross-sectional study using the Korea Youth Risk Behavior Web-based Survey

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The association between sleep duration, quality and food consumption in adolescent: A cross-sectional study using the Korea Youth Risk Behavior Web-based Survey

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ABSTRACT

Objective: This study examined the relationship between sleep duration and quality and food consumption among adolescents.

Design: Cross-sectional study.

Setting: Data from the 2014 and 2015 Korea Youth Risk Behavior Web-based Survey were used.

Participants: Participants of 12-18 years old (n = 118,462 [59,431 males, 59,031 females]) were selected.

Primary and secondary outcome measures: Sleep duration, sleep quality and the frequencies of fruits, soda, soft drinks, fast food, instant noodle, confectionaries, vegetables, and milk consumption.

Results: Short sleep durations (< 6 h) were associated with higher soft drinks and confectionaries intake than longer sleep durations (9+ h) (adjusted odds ratios, AORs [95% confidence intervals, CIs] for ≥ 5 times a week for soft drinks, 1.73 [1.57-1.91] and confectionaries, 1.32 [1.20-1.46]; P < 0.001). Poor sleep quality, with 7-8 h of sleep, was associated with a lower intake of fruits, vegetables and milk (AORs [95% CIs] for ≥ 5 times a week for fruits, 0.71 [0.65-0.77]; vegetables, 0.66 [0.58-0.75]; and milk, 0.80 [0.74-0.86]; each P < 0.001), and higher intake of soda, soft drinks, fast food, instant noodle and confectionaries (AORs [95% CIs] for ≥ 5 times a week for soda, 1.55 [1.40-1.70]; soft drinks, 1.58 [1.43-1.73]; fast food, 1.97 [1.65-2.35]; instant noodle, 1.55 [1.37-1.76]; and confectionaries, 1.30 [1.18-1.43]; each P < 0.001) than good sleep quality of the same duration.

Conclusion: Short sleep durations and poor sleep quality might be associated with higher consumption of unhealthier foods, such as sugar-sweetened beverages, fast food, instant noodle and confectionaries, and associated with lower consumption of fruits, vegetables and milk.

Key words: sleep duration, sleep quality, food consumption, food frequency, sugar-sweetened beverages, fast food, fruits, vegetables, adolescents, Korean

STRENGHTS AND LIMITATIONS OF THIS STUDY

- Our study was conducted on a representative population of Korean adolescents.
- We considered numerous socio-economic status variables as confounding factors to investigate the independent relationship between sleep status and food consumption.
- We considered not only sleep duration but also sleep quality in explaining sleep status.
- Our study was based on secondary data and it has some limitations in providing specific information.
- Because the data were collected based on a self-reported questionnaire, the precision of the information may be low.

INTRODUCTION

Sufficient sleep in adolescents is important to maintain good health status and school performance. According to the National Sleep Foundation [1], approximately 8 to 10 hours of sleep a night is best for adolescents. However, sleep durations for adolescents have been declining. [2] The reasons for decreasing sleep durations and reduced sleep quality among adolescents have been suggested to be associated with increased use of the internet and social media, and earlier school start times. [3 4] Inadequate sleep durations or quality could lead to poor school performance, physical health problems such as atopic conditions, headaches, mental health problems, and unhealthy behaviors. [4-7]

One of the outcomes of sleep deprivation among adolescents is obesity [8], which has become a serious public health problem worldwide. [9] The fundamental factor leading to obesity is an energy imbalance between the calories consumed and the calories expended [10]; therefore, dietary factors are closely related to the prevalence of obesity [11 12] and are considered as a potential link between sleep deprivation and obesity in adolescents. According to previous studies, the intake of fruits, vegetables and milk have a positive association, and the intake of sweets, snacks and fast food a negative association with sleep duration. [13-15] In short, adolescents who get less sleep may be more likely to consume more calories in the form of fast foods, sweets and snacks, and fewer micronutrients than adolescents who get more sleep. Previous studies demonstrated that one of the possible reasons for sleep deprivation in association with the consumption of higher energy foods might be changes in hormones such as decreased leptin and increased ghrelin levels, which can lead to an increase in appetite. [16 17] In summary, sleep deprivation in adolescents might affect dietary habits as a factor of health problems including obesity.

In Korea, the prevalence of childhood obesity in males and females was 15.3% and 11.1% in 2016, respectively and it increased steadily since 2010. [18] Lee, who performed a study using the Korea Youth Risk Behavior Web-based Survey (KYRBWS), reported that < 7 h of sleep per night in high school students was associated with increased cracker consumption. [19]

Meanwhile, studies of sleep deprivation should consider not only sleep duration but also sleep quality. However, few studies have investigated the relationship between sleep duration, along with sleep quality, and the intake of various foods while also adjusting for the numerous confounding factors among adolescents in population-based datasets. Lee utilized KYRBWS data which is population-based datasets with containing numerous variables, she did not consider the sleep quality. [19] The aim of our study was to identify the associations between sleep duration and quality and food intake among adolescents by using KYRBWS datasets. We utilized the data of the participants' level of recovery from fatigue after sleeping as sleep quality. We obtained consistent results for assessing the associations between sleep duration and quality, and the consumption of fruits, soda, soft drinks, fast food, instant noodle, confectionaries, vegetables, and milk with previous studies. [13-15 19]

MATERIALS AND METHODS

Data collection

The Institutional Review Board (IRB) of the Centers for Disease Control and Prevention of Korea (KCDC) approved this study (2014-06EXP-02-P-A). Written, informed consent was obtained from each participant prior to the survey. Because this web-based survey was performed at schools and included a large number of participants, informed consent from

their parents was exempted. This consent procedure was approved by the IRB of KCDC.

This was a cross-sectional study using data from the KYRBWS, covering only Korea and using statistical methods based on a designed sampling method and adjusted, weighted values. The results from the KYRBWS conducted in 2014 and 2015 were analyzed. The data were collected by the KCDC.

Public Involvement

The survey consists of 125 questions assessing demographic characteristics and health-related behaviors. Korean adolescents from the 7th through 12th grade completed the self-administered questionnaire voluntarily and anonymously. Using 43 regions (considering administrative districts, geographic accessibility, the number of schools, and population size) and the school participants attended, the mother population was stratified into 129 levels to identify the sample distribution. Groups were then selected using stratified, two-stage (schools and classes) clustered sampling based on data from the Education Ministry. Sampling was weighted by statisticians, who performed a post-stratification step and considered non-response rates and extreme values. Detailed methods are described at the KYRBWS website (https://yhs.cdc.go.kr/new/pages/main.asp).

Of a total of 140,103 participants, we excluded the following participants from analysis in this study; participants who slept less than 3 h or more than 12 h per night or who had no sleep records (18,594 participants); participants who did not give their age (403 participants); and participants without height or weight data (2,644 participants). Finally, 118,462 participants (84.5% of total participants; 59,431 males; 59,031 females; 12 to 18 years old)

were included in this study (Figure 1).

Sleep duration and quality

The times at which participants fall asleep and wake up were recorded to within 10 min. The participants were asked the time they fall asleep and the time they wake up for the 7 most recent days classified into weekdays and weekends. Sleep duration was calculated by subtracting the time they fall asleep from the time they wake up. The mean daily sleep duration was calculated by adding weekday and weekend sleep durations with weights of 5/7 and 2/7, respectively. Sleep duration was divided into five groups: < 6 h (6(-) h), ≥ 6 h and < 7 h (6 h), ≥ 7 h and < 8 h (7 h), ≥ 8 h and < 9 h (8 h), and ≥ 9 h (9+ h). The participants were asked about their recovery from fatigue after sleeping for the 7 most recent days (quality of sleep). The answer options were very good, good, moderate, poor, and very poor. We regrouped answers into three groups of sleep quality to simplify the categories: good (very good and good), moderate, and poor (poor and very poor). We analyzed the association between sleep quality and food consumption only in the 7 h and 8 h groups as sleep duration was closely related to its quality (S1 Table).

Food intake frequency

The KCDC collected the participants' certain food intake frequencies in the 7 most recent days. The foods were fruits (not fruit juice), soda, soft drinks (including sports drinks, coffee-based beverages, and fruit drinks; excluding soda), fast food (such as pizza, hamburgers, or chicken), instant noodle, confectionaries, vegetables and milk. The data were divided into 4

groups: ≥ 5 times a week, 3-4 times a week, 1-2 times a week, and 0 time a week.

Health examination and socio-economic status

The participants were asked their weight (kg) and height (cm). Obesity levels were categorized into 4 groups according to the Centers for Disease Control and Prevention guidelines regarding body mass index (BMI, kg/m^2) for children and teens [20] as follows: obese, ≥ 95th percentile; overweight, ≥ 85th percentile and < 95th percentile; healthy weight, ≥ 5th percentile and < 85th percentile; and underweight, < 5th percentile. The region of residence was divided into 3 groups by administrative district: large city, small city, and rural area. Subjective self-assessments of health were divided into 5 groups, from very good to very bad. The stress level of participants was divided into 5 groups: severe, moderate, mild, a little, and no stress. Self-reported economic level was grouped into 5 levels, from the highest to lowest. Parent educational level was divided into 4 groups: graduated college or higher, graduated high school, graduated middle school or below, unknown, and no parents. The participants who did not know the educational level of their parents or who had no parents were not excluded as this could have increased the number missing values for participants of relatively lower economic levels.

Statistical Analysis

Differences in the general characteristics according to sleep duration were calculated using linear regression analysis with complex sampling for age. The rate differences in relation to sex, region of residence, economic level, educational level of parents, stress level, food

consumption, and quality of sleep were compared using chi-square tests with Rao-Scott corrections.

Adjusted odd ratios (AORs) for sleep duration in relation to food consumption were calculated using multinomial logistic regression analysis with complex sampling for adjusted covariates (age, sex, obesity, region of residence, stress level, economic level, and educational level of parents).

AORs for sleep quality in relation to food consumption were calculated using multinomial logistic regression analysis with complex sampling for adjusted covariates in the 7 h and 8 h groups.

Two-tailed analyses were conducted. P-values lower than 0.05 were considered to indicate significance, and 95% confidence intervals (CIs) were calculated. The weighted values recommended by the KYRBWS were applied, and all results are presented as weighted values. The results were analyzed using SPSS ver. 21.0 (IBM, Armonk, NY, USA).

RESULTS

Analysis of the general characteristics of the study participants shows that an older age, being female, reporting being healthy, living in a large city, feeling severe or moderate stress, being at a lower economic level, and having higher parental educational levels were associated with shorter sleep durations (all P values < 0.001, Table 1).

Table 1. General characteristics of participants according to sleep duration.

Factors	Total	Sleep duration					P-value
		6(-) h	6 h	7 h	8 h	9+ h	
Number							
n	118,462	27,409	29,773	30,254	20,743	10,283	
%	100	23.1	25.1	25.5	17.5	8.7	
Mean Age (year, SD)	15.0 (1.7)	16.1 (1.5)	15.5 (1.6)	14.7 (1.6)	13.9 (1.5)	14.0 (1.6)	<0.001*
Sex (%)							<0.001†
Male	50.2	41.8	47.7	52.3	57.1	59.5	
Female	49.8	58.2	52.3	47.7	42.9	40.5	
Obesity (%)							<0.001†
Underweight	6.1	5.9	6.2	6.0	6.2	6.9	
Healthy	78.8	80.3	79.5	78.1	77.8	76.5	
Overweight	11.3	10.8	10.8	11.8	11.8	11.8	
Obese	3.8	3.0	3.5	4.1	4.2	4.8	
Region (%)							<0.001†
Large City	44.7	49.4	46.6	43.3	40.6	39.0	
Small City	47.3	44.5	46.4	48.1	49.8	50.1	
Rural Area	8.0	6.1	7.1	8.6	9.6	10.9	
Stress (%)							<0.001†
Severe	8.9	13.7	9.3	7.1	5.7	7.1	
Moderate	27.3	34.4	29.1	25.0	21.4	21.7	

	Mild	43.8	39.9	45.1	45.8	44.8	42.8	
	A little	16.6	10.1	14.3	18.8	23.0	21.9	
	No	3.3	1.9	2.3	3.3	5.2	6.6	
Economic Level (%)								<0.001†
	Highest	8.1	7.3	6.9	7.9	9.5	11.1	
	Middle High	26.5	26.7	25.5	25.7	28.1	27.7	
	Middle	48.3	46.9	48.9	49.5	48.3	46.3	
	Middle Low	14.0	15.2	15.2	13.9	11.8	11.9	
	Lowest	3.2	3.9	3.5	3.0	2.3	3.0	
Educational level, Father (%)								<0.001†
	Unknown	19.7	12.8	16.0	21.9	26.6	28.5	
	Middle School	2.7	2.6	2.8	2.8	2.4	2.6	
	High School	29.2	28.8	30.5	30.3	27.5	26.9	
	College, or over	48.4	55.8	50.8	45.0	43.6	42.0	
Educational level, Mother (%)								<0.001†
	Unknown	18.9	12.0	15.2	21.0	25.8	28.1	
	Middle School	2.3	2.3	2.5	2.3	2.0	2.2	
	High School	37.1	39.1	39.3	37.1	33.7	31.8	
	College, or over	41.7	46.7	43.0	39.6	38.5	37.9	

* Linear regression analysis with complex sampling, Significance at $P < 0.05$

† Chi-square test with Rao-Scott correction, Significance at $P < 0.05$

Higher frequencies of instant noodle, fruits, vegetables, and milk intake were associated with longer sleep durations, while higher frequencies of soda, soft drinks, fast food, and confectionaries intake were associated with shorter sleep durations (all P values < 0.001, Table 2).

Table 2. Food consumption of participants according to sleep duration.

Factors		Sleep duration					P-value
	Total	6(-) h	6 h	7 h	8 h	9+ h	
Fruits (%)							<0.001*
≥5 times a week	33.4	33.4	31.9	32.5	35.6	35.8	
3-4 times a week	28.9	28.2	29.0	29.2	29.4	28.0	
1-2 times a week	29.5	30.1	30.8	29.9	27.0	27.9	
0 time a week	8.3	8.3	8.3	8.4	8.0	8.7	
Soda (%)							<0.001*
≥5 times a week	8.0	8.3	8.1	8.0	7.7	8.0	
3-4 times a week	18.2	17.2	18.8	18.8	18.2	17.4	
1-2 times a week	48.9	48.0	49.0	49.8	49.0	48.0	
0 time a week	24.9	26.5	24.2	23.4	25.1	26.6	
Soft drinks (%)							<0.001*
≥5 times a week	13.9	16.3	14.5	13.1	12.0	11.6	
3-4 times a week	25.9	26.7	26.5	26.0	24.7	24.0	
1-2 times a week	44.1	42.2	43.9	44.8	45.6	44.6	
0 time a week	16.1	14.7	15.0	16.1	17.7	19.8	

Fast food (%)							<0.001*
≥5 times a week	2.5	2.8	2.6	2.2	2.2	2.7	
3-4 times a week	11.9	12.6	12.8	11.7	10.6	10.7	
1-2 times a week	59.8	60.0	60.7	60.5	58.8	56.2	
0 time a week	25.8	24.6	23.8	25.5	28.3	30.3	
Instant noodle (%)							<0.001*
≥5 times a week	4.6	4.4	4.3	4.8	4.8	5.4	
3-4 times a week	17.6	15.0	16.9	18.6	19.7	18.6	
1-2 times a week	51.6	49.8	51.9	52.4	52.6	51.3	
0 time a week	26.2	30.8	26.9	24.2	22.9	24.6	
Confectionaries (%)							<0.001*
≥5 times a week	10.7	12.2	11.1	9.9	9.7	9.7	
3-4 times a week	26.4	27.1	26.9	26.4	25.5	24.4	
1-2 times a week	45.4	44.3	45.6	45.9	45.9	45.6	
0 time a week	17.6	16.5	16.5	17.8	18.9	20.3	
Vegetables (%)							<0.001*
≥5 times a week	56.6	57.3	55.4	55.4	57.8	58.7	
3-4 times a week	24.1	23.8	24.5	25.1	23.2	22.6	
1-2 times a week	15.7	15.0	16.4	16.1	15.6	14.9	
0 time a week	3.6	4.0	3.7	3.4	3.4	3.8	
Milk (%)							<0.001*
≥5 times a week	41.9	36.7	38.4	42.9	48.4	50.4	
3-4 times a week	20.0	20.3	20.4	20.2	19.6	18.2	

1-2 times a week	22.4	24.3	24.0	22.2	19.4	18.6
0 time a week	15.7	18.7	17.3	14.8	12.5	12.8

* Chi-square test with Rao-Scott correction, Significance at $P < 0.05$

Short sleep durations (< 6 h) were associated with a higher intake of soft drinks (AOR [95% CI] for ≥ 5 times a week, 1.73 [1.57-1.91]; $P < 0.001$) and with a higher intake of confectionaries (AOR [95% CI] for ≥ 5 times a week, 1.32 [1.20-1.46]; $P < 0.001$). Soda and fast food intake showed an increasing trend in the group getting < 6 h of sleep. However, it was not definite. Fruits, instant noodle, vegetables, and milk intake did not show an evident association with getting < 6 h of sleep per night despite the significant association with sleep duration overall (Table 3). Unadjusted model was also analyzed (S2 Table).

Table 3. Adjusted odd ratios of sleep duration for food consumption using multiple logistic regression analysis with complex sampling (Reference of food frequency = 0 time a week).

Factors	AOR (95% Confidence interval) of sleep duration					P-value
	6(-) h	6 h	7 h	8 h	9+ h	
Fruits (%)						<0.001*
≥5 times a week	1.07 (0.97-1.18)	0.97 (0.89-1.06)	0.95 (0.87-1.04)	1.03 (0.94-1.12)	1	
3-4 times a week	1.04 (0.94-1.15)	1.05 (0.96-1.16)	1.05 (0.95-1.15)	1.11 (1.00-1.22)	1	
1-2 times a week	0.98 (0.89-1.08)	1.02 (0.92-1.12)	1.03 (0.94-1.13)	1.02 (0.92-1.12)	1	
Soda (%)						<0.001*
≥5 times a week	1.27 (1.14-1.41)	1.29 (1.17-1.42)	1.27 (1.16-1.40)	1.08 (0.97-1.19)	1	
3-4 times a week	1.08 (1.00-1.17)	1.25 (1.17-1.34)	1.29 (1.21-1.38)	1.13 (1.05-1.22)	1	
1-2 times a week	1.00 (0.94-1.07)	1.12 (1.06-1.18)	1.20 (1.14-1.27)	1.09 (1.03-1.16_	1	
Soft drinks (%)						<0.001*
≥5 times a week	1.73 (1.57-1.91)	1.57 (1.44-1.71)	1.38 (1.26-1.50)	1.16 (1.06-1.28)	1	

3-4 times a week	1.36 (1.25-1.47)	1.36 (1.37-1.46)	1.28 (1.19-1.38)	1.15 (1.07-1.24)	1	
1-2 times a week	1.16 (1.09-1.25)	1.22 (1.15-1.30)	1.18 (1.11-1.26)	1.14 (1.07-1.22)	1	
Fast food (%)						<0.001*
≥5 times a week	1.12 (0.95-1.32)	1.15 (0.99-1.34)	0.95 (0.82-1.11)	0.86 (0.74-1.00)	1	
3-4 times a week	1.18 (1.08-1.29)	1.31 (1.20-1.28)	1.22 (1.12-1.32)	1.07 (0.99-1.17)	1	
1-2 times a week	1.12 (1.05-1.19)	1.22 (1.15-1.28)	1.22 (1.15-1.28)	1.13 (1.07-1.19)	1	
Instant noodle (%)						<0.001*
≥5 times a week	1.09 (0.96-1.24)	1.03 (0.91-1.17)	1.07 (0.95-1.20)	0.98 (0.87-1.11)	1	
3-4 times a week	0.93 (0.86-1.01)	1.06 (0.98-1.14)	1.15 (1.07-1.23)	1.17 (1.08-1.26)	1	
1-2 times a week	0.92 (0.86-0.98)	1.04 (0.98-1.10)	1.09 (1.03-1.16)	1.11 (1.04-1.18)	1	
Confectionaries (%)						<0.001*
≥5 times a week	1.32 (1.20-1.46)	1.28 (1.17-1.41)	1.10 (1.00-1.20)	1.06 (0.97-1.17)	1	
3-4 times a week	1.20 (1.11-1.29)	1.22 (1.13-1.31)	1.16 (1.08-1.24)	1.10 (1.02-1.18)	1	
1-2 times a week	1.09 (1.12-1.17)	1.15 (1.07-1.23)	1.11 (1.04-1.18)	1.08 (1.01-1.16)	1	
Vegetables (%)						<0.001*

≥5 times a week	0.96 (0.85-1.10)	0.95 (0.83-1.07)	1.04 (0.92-1.17)	1.07 (0.94-1.22)	1	
3-4 times a week	0.92 (0.80-1.05)	0.98 (0.86-1.12)	1.15 (1.02-1.30)	1.10 (0.96-1.25)	1	
1-2 times a week	0.91 (0.79-1.05)	1.02 (0.90-1.17)	1.17 (1.03-1.33)	1.15 (1.01-1.33)	1	
Milk (%)						<0.001*
≥5 times a week	0.99 (0.91-1.07)	0.91 (0.85-0.98)	0.92 (0.85-0.99)	0.97 (0.89-1.04)	1	
3-4 times a week	1.06 (0.97-1.15)	1.04 (0.96-1.13)	1.09 (1.00-1.18)	1.09 (1.00-1.19)	1	
1-2 times a week	1.01 (0.93-1.09)	1.05 (0.97-1.14)	1.06 (0.98-1.14)	1.03 (0.95-1.12)	1	

* Significance at P < 0.05

Sleep quality was also associated with the frequency of food intake. Poor quality of sleep was associated with a lower intake of fruits, vegetables, and milk (AOR [95% CI] for ≥ 5 times a week for fruits, 0.71 [0.65-0.77]; vegetables, 0.66 [0.58-0.75]; and milk, 0.80 [0.74-0.86]; each P < 0.001). Poor sleep quality was also related with a higher intake of soda, soft drinks, fast food, instant noodle, and confectionaries (AOR [95% CI] for ≥ 5 times a week for soda, 1.55 [1.40-1.70]; soft drinks, 1.58 [1.43-1.73]; fast food, 1.97 [1.65-2.35]; instant noodle, 1.55 [1.37-1.76]; and confectionaries, 1.30 [1.18-1.43]; each P < 0.001, Table 4).

Table 4. Adjusted odd ratios of quality of sleep for food consumption using multiple logistic regression analysis with complex sampling (Reference of food frequency = 0 time a week) in 7 h and 8 h groups.

Factors	Quality of sleep			P-value
	Good	Moderate	Poor	
Fruits (%)				<0.001*
≥5 times a week	1	0.81 (0.74-0.89)	0.71 (0.65-0.77)	
3-4 times a week	1	0.93 (0.85-1.01)	0.79 (0.72-0.87)	
1-2 times a week	1	1.00 (0.92-1.09)	0.90 (0.82-0.99)	
Soda (%)				<0.001*
≥5 times a week	1	1.27 (1.16-1.40)	1.55 (1.40-1.70)	
3-4 times a week	1	1.25 (1.16-1.33)	1.35 (1.25-1.45)	
1-2 times a week	1	1.14 (1.08-1.20)	1.15 (1.08-1.22)	
Soft drinks (%)				<0.001*

≥5 times a week	1	1.24 (1.15-1.35)	1.58 (1.43-1.73)	
3-4 times a week	1	1.21 (1.13-1.29)	1.36 (1.26-1.46)	
1-2 times a week	1	1.09 (1.03-1.16)	1.10 (1.03-1.18)	
Fast food (%)				<0.001*
≥5 times a week	1	1.26 (1.07-1.49)	1.97 (1.65-2.35)	
3-4 times a week	1	1.28 (1.19-1.38)	1.49 (1.37-1.62)	
1-2 times a week	1	1.11 (1.06-1.17)	1.18 (1.11-1.25)	
Instant noodle (%)				<0.001*
≥5 times a week	1	1.29 (1.14-1.45)	1.55 (1.37-1.76)	
3-4 times a week	1	1.27 (1.19-1.36)	1.31 (1.22-1.42)	
1-2 times a week	1	1.14 (1.09-1.20)	1.11 (1.05-1.18)	
Confectionaries (%)				<0.001*
≥5 times a week	1	1.13 (1.03-1.23)	1.30 (1.18-1.43)	
3-4 times a week	1	1.12 (1.04-1.19)	1.08 (1.01-1.17)	
1-2 times a week	1	1.05 (0.99-1.12)	1.00 (0.93-1.07)	
Vegetables (%)				<0.001*
≥5 times a week	1	0.97 (0.86-1.10)	0.66 (0.58-0.75)	
3-4 times a week	1	1.14 (1.00-1.30)	0.78 (0.68-0.89)	
1-2 times a week	1	1.30 (1.14-1.49)	0.98 (0.85-1.12)	
Milk (%)				<0.001*
≥5 times a week	1	0.89 (0.83-0.95)	0.80 (0.74-0.86)	
3-4 times a week	1	1.01 (0.941.09)	0.86 (0.79-0.93)	
1-2 times a week	1	0.99 (0.92-1.06)	0.91 (0.84-0.99)	

239 * Significance at P < 0.05

DISCUSSION

We found that shorter sleep durations were associated with higher frequencies of consuming soft drinks and confectionaries than longer sleep durations. Additionally, poor sleep quality, with 7 to 8 h of sleep per night, was associated with a lower frequency of fruits, vegetables and milk intake, and a higher frequency of soda, soft drinks, fast food, instant noodle and confectionaries intake. Unlike in previous studies [13-15 19], we found an association between not only sleep duration but also between sleep quality and the intake of various foods.

Along with these outcomes, sleep duration in association with sleep quality might affect one's appetite and even be related to health problems such as obesity [21] and diabetes. [22] A short sleep duration or poor sleep quality is associated with appetite-related hormonal changes such as lower leptin and higher ghrelin levels in previous studies. These results were also associated with greater energy intake and a higher BMI. [16 17] Baron et al. reported that people who fall asleep later sleep less and consume more calories than people who fall asleep earlier. Moreover, consuming calories after 8 pm was associated with a higher BMI. [21] Rudnicka et al. reported that shorter sleep durations in children were associated with a higher prevalence of risk factors for type 2 diabetes, such as increases in the fat mass index, insulin resistance and fasting glucose level. [22] Meanwhile, Doo et al. reported that participants with shorter sleep durations and a higher consumption of dietary antioxidant vitamins had a lower risk of obesity than those with a lower consumption of dietary antioxidant vitamins. [23] In summary, a short sleep duration in association with poor sleep quality could affect dietary habits and appetite, which could result in health problems. Nevertheless, people who sleep for shorter durations can reduce the risks of health problems by consuming foods rich in

micronutrients such as vitamins.

Although nutrient profiles were not available in our study, sugar-sweetened beverages such as soda and soft drinks, confectionaries, fast food, and instant noodle have higher energy levels but less micronutrients than fruits, vegetables, and milk. Sugar-sweetened beverages contain mainly liquid calories provided by sugars and have very few of other nutrients. A potential biological mechanism for sugar-sweetened beverages leading to obesity is that liquid calories may result in decreased satiety, leading to the consumption of more sugar-sweetened beverages with subsequent weight gain. [24]

Fast food, confectionaries, and instant noodle contain high energy densities, with calories derived from carbohydrates and fats and with minimal amounts of other nutrients. Nevertheless, humans have a weak innate ability to recognize energy density, so humans fail to down-regulation the consumption of most of these foods accordingly. [25] Obesity is one of the risk factors of type 2 diabetes because it is related to an increase in insulin resistance. [26] In fact, previous studies reported that sugar-sweetened beverage and fast food consumption were associated with not only changes in bodyweight but also increased insulin resistance. [24] [27] Hence, consumption of these foods could be a potential mechanistic link between sleep duration in association with quality and health problems, including obesity and type 2 diabetes in adolescents.

On the other hand, food intake might affect sleep duration and sleep quality. Fruits, vegetables, and milk are sources of vitamins and minerals. Grandner et al. reported that sleep symptoms such as difficulty falling asleep, difficulty maintaining sleep, non-restorative sleep, and daytime sleepiness were associated with a lower intake of calcium, potassium, selenium, vitamin C, vitamin D, alpha-carotene, and lycopene. [28] Although mechanistic links between

vitamin intake and sleep quality are unclear, previous studies have verified the relationship between sleep duration and vitamin intake. [29 30] In addition, Grandner et al. reported that sleep symptoms associated with poor sleep quality were associated with a higher intake of salt [28], and fast food and instant noodle intake are associated with salt intake. In accordance with the Korean food composition table, the sodium content of cooked hamburger is 498 mg/100 g, and that of cheese pizza is 447 mg/100 g. Instant noodle seasoning contains 2,225 mg of sodium in one portion (10.5 g). [31] Excessive salt (and therefore sodium) intake leads to elevated blood pressure, whereas calcium and potassium lower blood pressure. [32] Fereidoun et al. reported that providing 0.05 g/kg of salt to participants resulted in poor sleep quality. [33] According to a study by Javaheri et al., poor sleep quality in adolescents was associated with prehypertension. [34] The findings of previous studies and those of our study show that consuming foods with high levels of salt and low levels of other micronutrients might result in reduced sleep durations and poor sleep quality.

The limitations of our study are as follows. First, our study was based on data collected by the KYRBWS, and as secondary data, it has some limitations in providing specific information. For example, the dataset did not have information on nutrient contents or the quantity of food consumed to go along with intake frequency data. In addition, data on other confounding factors such as school examination periods or the timing of food intake across the 24 h were not present. Second, because the data were collected based on a self-reported questionnaire including weight and height, the precision of the information may be low such as BMI have possibility of underestimation. [35] Third, the validity of questionnaires of sleep duration, sleep quality and food intake frequencies is unclear. Hence, the responses on the questionnaire may not represent the usual sleep duration, sleep quality or food intake

frequency of each participant. To collect usual sleep duration, sleep quality and food intake data, the validity and reliability of the questionnaire should be evaluated in a further study. Finally, because of the cross-sectional design, the causal relationship between sleep duration and quality and food intake frequency is unclear. Longitudinal, randomized, controlled studies should be conducted to determine the causal relationship.

Nevertheless, our findings provide valuable information for the following reasons. First, our study was conducted on a representative population of Korean adolescents. Second, we considered numerous socio-economic status variables as confounding factors to investigate the independent relationship between sleep status and food consumption. Third, we considered not only sleep duration but also sleep quality in explaining sleep status. Finally, we investigated the intake frequency of various foods to show the relationship between sleep status and food consumption.

CONCLUSION

A short sleep duration was related to a higher frequency of soft drinks and confectionaries intake. Additionally, poor sleep quality with a normal sleep duration was related to a lower frequency of fruits, vegetables and milk intake, and a higher frequency of soda, soft drinks, fast food, instant noodle and confectionaries intake in adolescents. Hence, we demonstrate that short sleep durations and poor sleep quality might be associated with unhealthy food consumption, such as consuming more sugar-sweetened beverages, fast food, instant noodle and confectionaries, and fewer fruits, vegetables and milk. Further studies with a longitudinal, randomized, controlled design are needed to elucidate the specific causal relationship between sleep status and food consumption in adolescents.

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DATA SHARING STATEMENT

No additional data are available.

FUNDING STATEMENT

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COMPETING INTERESTS STATEMENT

There are no competing interests for any author.

CONTRIBUTORS

CM wrote the manuscript. HJK designed the study. ISP performed the data processing. BP performed the data interpretation. JHK analyzed the data. SS gave statistical techniques and reviewed the manuscript. HGC conceptualized the study and wrote and reviewed the manuscript.

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FIGURE

Figure 1. A schematic illustration of the participant selection. From a total of 140,103 participants, those getting < 3 h or > 12 h of sleep per night or with no sleep records (n = 18,594), without a record of their age (403) or without height or weight data (2,644) were excluded. The data for the 118,462 participants from whom complete records were obtained were analyzed.

SUPPLEMETARY FILES

S1 Table. Quality of sleep rates of participants according to sleep duration. * Chi-square test with Rao-Scott correction, Significance at $P < 0.05$

S2 Table. Unadjusted odd ratios of sleep duration for food consumption using multiple logistic regression analysis with complex sampling (Reference of food frequency = 0 time a week). * Significance at $P < 0.05$

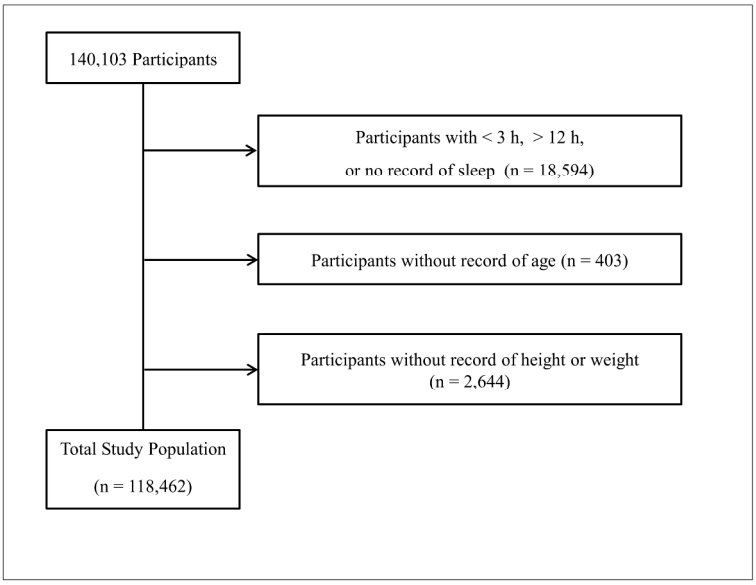

Figure 1. A schematic illustration of the participant selection.

Among a total of 140,103 participants, the participants Participants with < 3 h, > 12 h, or no record of sleep (n = 18,594) or without record of age (403) and height or weight records (2,644) were excluded. The data for the 118,462 participants from whom complete data were obtained were analyzed.

254x190mm (300 x 300 DPI)

S1 Table. Quality of sleep rates of participants according to sleep duration.

Factors	Total	Sleep time					P-value
		6(-) h	6 h	7 h	8 h	9+ h	
Quality of sleep (%)							<0.001*
Good	26.6	10.1	17.9	29.8	45.4	48.3	
Moderate	32.9	25.7	35.0	37.8	33.9	29.9	
Poor	40.5	64.2	47.0	32.4	20.7	21.8	

* Chi-square test with Rao-Scott correction, Significance at $P < 0.05$

S2 Table. Unadjusted odd ratios of sleep duration for food consumption using multiple logistic regression analysis with complex sampling (Reference of food frequency = 0 time a week).

Factors	AOR (95% Confidence interval) of Sleep time					P-value
	6(-) h	6 h	7 h	8 h	9+ h	
Fruits (%)						<0.001*
≥5 times a week	0.95 (0.87-1.04)	0.89 (0.82-0.97)	0.92 (0.84-1.00)	1.06 (0.97-1.16)	1	
3-6 times a week	1,06 (0.97-1.16)	1.09 (0.99-1.19)	1.07 (0.98-1.18)	1.15 (1.04-1.26)	1	
1-2 times a week	1.13 (1.03-1.24)	1.14 (1.05-.125)	1.11 (1.01-1.21)	1.04 (0.95-1.14)	1	
Soda (%)						<0.001*
≥5 times a week	1.07 (0.96-1.20)	1.12 (1.02-1.24)	1.14 (1.04-1.26)	1.01 (0.92-1.12)	1	
3-6 times a week	1.02 (0.94-1.10)	1.20 (1.12-1.29)	1.25 (1.17-1.33)	1.10 (1.02-1.18)	1	
1-2 times a week	1.02 (0.96-1.08)	1.14 (1.08-1.21)	1.21 (1.14-1.28)	1.08 (1.02-1.15)	1	
Soft drinks (%)						<0.001*
≥5 times a week	1.90 (1.73-2.09)	1.66 (1.52-1.81)	1.39 (1.28-1.52)	1.14 (1.04-1.25)	1	
3-6 times a week	1.52 (1.41-1.64)	1.49 (1.39-1.60)	1.35 (1.25-1.45)	1.15 (1.07-1.24)	1	

1-2 times a week	1.28 (1.20-1.36)	1.32 (1.25-1.41)	1.24 (1.17-1.32)	1.15 (1.08-1.23)	1	
Fast food (%)						<0.001*
≥5 times a week	1.26 (.09-1.46)	1.21 (1.05-1.39)	0.94 (0.81-1.09)	0.81 (0.70-0.94)	1	
3-6 times a week	1.45 (1.33-1.58	1.51 (1.39-1.64)	1.29 (1.19-1.40)	1.06 (0.98-1.16)	1	
1-2 times a week	1.33 (1.26-1.41)	1.38 (1.31-1.46)	1.30 (1.23-1.37)	1.13 (1.07-1.19)	1	
Instant noodle (%)						<0.001*
≥5 times a week	0.66 (0.59-0.75)	0.71 (0.63-0.80)	0.87 (0.78-0.97)	0.93 (0.83-1.05)	1	
3-6 times a week	0.67 (0.62-0.73)	0.85 (0.79-0.91)	1.03 (0.95-1.10)	1.15 (1.07-1.24)	1	
1-2 times a week	0.79 (0.75-0.84)	0.95 (0.89-1.00)	1.05 (0.99-1.11)	1.11 (1.05-1.18)	1	
Confectionaries (%)						<0.001*
≥5 times a week	1.53 (1.39-1.67)	1.40 (1.28-1.53)	1.14 (1.04-1.24)	1.07 (0.97-1.17)	1	
3-6 times a week	1.39 (1.29-1.49)	1.36 (1.27-1.46)	1.24 (1.16-1.32)	1.13 (1.05-1.21)	1	
1-2 times a week	1.23 (1.15-1.31)	1.26 (1.18-1.35)	1.17 (1.10-1.25)	1.10 (1.03-1.18)	1	
Vegetables (%)						<0.001*
≥5 times a week	0.94 (0.84-1.06)	0.96 (0.85-1.08)	1.07 (0.95-1.20)	1.11 (0.98-1.26)	1	
3-6 times a week	1.00 (0.89-1.13)	1.10 (0.97-1.24)	1.25 (1.11-1.41)	1.14 (1.00-1.31)	1	

1-2 times a week	0.98 (0.87-1.11)	1.12 (0.99-1.28)	1.25 (1.10-1.43)	1.19 (1.04-1.37)	1	
Milk (%)						<0.001*
≥5 times a week	0.51 (0.47-0.55)	0.57 (0.53-0.62)	0.73 (0.68-0.79)	0.97 (0.90-1.04)	1	
3-6 times a week	0.79 (0.73-0.86)	0.86 (0.79-0.93)	1.00 (0.92-1.08)	1.11 (1.02-1.21)	1	
1-2 times a week	0.91 (084-0.98)	0.98 (0.91-1.06)	1.03 (0.96-1.12)	1.05 (0.96-1.14)	1	

* Significance at P < 0.05

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectional reporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Reporting Item	Page Number
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	3-4
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	6-7
Objectives	#3	State specific objectives, including any prespecified hypotheses	7
Study design	#4	Present key elements of study design early in the paper	8
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	8

	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-10
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	8-10
Bias	#9	Describe any efforts to address potential sources of bias	9-10
Study size	#10	Explain how the study size was arrived at	8
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	8
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	10-11
	#12b	Describe any methods used to examine subgroups and interactions	8-10
	#12c	Explain how missing data were addressed	8
	#12d	If applicable, describe analytical methods taking account of sampling strategy	8
	#12e	Describe any sensitivity analyses	10-11
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	11-12
	#13b	Give reasons for non-participation at each stage	8
	#13c	Consider use of a flow diagram	8
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	11-15

	#14b	Indicate number of participants with missing data for each variable of interest	11-15
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	11-13
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	20-22
	#16b	Report category boundaries when continuous variables were categorized	20-22
	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	20-22
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	16-19
Key results	#18	Summarise key results with reference to study objectives	22
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	24-25
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	22-24
Generalisability	#21	Discuss the generalisability (external validity) of the study results	25
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	26

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The association between sleep duration, quality and food consumption in adolescent: A cross-sectional study using the Korea Youth Risk Behavior Web-based Survey

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ABSTRACT

Objective: This study examined the relationship between sleep duration and quality and food consumption among adolescents.

Design: Cross-sectional study.

Setting: Data from the 2014 and 2015 Korea Youth Risk Behavior Web-based Survey were used.

Participants: Participants of 12-18 years old (n = 118,462 [59,431 males, 59,031 females]) were selected.

Primary and secondary outcome measures: Sleep duration, sleep quality and the frequencies of fruits, soda, soft drinks, fast food, instant noodle, confectionaries, vegetables, and milk consumption.

Results: Short sleep durations (< 6 h) were associated with higher soft drinks and confectionaries intake than longer sleep durations (9+ h) (adjusted odds ratios, AORs [95% confidence intervals, CIs] for ≥ 5 times a week for soft drinks, 1.73 [1.57-1.91] and confectionaries, 1.32 [1.20-1.46]; P < 0.001). Poor sleep quality, with 7-8 h of sleep, was associated with a lower intake of fruits, vegetables and milk (AORs [95% CIs] for ≥ 5 times a week for fruits, 0.71 [0.65-0.77]; vegetables, 0.66 [0.58-0.75]; and milk, 0.80 [0.74-0.86]; each P < 0.001), and higher intake of soda, soft drinks, fast food, instant noodle and confectionaries (AORs [95% CIs] for ≥ 5 times a week for soda, 1.55 [1.40-1.70]; soft drinks, 1.58 [1.43-1.73]; fast food, 1.97 [1.65-2.35]; instant noodle, 1.55 [1.37-1.76]; and confectionaries, 1.30 [1.18-1.43]; each P < 0.001) than good sleep quality of the same duration.

Conclusion: Short sleep durations and poor sleep quality might be associated with higher consumption of unhealthier foods, such as sugar-sweetened beverages, fast food, instant noodle and confectionaries, and associated with lower consumption of fruits, vegetables and milk.

Key words: sleep duration, sleep quality, food consumption, food frequency, sugar-sweetened beverages, fast food, fruits, vegetables, adolescents, Korean

STRENGHTS AND LIMITATIONS OF THIS STUDY

- Our study was conducted on a representative population of Korean adolescents.
- We considered numerous socio-economic status variables as confounding factors to investigate the independent relationship between sleep status and food consumption.
- We considered not only sleep duration but also sleep quality in explaining sleep status.
- Our study was based on secondary data and it has some limitations in providing specific information.
- Because the data were collected based on a self-reported questionnaire, the precision of the information may be low.

INTRODUCTION

Sufficient sleep in adolescents is important to maintain good health status and school performance. According to the National Sleep Foundation [1], approximately 8 to 10 hours of sleep a night is best for adolescents. However, sleep durations for adolescents have been declining. [2] The reasons for decreasing sleep durations and reduced sleep quality among adolescents have been suggested to be associated with increased use of the internet and social media, and earlier school start times. [3 4] Inadequate sleep durations or quality could lead to poor school performance, physical health problems such as atopic conditions, headaches, mental health problems, and unhealthy behaviors. [4-7]

One of the outcomes of sleep deprivation among adolescents is obesity [8], which has become a serious public health problem worldwide. [9] The fundamental factor leading to obesity is an energy imbalance between the calories consumed and the calories expended [10]; therefore, dietary factors are closely related to the prevalence of obesity [11 12] and are considered as a potential link between sleep deprivation and obesity in adolescents. According to previous studies, the intake of fruits, vegetables and milk have a positive association, and the intake of sweets, snacks and fast food a negative association with sleep duration. [13-15] In short, adolescents who get less sleep may be more likely to consume more calories in the form of fast foods, sweets and snacks, and fewer micronutrients than adolescents who get more sleep. Previous studies demonstrated that one of the possible reasons for sleep deprivation in association with the consumption of higher energy foods might be changes in hormones such as decreased leptin and increased ghrelin levels, which can lead to an increase in appetite. [16 17] In summary, sleep deprivation in adolescents might affect dietary habits as a factor of health problems including obesity.

In Korea, the prevalence of childhood obesity in males and females was 15.3% and 11.1% in 2016, respectively and it increased steadily since 2010. [18] Lee, who performed a study using the Korea Youth Risk Behavior Web-based Survey (KYRBWS), reported that < 7 h of sleep per night in high school students was associated with increased cracker consumption. [19]

Meanwhile, studies of sleep deprivation should consider not only sleep duration but also sleep quality. However, few studies have investigated the relationship between sleep duration, along with sleep quality, and the intake of various foods while also adjusting for the numerous confounding factors among adolescents in population-based datasets. Lee utilized KYRBWS data which is population-based datasets with containing numerous variables, but she did not consider the sleep quality. [19] The aim of our study was to identify the associations between sleep duration and quality and food intake among adolescents by using KYRBWS datasets. We utilized the data of the participants' level of recovery from fatigue after sleeping as sleep quality.

MATERIALS AND METHODS

Data collection

The Institutional Review Board (IRB) of the Centers for Disease Control and Prevention of Korea (KCDC) approved this study (2014-06EXP-02-P-A). Written, informed consent was obtained from each participant prior to the survey. Because this web-based survey was performed at schools and included a large number of participants, informed consent from their parents was exempted. This consent procedure was approved by the IRB of KCDC.

This was a cross-sectional study using data from the KYRBWS, covering only Korea and

using statistical methods based on a designed sampling method and adjusted, weighted values. The results from the KYRBWS conducted in 2014 and 2015 were analyzed. The data were collected by the KCDC.

Patient and Public Involvement

The survey consists of 125 questions assessing demographic characteristics and health-related behaviors. Korean adolescents from the 7th through 12th grade completed the self-administered questionnaire voluntarily and anonymously. Using 43 regions (considering administrative districts, geographic accessibility, the number of schools, and population size) and the school participants attended, the mother population was stratified into 129 levels to identify the sample distribution. Groups were then selected using stratified, two-stage (schools and classes) clustered sampling based on data from the Education Ministry. Sampling was weighted by statisticians, who performed a post-stratification step and considered non-response rates and extreme values. Detailed methods are described at the KYRBWS website (https://yhs.cdc.go.kr/new/pages/main.asp).

Of a total of 140,103 participants, we excluded the following participants from analysis in this study; participants who slept less than 3 h or more than 12 h per night or who had no sleep records (18,594 participants); participants who did not give their age (403 participants); and participants without height or weight data (2,644 participants). Finally, 118,462 participants (84.5% of total participants; 59,431 males; 59,031 females; 12 to 18 years old) were included in this study (Figure 1).

Sleep duration and quality

The times at which participants fall asleep and wake up were recorded to within 10 min. The participants were asked the time they fall asleep and the time they wake up for the 7 most recent days classified into weekdays and weekends. Sleep duration was calculated by subtracting the time they fall asleep from the time they wake up. The mean daily sleep duration was calculated by adding weekday and weekend sleep durations with weights of 5/7 and 2/7, respectively. Sleep duration was divided into five groups: < 6 h (6(-) h), ≥ 6 h and < 7 h (6 h), ≥ 7 h and < 8 h (7 h), ≥ 8 h and < 9 h (8 h), and ≥ 9 h (9+ h). The participants were asked about their recovery from fatigue after sleeping for the 7 most recent days (quality of sleep). The answer options were very good, good, moderate, poor, and very poor. We regrouped answers into three groups of sleep quality to simplify the categories: good (very good and good), moderate, and poor (poor and very poor). We analyzed the association between sleep quality and food consumption only in the 7 h and 8 h groups as sleep duration was closely related to its quality (S1 Table).

Food intake frequency

The KCDC collected the participants' certain food intake frequencies in the 7 most recent days. The foods were fruits (not fruit juice), soda, soft drinks (including sports drinks, coffee-based beverages, and fruit drinks; excluding soda), fast food (such as pizza, hamburgers, or chicken), instant noodle, confectionaries, vegetables and milk. The data were divided into 4 groups: ≥ 5 times a week, 3-4 times a week, 1-2 times a week, and 0 time a week.

Health examination and socio-economic status

The participants were asked their weight (kg) and height (cm). Obesity levels were categorized into 4 groups according to the Centers for Disease Control and Prevention guidelines regarding body mass index (BMI, kg/m^2) for children and teens [20] as follows: obese, $\geq 95^{th}$ percentile; overweight, $\geq 85^{th}$ percentile and $< 95^{th}$ percentile; healthy weight, $\geq 5^{th}$ percentile and $< 85^{th}$ percentile; and underweight, $< 5^{th}$ percentile. The region of residence was divided into 3 groups by administrative district: large city, small city, and rural area. Subjective self-assessments of health were divided into 5 groups, from very good to very bad. The stress level of participants was divided into 5 groups: severe, moderate, mild, a little, and no stress. Self-reported economic level was grouped into 5 levels, from the highest to lowest. Parent educational level was divided into 4 groups: graduated college or higher, graduated high school, graduated middle school or below, unknown, and no parents. The participants who did not know the educational level of their parents or who had no parents were not excluded as this could have increased the number missing values for participants of relatively lower economic levels.

Statistical Analysis

Differences in the general characteristics according to sleep duration were calculated using linear regression analysis with complex sampling for age. The rate differences in relation to sex, region of residence, economic level, educational level of parents, stress level, food consumption, and quality of sleep were compared using chi-square tests with Rao-Scott corrections.

Adjusted odd ratios (AORs) for sleep duration in relation to food consumption were calculated using multinomial logistic regression analysis with complex sampling for adjusted covariates (age, sex, obesity, region of residence, stress level, economic level, and educational level of parents).

AORs for sleep quality in relation to food consumption were calculated using multinomial logistic regression analysis with complex sampling for adjusted covariates in the 7 h and 8 h groups.

Two-tailed analyses were conducted. P-values lower than 0.05 were considered to indicate significance, and 95% confidence intervals (CIs) were calculated. The weighted values recommended by the KYRBWS were applied, and all results are presented as weighted values. The results were analyzed using SPSS ver. 21.0 (IBM, Armonk, NY, USA).

RESULTS

Analysis of the general characteristics of the study participants shows that an older age, being female, reporting being healthy, living in a large city, feeling severe or moderate stress, being at a lower economic level, and having higher parental educational levels were associated with shorter sleep durations (all P values < 0.001, Table 1).

Table 1. General characteristics of participants according to sleep duration.

Factors	Total	Sleep duration					P-value
		6(-) h	6 h	7 h	8 h	9+ h	

Number							
n	118,462	27,409	29,773	30,254	20,743	10,283	
%	100	23.1	25.1	25.5	17.5	8.7	
Mean Age (year, SD)	15.0 (1.7)	16.1 (1.5)	15.5 (1.6)	14.7 (1.6)	13.9 (1.5)	14.0 (1.6)	<0.001*
Sex (%)							<0.001†
Male	50.2	41.8	47.7	52.3	57.1	59.5	
Female	49.8	58.2	52.3	47.7	42.9	40.5	
Obesity (%)							<0.001†
Underweight	6.1	5.9	6.2	6.0	6.2	6.9	
Healthy	78.8	80.3	79.5	78.1	77.8	76.5	
Overweight	11.3	10.8	10.8	11.8	11.8	11.8	
Obese	3.8	3.0	3.5	4.1	4.2	4.8	
Region (%)							<0.001†
Large City	44.7	49.4	46.6	43.3	40.6	39.0	
Small City	47.3	44.5	46.4	48.1	49.8	50.1	
Rural Area	8.0	6.1	7.1	8.6	9.6	10.9	
Stress (%)							<0.001†
Severe	8.9	13.7	9.3	7.1	5.7	7.1	
Moderate	27.3	34.4	29.1	25.0	21.4	21.7	
Mild	43.8	39.9	45.1	45.8	44.8	42.8	
A little	16.6	10.1	14.3	18.8	23.0	21.9	

	No	3.3	1.9	2.3	3.3	5.2	6.6	
Economic Level (%)								<0.001†
	Highest	8.1	7.3	6.9	7.9	9.5	11.1	
	Middle High	26.5	26.7	25.5	25.7	28.1	27.7	
	Middle	48.3	46.9	48.9	49.5	48.3	46.3	
	Middle Low	14.0	15.2	15.2	13.9	11.8	11.9	
	Lowest	3.2	3.9	3.5	3.0	2.3	3.0	
Educational level, Father (%)								<0.001†
	Unknown	19.7	12.8	16.0	21.9	26.6	28.5	
	Middle School	2.7	2.6	2.8	2.8	2.4	2.6	
	High School	29.2	28.8	30.5	30.3	27.5	26.9	
	College, or over	48.4	55.8	50.8	45.0	43.6	42.0	
Educational level, Mother (%)								<0.001†
	Unknown	18.9	12.0	15.2	21.0	25.8	28.1	
	Middle School	2.3	2.3	2.5	2.3	2.0	2.2	
	High School	37.1	39.1	39.3	37.1	33.7	31.8	
	College, or over	41.7	46.7	43.0	39.6	38.5	37.9	

* Linear regression analysis with complex sampling, Significance at $P < 0.05$

† Chi-square test with Rao-Scott correction, Significance at $P < 0.05$

Higher frequencies of instant noodle, fruits, vegetables, and milk intake were associated

with longer sleep durations, while higher frequencies of soda, soft drinks, fast food, and confectionaries intake were associated with shorter sleep durations (all P values < 0.001, Table 2).

Table 2. Food consumption of participants according to sleep duration.

Factors	Total	Sleep duration					P-value
		6(-) h	6 h	7 h	8 h	9+ h	
Fruits (%)							<0.001*
≥5 times a week	33.4	33.4	31.9	32.5	35.6	35.8	
3-4 times a week	28.9	28.2	29.0	29.2	29.4	28.0	
1-2 times a week	29.5	30.1	30.8	29.9	27.0	27.9	
0 time a week	8.3	8.3	8.3	8.4	8.0	8.7	
Soda (%)							<0.001*
≥5 times a week	8.0	8.3	8.1	8.0	7.7	8.0	
3-4 times a week	18.2	17.2	18.8	18.8	18.2	17.4	
1-2 times a week	48.9	48.0	49.0	49.8	49.0	48.0	
0 time a week	24.9	26.5	24.2	23.4	25.1	26.6	
Soft drinks (%)							<0.001*
≥5 times a week	13.9	16.3	14.5	13.1	12.0	11.6	
3-4 times a week	25.9	26.7	26.5	26.0	24.7	24.0	
1-2 times a week	44.1	42.2	43.9	44.8	45.6	44.6	
0 time a week	16.1	14.7	15.0	16.1	17.7	19.8	
Fast food (%)							<0.001*
≥5 times a week	2.5	2.8	2.6	2.2	2.2	2.7	

3-4 times a week	11.9	12.6	12.8	11.7	10.6	10.7	
1-2 times a week	59.8	60.0	60.7	60.5	58.8	56.2	
0 time a week	25.8	24.6	23.8	25.5	28.3	30.3	
Instant noodle (%)							<0.001*
≥5 times a week	4.6	4.4	4.3	4.8	4.8	5.4	
3-4 times a week	17.6	15.0	16.9	18.6	19.7	18.6	
1-2 times a week	51.6	49.8	51.9	52.4	52.6	51.3	
0 time a week	26.2	30.8	26.9	24.2	22.9	24.6	
Confectionaries (%)							<0.001*
≥5 times a week	10.7	12.2	11.1	9.9	9.7	9.7	
3-4 times a week	26.4	27.1	26.9	26.4	25.5	24.4	
1-2 times a week	45.4	44.3	45.6	45.9	45.9	45.6	
0 time a week	17.6	16.5	16.5	17.8	18.9	20.3	
Vegetables (%)							<0.001*
≥5 times a week	56.6	57.3	55.4	55.4	57.8	58.7	
3-4 times a week	24.1	23.8	24.5	25.1	23.2	22.6	
1-2 times a week	15.7	15.0	16.4	16.1	15.6	14.9	
0 time a week	3.6	4.0	3.7	3.4	3.4	3.8	
Milk (%)							<0.001*
≥5 times a week	41.9	36.7	38.4	42.9	48.4	50.4	
3-4 times a week	20.0	20.3	20.4	20.2	19.6	18.2	
1-2 times a week	22.4	24.3	24.0	22.2	19.4	18.6	
0 time a week	15.7	18.7	17.3	14.8	12.5	12.8	

* Chi-square test with Rao-Scott correction, Significance at $P < 0.05$

Short sleep durations (< 6 h) were associated with a higher intake of soft drinks (AOR [95% CI] for ≥ 5 times a week, 1.73 [1.57-1.91]; P < 0.001) and with a higher intake of confectionaries (AOR [95% CI] for ≥ 5 times a week, 1.32 [1.20-1.46]; P < 0.001). Soda and fast food intake showed an increasing trend in the group getting < 6 h of sleep. However, it was not definite. Fruits, instant noodle, vegetables, and milk intake did not show an evident association with getting < 6 h of sleep per night despite the significant association with sleep duration overall (Table 3). Unadjusted model was also analyzed (S2 Table).

Table 3. Adjusted odd ratios of sleep duration for food consumption using multiple logistic regression analysis with complex sampling (Reference of food frequency = 0 time a week).

Factors	AOR (95% Confidence interval) of sleep duration					P-value
	6(-) h	6 h	7 h	8 h	9+ h	
Fruits (%)						<0.001*
≥5 times a week	1.07 (0.97-1.18)	0.97 (0.89-1.06)	0.95 (0.87-1.04)	1.03 (0.94-1.12)	1	
3-4 times a week	1.04 (0.94-1.15)	1.05 (0.96-1.16)	1.05 (0.95-1.15)	1.11 (1.00-1.22)	1	
1-2 times a week	0.98 (0.89-1.08)	1.02 (0.92-1.12)	1.03 (0.94-1.13)	1.02 (0.92-1.12)	1	
Soda (%)						<0.001*
≥5 times a week	1.27 (1.14-1.41)	1.29 (1.17-1.42)	1.27 (1.16-1.40)	1.08 (0.97-1.19)	1	
3-4 times a week	1.08 (1.00-1.17)	1.25 (1.17-1.34)	1.29 (1.21-1.38)	1.13 (1.05-1.22)	1	
1-2 times a week	1.00 (0.94-1.07)	1.12 (1.06-1.18)	1.20 (1.14-1.27)	1.09 (1.03-1.16_	1	
Soft drinks (%)						<0.001*
≥5 times a week	1.73 (1.57-1.91)	1.57 (1.44-1.71)	1.38 (1.26-1.50)	1.16 (1.06-1.28)	1	

3-4 times a week	1.36 (1.25-1.47)	1.36 (1.37-1.46)	1.28 (1.19-1.38)	1.15 (1.07-1.24)	1	
1-2 times a week	1.16 (1.09-1.25)	1.22 (1.15-1.30)	1.18 (1.11-1.26)	1.14 (1.07-1.22)	1	
Fast food (%)						<0.001*
≥5 times a week	1.12 (0.95-1.32)	1.15 (0.99-1.34)	0.95 (0.82-1.11)	0.86 (0.74-1.00)	1	
3-4 times a week	1.18 (1.08-1.29)	1.31 (1.20-1.28)	1.22 (1.12-1.32)	1.07 (0.99-1.17)	1	
1-2 times a week	1.12 (1.05-1.19)	1.22 (1.15-1.28)	1.22 (1.15-1.28)	1.13 (1.07-1.19)	1	
Instant noodle (%)						<0.001*
≥5 times a week	1.09 (0.96-1.24)	1.03 (0.91-1.17)	1.07 (0.95-1.20)	0.98 (0.87-1.11)	1	
3-4 times a week	0.93 (0.86-1.01)	1.06 (0.98-1.14)	1.15 (1.07-1.23)	1.17 (1.08-1.26)	1	
1-2 times a week	0.92 (0.86-0.98)	1.04 (0.98-1.10)	1.09 (1.03-1.16)	1.11 (1.04-1.18)	1	
Confectionaries (%)						<0.001*
≥5 times a week	1.32 (1.20-1.46)	1.28 (1.17-1.41)	1.10 (1.00-1.20)	1.06 (0.97-1.17)	1	
3-4 times a week	1.20 (1.11-1.29)	1.22 (1.13-1.31)	1.16 (1.08-1.24)	1.10 (1.02-1.18)	1	
1-2 times a week	1.09 (1.12-1.17)	1.15 (1.07-1.23)	1.11 (1.04-1.18)	1.08 (1.01-1.16)	1	
Vegetables (%)						<0.001*

≥5 times a week	0.96 (0.85-1.10)	0.95 (0.83-1.07)	1.04 (0.92-1.17)	1.07 (0.94-1.22)	1	
3-4 times a week	0.92 (0.80-1.05)	0.98 (0.86-1.12)	1.15 (1.02-1.30)	1.10 (0.96-1.25)	1	
1-2 times a week	0.91 (0.79-1.05)	1.02 (0.90-1.17)	1.17 (1.03-1.33)	1.15 (1.01-1.33)	1	
Milk (%)						<0.001*
≥5 times a week	0.99 (0.91-1.07)	0.91 (0.85-0.98)	0.92 (0.85-0.99)	0.97 (0.89-1.04)	1	
3-4 times a week	1.06 (0.97-1.15)	1.04 (0.96-1.13)	1.09 (1.00-1.18)	1.09 (1.00-1.19)	1	
1-2 times a week	1.01 (0.93-1.09)	1.05 (0.97-1.14)	1.06 (0.98-1.14)	1.03 (0.95-1.12)	1	

* Significance at P < 0.05

Sleep quality was also associated with the frequency of food intake. Poor quality of sleep was associated with a lower intake of fruits, vegetables, and milk (AOR [95% CI] for ≥ 5 times a week for fruits, 0.71 [0.65-0.77]; vegetables, 0.66 [0.58-0.75]; and milk, 0.80 [0.74-0.86]; each P < 0.001). Poor sleep quality was also related with a higher intake of soda, soft drinks, fast food, instant noodle, and confectionaries (AOR [95% CI] for ≥ 5 times a week for soda, 1.55 [1.40-1.70]; soft drinks, 1.58 [1.43-1.73]; fast food, 1.97 [1.65-2.35]; instant noodle, 1.55 [1.37-1.76]; and confectionaries, 1.30 [1.18-1.43]; each P < 0.001, Table 4).

Table 4. Adjusted odd ratios of quality of sleep for food consumption using multiple logistic regression analysis with complex sampling (Reference of food frequency = 0 time a week) in 7 h and 8 h groups.

Factors	Quality of sleep			P-value
	Good	Moderate	Poor	
Fruits (%)				<0.001*
≥5 times a week	1	0.81 (0.74-0.89)	0.71 (0.65-0.77)	
3-4 times a week	1	0.93 (0.85-1.01)	0.79 (0.72-0.87)	
1-2 times a week	1	1.00 (0.92-1.09)	0.90 (0.82-0.99)	
Soda (%)				<0.001*
≥5 times a week	1	1.27 (1.16-1.40)	1.55 (1.40-1.70)	
3-4 times a week	1	1.25 (1.16-1.33)	1.35 (1.25-1.45)	
1-2 times a week	1	1.14 (1.08-1.20)	1.15 (1.08-1.22)	
Soft drinks (%)				<0.001*

≥5 times a week	1	1.24 (1.15-1.35)	1.58 (1.43-1.73)	
3-4 times a week	1	1.21 (1.13-1.29)	1.36 (1.26-1.46)	
1-2 times a week	1	1.09 (1.03-1.16)	1.10 (1.03-1.18)	
Fast food (%)				<0.001*
≥5 times a week	1	1.26 (1.07-1.49)	1.97 (1.65-2.35)	
3-4 times a week	1	1.28 (1.19-1.38)	1.49 (1.37-1.62)	
1-2 times a week	1	1.11 (1.06-1.17)	1.18 (1.11-1.25)	
Instant noodle (%)				<0.001*
≥5 times a week	1	1.29 (1.14-1.45)	1.55 (1.37-1.76)	
3-4 times a week	1	1.27 (1.19-1.36)	1.31 (1.22-1.42)	
1-2 times a week	1	1.14 (1.09-1.20)	1.11 (1.05-1.18)	
Confectionaries (%)				<0.001*
≥5 times a week	1	1.13 (1.03-1.23)	1.30 (1.18-1.43)	
3-4 times a week	1	1.12 (1.04-1.19)	1.08 (1.01-1.17)	
1-2 times a week	1	1.05 (0.99-1.12)	1.00 (0.93-1.07)	
Vegetables (%)				<0.001*
≥5 times a week	1	0.97 (0.86-1.10)	0.66 (0.58-0.75)	
3-4 times a week	1	1.14 (1.00-1.30)	0.78 (0.68-0.89)	
1-2 times a week	1	1.30 (1.14-1.49)	0.98 (0.85-1.12)	
Milk (%)				<0.001*
≥5 times a week	1	0.89 (0.83-0.95)	0.80 (0.74-0.86)	
3-4 times a week	1	1.01 (0.941.09)	0.86 (0.79-0.93)	
1-2 times a week	1	0.99 (0.92-1.06)	0.91 (0.84-0.99)	

* Significance at $P < 0.05$

DISCUSSION

We found that shorter sleep durations were associated with higher frequencies of consuming soft drinks and confectionaries than longer sleep durations. Additionally, poor sleep quality, with 7 to 8 h of sleep per night, was associated with a lower frequency of fruits, vegetables and milk intake, and a higher frequency of soda, soft drinks, fast food, instant noodle and confectionaries intake. These results are consistent with the results from previous studies in regard to the association between sleep duration and food consumption. [13-15 19] Furthermore, we found an association between not only sleep duration but also between sleep quality and the intake of various foods.

Along with these outcomes, sleep duration in association with sleep quality might affect one's appetite and even be related to health problems such as obesity [21] and diabetes. [22] A short sleep duration or poor sleep quality is associated with appetite-related hormonal changes such as lower leptin and higher ghrelin levels in previous studies. These results were also associated with greater energy intake and a higher BMI. [16 17] Baron et al. reported that people who fall asleep later sleep less and consume more calories than people who fall asleep earlier. Moreover, consuming calories after 8 pm was associated with a higher BMI. [21] Rudnicka et al. reported that shorter sleep durations in children were associated with a higher prevalence of risk factors for type 2 diabetes, such as increases in the fat mass index, insulin resistance and fasting glucose level. [22] Meanwhile, Doo et al. reported that participants with shorter sleep durations and a higher consumption of dietary antioxidant vitamins had a lower risk of obesity than those with a lower consumption of dietary antioxidant vitamins. [23] In summary, a short sleep duration in association with poor sleep quality could affect dietary

habits and appetite, which could result in health problems. Nevertheless, people who sleep for shorter durations can reduce the risks of health problems by consuming foods rich in micronutrients such as vitamins.

Although nutrient profiles were not available in our study, sugar-sweetened beverages such as soda and soft drinks, confectionaries, fast food, and instant noodle have higher energy levels but less micronutrients than fruits, vegetables, and milk. Sugar-sweetened beverages contain mainly liquid calories provided by sugars and have very few of other nutrients. A potential biological mechanism for sugar-sweetened beverages leading to obesity is that liquid calories may result in decreased satiety, leading to the consumption of more sugar-sweetened beverages with subsequent weight gain. [24]

Fast food, confectionaries, and instant noodle contain high energy densities, with calories derived from carbohydrates and fats and with minimal amounts of other nutrients. Nevertheless, humans have a weak innate ability to recognize energy density, so humans fail to down-regulation the consumption of most of these foods accordingly. [25] Obesity is one of the risk factors of type 2 diabetes because it is related to an increase in insulin resistance. [26] In fact, previous studies reported that sugar-sweetened beverage and fast food consumption were associated with not only changes in bodyweight but also increased insulin resistance. [24] [27] Hence, consumption of these foods could be a potential mechanistic link between sleep duration in association with quality and health problems, including obesity and type 2 diabetes in adolescents.

On the other hand, food intake might affect sleep duration and sleep quality. Fruits, vegetables, and milk are sources of vitamins and minerals. Grandner et al. reported that sleep symptoms such as difficulty falling asleep, difficulty maintaining sleep, non-restorative sleep,

and daytime sleepiness were associated with a lower intake of calcium, potassium, selenium, vitamin C, vitamin D, alpha-carotene, and lycopene. [28] Although mechanistic links between vitamin intake and sleep quality are unclear, previous studies have verified the relationship between sleep duration and vitamin intake. [29 30] In addition, Grandner et al. reported that sleep symptoms associated with poor sleep quality were associated with a higher intake of salt [28], and fast food and instant noodle intake are associated with salt intake. In accordance with the Korean food composition table, the sodium content of cooked hamburger is 498 mg/100 g, and that of cheese pizza is 447 mg/100 g. Instant noodle seasoning contains 2,225 mg of sodium in one portion (10.5 g). [31] Excessive salt (and therefore sodium) intake leads to elevated blood pressure, whereas calcium and potassium lower blood pressure. [32] Fereidoun et al. reported that providing 0.05 g/kg of salt to participants resulted in poor sleep quality. [33] According to a study by Javaheri et al., poor sleep quality in adolescents was associated with prehypertension. [34] The findings of previous studies and those of our study show that consuming foods with high levels of salt and low levels of other micronutrients might result in reduced sleep durations and poor sleep quality.

The limitations of our study are as follows. First, our study was based on data collected by the KYRBWS, and as secondary data, it has some limitations in providing specific information. For example, the dataset did not have information on nutrient contents or the quantity of food consumed to go along with intake frequency data. In addition, data on other confounding factors such as school examination periods or the timing of food intake across the 24 h were not present. Second, because the data were collected based on a self-reported questionnaire including weight and height, the precision of the information may be low such as BMI have possibility of underestimation. [35] Third, the validity of questionnaires of sleep

duration, sleep quality and food intake frequencies is unclear. Hence, the responses on the questionnaire may not represent the usual sleep duration, sleep quality or food intake frequency of each participant. To collect usual sleep duration, sleep quality and food intake data, the validity and reliability of the questionnaire should be evaluated in a further study. Finally, because of the cross-sectional design, the causal relationship between sleep duration and quality and food intake frequency is unclear. Longitudinal, randomized, controlled studies should be conducted to determine the causal relationship.

Nevertheless, our findings provide valuable information for the following reasons. First, our study was conducted on a representative population of Korean adolescents. Second, we considered numerous socio-economic status variables as confounding factors to investigate the independent relationship between sleep status and food consumption. Third, we considered not only sleep duration but also sleep quality in explaining sleep status. Finally, we investigated the intake frequency of various foods to show the relationship between sleep status and food consumption.

CONCLUSION

A short sleep duration was related to a higher frequency of soft drinks and confectionaries intake. Additionally, poor sleep quality with a normal sleep duration was related to a lower frequency of fruits, vegetables and milk intake, and a higher frequency of soda, soft drinks, fast food, instant noodle and confectionaries intake in adolescents. Hence, we demonstrate that short sleep durations and poor sleep quality might be associated with unhealthy food consumption, such as consuming more sugar-sweetened beverages, fast food, instant noodle and confectionaries, and fewer fruits, vegetables and milk. Further studies with a longitudinal,

randomized, controlled design are needed to elucidate the specific causal relationship between sleep status and food consumption in adolescents.

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DATA SHARING STATEMENT

No additional data are available.

FUNDING STATEMENT

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COMPETING INTERESTS STATEMENT

There are no competing interests for any author.

CONTRIBUTORS

CM wrote the manuscript. HJK designed the study. ISP performed the data processing. BP

performed the data interpretation. JHK analyzed the data. SS gave statistical techniques and reviewed the manuscript. HGC conceptualized the study and wrote and reviewed the manuscript.

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FIGURE

Figure 1. A schematic illustration of the participant selection. From a total of 140,103 participants, those getting < 3 h or > 12 h of sleep per night or with no sleep records (n = 18,594), without a record of their age (403) or without height or weight data (2,644) were excluded. The data for the 118,462 participants from whom complete records were obtained were analyzed.

SUPPLEMETARY FILES

S1 Table. Quality of sleep rates of participants according to sleep duration. * Chi-square test with Rao-Scott correction, Significance at $P < 0.05$

S2 Table. Unadjusted odd ratios of sleep duration for food consumption using multiple logistic regression analysis with complex sampling (Reference of food frequency = 0 time a week). * Significance at $P < 0.05$

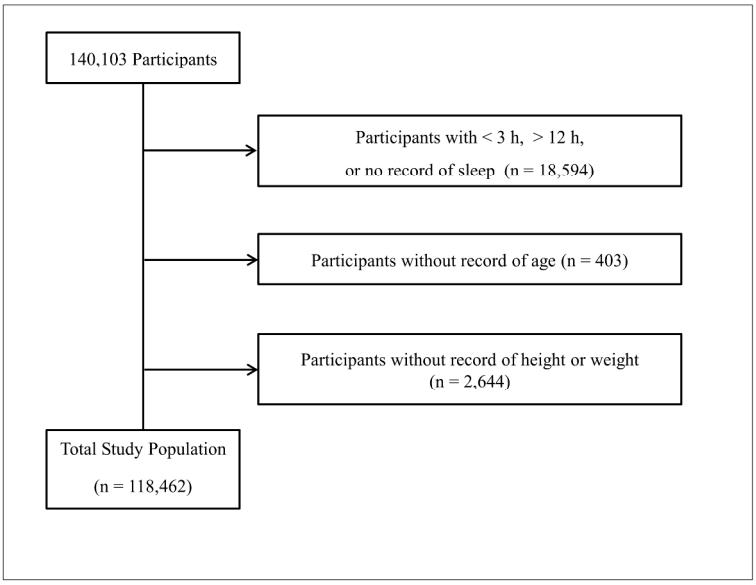

Figure 1. A schematic illustration of the participant selection.

Among a total of 140,103 participants, the participants Participants with < 3 h, > 12 h, or no record of sleep (n = 18,594) or without record of age (403) and height or weight records (2,644) were excluded. The data for the 118,462 participants from whom complete data were obtained were analyzed.

254x190mm (300 x 300 DPI)

S1 Table. Quality of sleep rates of participants according to sleep duration.

Factors	Total	Sleep time					P-value
		6(-) h	6 h	7 h	8 h	9+ h	
Quality of sleep (%)							<0.001*
Good	26.6	10.1	17.9	29.8	45.4	48.3	
Moderate	32.9	25.7	35.0	37.8	33.9	29.9	
Poor	40.5	64.2	47.0	32.4	20.7	21.8	

* Chi-square test with Rao-Scott correction, Significance at $P < 0.05$

S2 Table. Unadjusted odd ratios of sleep duration for food consumption using multiple logistic regression analysis with complex sampling (Reference of food frequency = 0 time a week).

Factors	AOR (95% Confidence interval) of Sleep time					P-value
	6(-) h	6 h	7 h	8 h	9+ h	
Fruits (%)						<0.001*
≥5 times a week	0.95 (0.87-1.04)	0.89 (0.82-0.97)	0.92 (0.84-1.00)	1.06 (0.97-1.16)	1	
3-6 times a week	1,06 (0.97-1.16)	1.09 (0.99-1.19)	1.07 (0.98-1.18)	1.15 (1.04-1.26)	1	
1-2 times a week	1.13 (1.03-1.24)	1.14 (1.05-.125)	1.11 (1.01-1.21)	1.04 (0.95-1.14)	1	
Soda (%)						<0.001*
≥5 times a week	1.07 (0.96-1.20)	1.12 (1.02-1.24)	1.14 (1.04-1.26)	1.01 (0.92-1.12)	1	
3-6 times a week	1.02 (0.94-1.10)	1.20 (1.12-1.29)	1.25 (1.17-1.33)	1.10 (1.02-1.18)	1	
1-2 times a week	1.02 (0.96-1.08)	1.14 (1.08-1.21)	1.21 (1.14-1.28)	1.08 (1.02-1.15)	1	
Soft drinks (%)						<0.001*
≥5 times a week	1.90 (1.73-2.09)	1.66 (1.52-1.81)	1.39 (1.28-1.52)	1.14 (1.04-1.25)	1	
3-6 times a week	1.52 (1.41-1.64)	1.49 (1.39-1.60)	1.35 (1.25-1.45)	1.15 (1.07-1.24)	1	

1-2 times a week	1.28 (1.20-1.36)	1.32 (1.25-1.41)	1.24 (1.17-1.32)	1.15 (1.08-1.23)	1	
Fast food (%)						<0.001*
≥5 times a week	1.26 (.09-1.46)	1.21 (1.05-1.39)	0.94 (0.81-1.09)	0.81 (0.70-0.94)	1	
3-6 times a week	1.45 (1.33-1.58	1.51 (1.39-1.64)	1.29 (1.19-1.40)	1.06 (0.98-1.16)	1	
1-2 times a week	1.33 (1.26-1.41)	1.38 (1.31-1.46)	1.30 (1.23-1.37)	1.13 (1.07-1.19)	1	
Instant noodle (%)						<0.001*
≥5 times a week	0.66 (0.59-0.75)	0.71 (0.63-0.80)	0.87 (0.78-0.97)	0.93 (0.83-1.05)	1	
3-6 times a week	0.67 (0.62-0.73)	0.85 (0.79-0.91)	1.03 (0.95-1.10)	1.15 (1.07-1.24)	1	
1-2 times a week	0.79 (0.75-0.84)	0.95 (0.89-1.00)	1.05 (0.99-1.11)	1.11 (1.05-1.18)	1	
Confectionaries (%)						<0.001*
≥5 times a week	1.53 (1.39-1.67)	1.40 (1.28-1.53)	1.14 (1.04-1.24)	1.07 (0.97-1.17)	1	
3-6 times a week	1.39 (1.29-1.49)	1.36 (1.27-1.46)	1.24 (1.16-1.32)	1.13 (1.05-1.21)	1	
1-2 times a week	1.23 (1.15-1.31)	1.26 (1.18-1.35)	1.17 (1.10-1.25)	1.10 (1.03-1.18)	1	
Vegetables (%)						<0.001*
≥5 times a week	0.94 (0.84-1.06)	0.96 (0.85-1.08)	1.07 (0.95-1.20)	1.11 (0.98-1.26)	1	
3-6 times a week	1.00 (0.89-1.13)	1.10 (0.97-1.24)	1.25 (1.11-1.41)	1.14 (1.00-1.31)	1	

1-2 times a week	0.98 (0.87-1.11)	1.12 (0.99-1.28)	1.25 (1.10-1.43)	1.19 (1.04-1.37)	1	
Milk (%)						<0.001*
≥5 times a week	0.51 (0.47-0.55)	0.57 (0.53-0.62)	0.73 (0.68-0.79)	0.97 (0.90-1.04)	1	
3-6 times a week	0.79 (0.73-0.86)	0.86 (0.79-0.93)	1.00 (0.92-1.08)	1.11 (1.02-1.21)	1	
1-2 times a week	0.91 (084-0.98)	0.98 (0.91-1.06)	1.03 (0.96-1.12)	1.05 (0.96-1.14)	1	

* Significance at $P < 0.05$

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectional reporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Reporting Item	Page Number
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	3-4
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	6-7
Objectives	#3	State specific objectives, including any prespecified hypotheses	7
Study design	#4	Present key elements of study design early in the paper	8
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	8

	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-10
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	8-10
Bias	#9	Describe any efforts to address potential sources of bias	9-10
Study size	#10	Explain how the study size was arrived at	8
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	8
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	10-11
	#12b	Describe any methods used to examine subgroups and interactions	8-10
	#12c	Explain how missing data were addressed	8
	#12d	If applicable, describe analytical methods taking account of sampling strategy	8
	#12e	Describe any sensitivity analyses	10-11
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	11-12
	#13b	Give reasons for non-participation at each stage	8
	#13c	Consider use of a flow diagram	8
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	11-15

	#14b	Indicate number of participants with missing data for each variable of interest	11-15
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	11-13
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	20-22
	#16b	Report category boundaries when continuous variables were categorized	20-22
	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	20-22
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	16-19
Key results	#18	Summarise key results with reference to study objectives	22
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	24-25
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	22-24
Generalisability	#21	Discuss the generalisability (external validity) of the study results	25
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	26