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Sleep duration and quality is associated with food consumption in adolescents

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Sleep duration and quality is associated with food consumption in adolescents

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4 30 **ABSTRACT**

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7 31 Objective: This study examined the relationship between sleep duration and quality and food
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9 32 consumption among adolescents.

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11 33 Design: Cross-sectional study.

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14 34 Setting: Data from the 2014 and 2015 Korea Youth Risk Behavior Web-based Survey were
15
16 35 used.

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19 36 Participants: Participants of 12-18 years old (n = 118,462 (59,431 males, 59,031 females))
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21 37 were selected.

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24 38 Primary and secondary outcome measures: Sleep duration, sleep quality and the frequencies
25
26 39 of fruits, soda, soft drinks, fast food, instant noodle, confectionaries, vegetables, and milk
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28 40 consumption.

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31 41 Results: Short sleep durations (< 6 h) were associated with higher soft drinks and
32
33 42 confectionaries intake than longer sleep durations (adjusted odds ratios (AORs) [95%
34
35 43 confidence intervals (CIs)] for ≥ 5 times a week for soft drinks, 1.73 [1.57-1.91] and
36
37 44 confectionaries, 1.32 [1.20-1.46]; $P < 0.001$). Poor sleep quality, with 7-8 h of sleep, was
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39 45 associated with a lower intake of fruits, vegetables and milk (AORs [95% CIs] for ≥ 5 times a
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41 46 week for fruits, 0.71 [0.65-0.77]; vegetables, 0.66 [0.58-0.75]; and milk, 0.80 [0.74-0.86];
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43 47 each $P < 0.001$), and higher intake of soda, soft drinks, fast food, instant noodle and
44
45 48 confectionaries (AORs [95% CIs] for ≥ 5 times a week for soda, 1.55 [1.40-1.70]; soft drinks,
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47 49 1.58 [1.43-1.73]; fast food, 1.97 [1.65-2.35]; instant noodle, 1.55 [1.37-1.76]; and
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49 50 confectionaries, 1.30 [1.18-1.43]; each $P < 0.001$) than was good sleep quality of the same
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51 51 duration.

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4 52 Conclusion: Short sleep durations and poor sleep quality might be associated with higher
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6 53 consumption of unhealthier foods, such as sugar-sweetened beverages, fast food, instant
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8 54 noodle and confectionaries, and associated with lower consumption of fruits, vegetables and
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10 55 milk.

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13 56 Key words: sleep duration, sleep quality, food consumption, food frequency, sugar-sweetened
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15 57 beverages, fast food, fruits, vegetables, adolescents, Korean
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4 60 **STRENGTHS AND LIMITATIONS OF THIS STUDY**

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7 61 ♦ Our study was conducted on a representative population of Korean adolescents.
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9 62 ♦ We considered numerous socio-economic status variables as confounding factors to
10
11 63 investigate the independent relationship between sleep status and food consumption.
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14 64 ♦ We considered not only sleep duration but also sleep quality in explaining sleep
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16 65 status.
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19 66 ♦ Our study was based on secondary data and it has some limitations in providing
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21 67 specific information.
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24 68 ♦ Because the data were collected based on a self-reported questionnaire, the precision
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26 69 of the information may be low.
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71 INTRODUCTION

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

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

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4 94 In Korea, the prevalence of childhood obesity in males and females was 15.3% and 11.1%
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6 95 in 2016, respectively and it increased steadily since 2010.¹⁸ Lee, who performed a study
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8 96 using the Korea Youth Risk Behavior Web-based Survey (KYRBWS), reported that < 7 h of
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10 97 sleep per night in high school students was associated with increased cracker consumption.¹⁹
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13 98 Meanwhile, studies of sleep deprivation should consider not only sleep duration but also
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15 99 sleep quality. However, few studies have investigated the relationship between sleep duration,
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17 100 along with sleep quality, and the intake of various foods while also adjusting for the
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19 101 numerous confounding factors among adolescents in population-based datasets. Lee utilized
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21 102 KYRBWS data which is population-based datasets with containing numerous variables, she
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23 103 did not consider the sleep quality.¹⁹ The aim of our study was to identify the associations
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25 104 between sleep duration and quality and food intake among adolescents by using KYRBWS
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27 105 datasets. We utilized the data of the participants' level of recovery from fatigue after sleeping
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29 106 as sleep quality. We obtained reliable results for assessing the associations between sleep
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31 107 duration and quality, and the consumption of each of food type.
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38 109 **MATERIALS AND METHODS**

41 110 **Data collection**

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43 111 The Institutional Review Board (IRB) of the Centers for Disease Control and Prevention of
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45 112 Korea (KCDC) approved this study (2014-06EXP-02-P-A). Written, informed consent was
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47 113 obtained from each participant prior to the survey. Because this web-based survey was
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49 114 performed at schools and included a large number of participants, informed consent from
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51 115 their parents was exempted. This consent procedure was approved by the IRB of KCDC.
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4 116 This was a cross-sectional study using data from the KYRBWS, covering only Korea and
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6 117 using statistical methods based on a designed sampling method and adjusted, weighted values.
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8 118 The results from the KYRBWS conducted in 2014 and 2015 were analyzed. The data were
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10 119 collected by the KCDC.
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16 121 **Public Involvement**

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18 122 The survey consists of 125 questions assessing demographic characteristics and health-related
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20 123 behaviors. Korean adolescents from the 7th through 12th grade completed the self-
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22 124 administered questionnaire voluntarily and anonymously. Using 43 regions (considering
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24 125 administrative districts, geographic accessibility, the number of schools, and population size)
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26 126 and the school participants attended, the mother population was stratified into 129 levels to
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28 127 identify the sample distribution. Groups were then selected using stratified, two-stage
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30 128 (schools and classes) clustered sampling based on data from the Education Ministry.
31
32 129 Sampling was weighted by statisticians, who performed a post-stratification step and
33
34 130 considered non-response rates and extreme values. Detailed methods are described at the
35
36 131 KYRBWS website (<https://yhs.cdc.go.kr/new/pages/main.asp>).
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41 132 Of a total of 140,103 participants, we excluded the following participants from analysis in
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43 133 this study; participants who slept less than 3 h or more than 12 h per night or who had no
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45 134 sleep records (18,594 participants); participants who did not give their age (403 participants);
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47 135 and participants without height or weight data (2,644 participants). Finally, 118,462
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49 136 participants (59,431 males; 59,031 females; 12 to 18 years old) were included in this study
50
51 137 (Figure 1).
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139 Sleep duration and quality

140 The times at which participants fall asleep and wake up were recorded to within 10 min. The
141 participants were asked the time they fall asleep and the time they wake up for the 7 most
142 recent days classified into weekdays and weekends. Sleep duration was calculated by
143 subtracting the time they fall asleep from the time they wake up. The mean daily sleep
144 duration was calculated by adding weekday and weekend sleep durations with weights of 5/7
145 and 2/7, respectively. Sleep duration was divided into five groups: < 6 h (6(-) h), ≥ 6 h and <
146 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
147 asked about their recovery from fatigue after sleeping for the 7 most recent days (quality of
148 sleep). The answer options were very good, good, moderate, poor, and very poor. We
149 regrouped answers into three groups of sleep quality to simplify the categories: good (very
150 good and good), moderate, and poor (poor and very poor). We analyzed the association
151 between sleep quality and food consumption only in the 7 h and 8 h groups as sleep duration
152 was closely related to its quality (S1 Table).

153

154 Food intake frequency

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

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7 161 **Health examination and socio-economic status**

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9 162 The participants were asked their weight (kg) and height (cm). Obesity levels were
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11 163 categorized into 4 groups according to the Centers for Disease Control and Prevention
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13 164 guidelines regarding body mass index (BMI, kg/m²) for children and teens ²⁰ as follows:
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15 165 obese, $\geq 95^{\text{th}}$ percentile; overweight, $\geq 85^{\text{th}}$ percentile and $< 95^{\text{th}}$ percentile; healthy weight, \geq
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17 166 5^{th} percentile and $< 85^{\text{th}}$ percentile; and underweight, $< 5^{\text{th}}$ percentile. The region of residence
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19 167 was divided into 3 groups by administrative district: large city, small city, and rural area.
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21 168 Subjective self-assessments of health were divided into 5 groups, from very good to very bad.
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23 169 The stress level of participants was divided into 5 groups: severe, moderate, mild, a little, and
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25 170 no stress. Self-reported economic level was grouped into 5 levels, from the highest to lowest.
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27 171 Parent educational level was divided into 4 groups: graduated college or higher, graduated
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29 172 high school, graduated middle school or below, unknown, and no parents. The participants
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31 173 who did not know the educational level of their parents or who had no parents were not
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33 174 excluded as this could have increased the number missing values for participants of relatively
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35 175 lower economic levels.
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43 177 **Statistical Analysis**

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45 178 Differences in the general characteristics according to sleep duration were calculated using
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47 179 linear regression analysis with complex sampling for age. The rate differences in relation to
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49 180 sex, region of residence, economic level, educational level of parents, stress level, food
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51 181 consumption, and quality of sleep were compared using chi-square tests with Rao-Scott
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4 182 corrections.

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6 183 Adjusted odd ratios (AORs) for sleep duration in relation to food consumption were
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8 184 calculated using multinomial logistic regression analysis with complex sampling for adjusted
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10 185 covariates (age, sex, obesity, region of residence, stress level, economic level, and
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12 186 educational level of parents).

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15 187 AORs for sleep quality in relation to food consumption were calculated using
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17 188 multinomial logistic regression analysis with complex sampling for adjusted covariates in the
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19 189 7 h and 8 h groups.

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22 190 Two-tailed analyses were conducted. P-values lower than 0.05 were considered to
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24 191 indicate significance, and 95% confidence intervals (CIs) were calculated. The weighted
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26 192 values recommended by the KYRBWS were applied, and all results are presented as
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28 193 weighted values. The results were analyzed using SPSS ver. 21.0 (IBM, Armonk, NY, USA).

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35 195 **RESULTS**

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37 196 Analysis of the general characteristics of the study participants shows that an older age, being
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39 197 female, reporting being healthy, living in a large city, feeling severe or moderate stress, being
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41 198 at a lower economic level, and having higher parental educational levels were associated with
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43 199 shorter sleep durations (all P values < 0.001, Table 1).

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49 201 **Table 1. General characteristics of participants according to sleep duration.**

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Factors	Total	Sleep duration	P-value

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		6(-) h	6 h	7 h	8 h	9+ h	
Number							
n	118,4 62	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	

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

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

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

209 **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	

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

211

212 Short sleep durations (< 6 h) were associated with a higher intake of soft drinks (AOR
 213 [95% CI] for ≥ 5 times a week, 1.73 [1.57-1.91]; $P < 0.001$) and with a higher intake of
 214 confectionaries (AOR [95% CI] for ≥ 5 times a week, 1.32 [1.20-1.46]; $P < 0.001$). Soda and
 215 fast food intake showed an increasing trend in the group getting < 6 h of sleep. However, it
 216 was not definite. Fruits, instant noodle, vegetables, and milk intake did not show an evident
 217 association with getting < 6 h of sleep per night despite the significant association with sleep
 218 duration overall (Table 3). Unadjusted model was also analyzed (S2 Table).

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221 **Table 3. Adjusted odd ratios of sleep duration for food consumption using multiple logistic regression analysis with complex sampling**
 222 **(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	

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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

226 Sleep quality was also associated with the frequency of food intake. Poor quality of sleep
 227 was associated with a lower intake of fruits, vegetables, and milk (AOR [95% CI] for ≥ 5
 228 times a week for fruits, 0.71 [0.65-0.77]; vegetables, 0.66 [0.58-0.75]; and milk, 0.80 [0.74-
 229 0.86]; each $P < 0.001$). Poor sleep quality was also related with a higher intake of soda, soft
 230 drinks, fast food, instant noodle, and confectionaries (AOR [95% CI] for ≥ 5 times a week for
 231 soda, 1.55 [1.40-1.70]; soft drinks, 1.58 [1.43-1.73]; fast food, 1.97 [1.65-2.35]; instant
 232 noodle, 1.55 [1.37-1.76]; and confectionaries, 1.30 [1.18-1.43]; each $P < 0.001$, Table 4).

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 234 **Table 4. Adjusted odd ratios of quality of sleep for food consumption using multiple**
 235 **logistic regression analysis with complex sampling (Reference of food frequency = 0 time**
 236 **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 (0.94-1.09)	0.86 (0.79-0.93)	
1-2 times a week	1	0.99 (0.92-1.06)	0.91 (0.84-0.99)	

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4 237 * Significance at $P < 0.05$
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9 239 **DISCUSSION**
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12 240 We found that shorter sleep durations were associated with higher frequencies of consuming
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14 241 soft drinks and confectionaries than were longer sleep durations. Additionally, poor sleep
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16 242 quality, with 7 to 8 h of sleep per night, was associated with a lower frequency of fruits,
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18 243 vegetables and milk intake, and a higher frequency of soda, soft drinks, fast food, instant
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20 244 noodle and confectionaries intake. Unlike in previous studies, we found an association
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22 245 between not only sleep duration but also between sleep quality and the intake of various
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24 246 foods.
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28 247 According to these outcomes, sleep duration in association with sleep quality might
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30 248 affect one's appetite and even be related to health problems. According to previous studies, a
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32 249 short sleep duration or poor sleep quality is associated with appetite-related hormonal
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34 250 changes such as lower leptin and higher ghrelin levels. These results were also associated
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36 251 with greater energy intake and a higher BMI.^{16 17} According to a study by Baron et al.,
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38 252 people who fall asleep later sleep less and consume more calories than people who fall asleep
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40 253 earlier. Moreover, consuming calories after 8 pm was associated with a higher BMI.²¹
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42 254 Rudnicka et al. reported that shorter sleep durations in children were associated with a higher
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44 255 prevalence of risk factors for type 2 diabetes, such as increases in the fat mass index, insulin
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46 256 resistance and fasting glucose level.²² Meanwhile, Doo et al. reported that participants with
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48 257 shorter sleep durations and a higher consumption of dietary antioxidant vitamins had a lower
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50 258 risk of obesity than those with a lower consumption of dietary antioxidant vitamins.²³ In
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52 259 summary, a short sleep duration in association with poor sleep quality could affect dietary
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4 260 habits and appetite, which could result in health problems. Nevertheless, people who sleep for
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6 261 shorter durations can reduce the risks of health problems by consuming foods rich in
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8 262 micronutrients such as vitamins. Although nutrient profiles were not available in our study,
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10 263 sugar-sweetened beverages such as soda and soft drinks, confectionaries, fast food, and
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12 264 instant noodle have higher energy levels but less micronutrients than fruits, vegetables, and
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14 265 milk. Sugar-sweetened beverages contain mainly liquid calories provided by sugars and have
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16 266 very few of other nutrients. A potential biological mechanism for sugar-sweetened beverages
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18 267 leading to obesity is that liquid calories may result in decreased satiety, leading to the
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20 268 consumption of more sugar-sweetened beverages with subsequent weight gain.²⁴ Fast food,
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22 269 confectionaries, and instant noodle contain high energy densities, with calories derived from
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24 270 carbohydrates and fats and with minimal amounts of other nutrients. Nevertheless, humans
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26 271 have a weak innate ability to recognize energy density, so humans fail to down-regulation the
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28 272 consumption of most of these foods accordingly.²⁵ Obesity is one of the risk factors of type 2
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30 273 diabetes because it is related to an increase in insulin resistance.²⁶ In fact, previous studies
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32 274 reported that sugar-sweetened beverage and fast food consumption were associated with not
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34 275 only changes in bodyweight but also increased insulin resistance.^{24,27} Hence, consumption of
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36 276 these foods could be a potential mechanistic link between sleep duration in association with
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38 277 quality and health problems, including obesity and type 2 diabetes in adolescents.

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43 278 On the other hand, food intake might affect sleep duration in association with quality.
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45 279 Fruits, vegetables, and milk are sources of vitamins and minerals. Grandner et al. reported
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47 280 that sleep symptoms such as difficulty falling asleep, difficulty maintaining sleep, non-
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49 281 restorative sleep, and daytime sleepiness was associated with a lower intake of calcium,
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51 282 potassium, selenium, vitamin C, vitamin D, alpha-carotene, and lycopene.²⁸ Although

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4 283 mechanistic links between vitamin intake and sleep quality are unclear, previous studies have
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6 284 verified the relationship between sleep duration and vitamin intake.^{29 30} In addition, Grandner
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8 285 et al. reported that sleep symptoms associated with poor sleep quality were associated with a
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10 286 higher intake of salt²⁸, and fast food and instant noodle intake are associated with salt intake.
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12 287 According to the Korean food composition table, the sodium content of cooked hamburger is
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14 288 498 mg/100 g, and that of cheese pizza is 447 mg/100 g. Instant noodle seasoning contains
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16 289 2,225 mg of sodium in one portion (10.5 g).³¹ Excessive salt (and therefore sodium) intake
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18 290 leads to elevated blood pressure, whereas calcium and potassium lower blood pressure.³²
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20 291 According to the intervention study by Fereidoun et al., providing 0.05 g/kg of salt to
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22 292 participants resulted in poor sleep quality.³³ According to a study by Javaheri et al., poor
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24 293 sleep quality in adolescents was associated with prehypertension.³⁴ The findings of previous
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26 294 studies and those of our study show that consuming foods with high levels of salt and low
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28 295 levels of other micronutrients might result in reduced sleep durations and poor sleep quality.

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32 296 The limitations of our study are as follows. First, our study was based on data collected
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34 297 by the KYRBWS, and as secondary data, it has some limitations in providing specific
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36 298 information. For example, the dataset did not have information on nutrient contents or the
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38 299 quantity of food consumed to go along with intake frequency data. In addition, data on other
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40 300 confounding factors such as school examination periods or the time of eating before bed were
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42 301 not present. Second, because the data were collected based on a self-reported questionnaire
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44 302 including weight and height, the precision of the information may be low such as BMI have
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46 303 possibility of underestimation.³⁵ Third, the questionnaire for sleep duration and food intake
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48 304 frequency was limited to asking about the previous 7 days. Hence, the responses on the
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50 305 questionnaire may not represent the usual sleep duration, sleep quality or food intake
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4 306 frequency of each participant. To collect usual sleep duration and food intake data, the
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6 307 validity and reliability of the questionnaire should be evaluated in a further study. Finally,
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8 308 because of the cross-sectional design, the causal relationship between sleep duration and
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10 309 quality and food intake frequency is unclear. Longitudinal, randomized, controlled studies
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12 310 should be conducted to determine the causal relationship. Despite of these limitations, our
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14 311 findings provide valuable information for the following reasons. First, our study was
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16 312 conducted on a representative population of Korean adolescents. Second, we considered
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18 313 numerous socio-economic status variables as confounding factors to investigate the
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20 314 independent relationship between sleep status and food consumption. Third, we considered
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22 315 not only sleep duration but also sleep quality in explaining sleep status. Finally, we
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24 316 investigated the intake frequency of various foods to show the relationship between sleep
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26 317 status and food consumption.
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319 **CONCLUSION**

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

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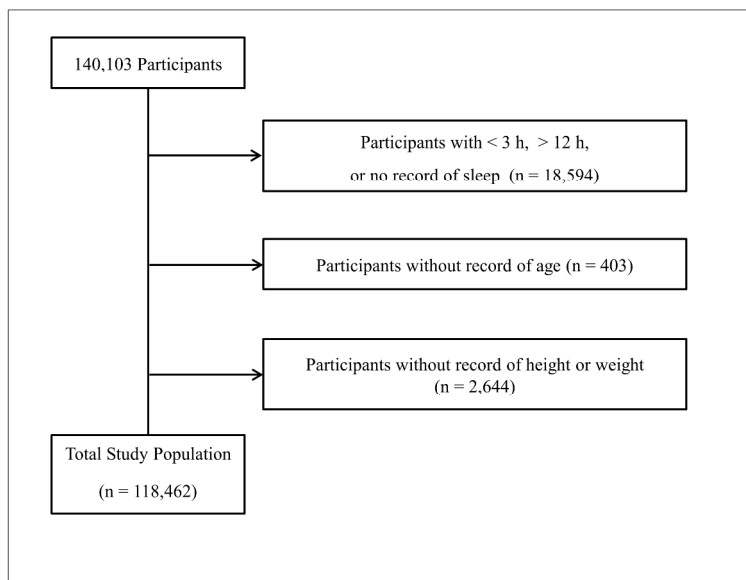
448 **FIGURE**

449 **Figure 1. A schematic illustration of the participant selection.** From a total of 140,103
450 participants, those getting < 3 h or > 12 h of sleep per night or with no sleep records (n =
451 18,594), without a record of their age (403) or without height or weight data (2,644) were
452 excluded. The data for the 118,462 participants from whom complete records were obtained
453 were analyzed.

455 **SUPPLEMENTARY FILES**

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

458 **S2 Table. Unadjusted odd ratios of sleep duration for food consumption using multiple**
459 **logistic regression analysis with complex sampling (Reference of food frequency = 0 time**
460 **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 (1.05-1.25)	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 (0.84-0.98)	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.

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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, Gotsche PC, Vandembroucke 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

1		#7	Clearly define all outcomes, exposures, predictors, potential	8-10
2			confounders, and effect modifiers. Give diagnostic criteria, if	
3			applicable	
4				
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6	Data sources /	#8	For each variable of interest give sources of data and details of	8-10
7	measurement		methods of assessment (measurement). Describe	
8			comparability of assessment methods if there is more than one	
9			group. Give information separately for for exposed and	
10			unexposed groups if applicable.	
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14	Bias	#9	Describe any efforts to address potential sources of bias	9-10
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17	Study size	#10	Explain how the study size was arrived at	8
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19	Quantitative	#11	Explain how quantitative variables were handled in the	8
20	variables		analyses. If applicable, describe which groupings were chosen,	
21			and why	
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24	Statistical	#12a	Describe all statistical methods, including those used to control	10-11
25	methods		for confounding	
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28		#12b	Describe any methods used to examine subgroups and	8-10
29			interactions	
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32		#12c	Explain how missing data were addressed	8
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35		#12d	If applicable, describe analytical methods taking account of	8
36			sampling strategy	
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39		#12e	Describe any sensitivity analyses	10-11
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41	Participants	#13a	Report numbers of individuals at each stage of study—eg	11-12
42			numbers potentially eligible, examined for eligibility, confirmed	
43			eligible, included in the study, completing follow-up, and	
44			analysed. Give information separately for for exposed and	
45			unexposed groups if applicable.	
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49		#13b	Give reasons for non-participation at each stage	8
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52		#13c	Consider use of a flow diagram	8
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54	Descriptive data	#14a	Give characteristics of study participants (eg demographic,	11-15
55			clinical, social) and information on exposures and potential	
56			confounders. Give information separately for exposed and	
57			unexposed groups if applicable.	
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1		#14b	Indicate number of participants with missing data for each	11-15
2			variable of interest	
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5	Outcome data	#15	Report numbers of outcome events or summary measures.	11-13
6			Give information separately for exposed and unexposed	
7			groups if applicable.	
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10	Main results	#16a	Give unadjusted estimates and, if applicable, confounder-	20-22
11			adjusted estimates and their precision (eg, 95% confidence	
12			interval). Make clear which confounders were adjusted for and	
13			why they were included	
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17		#16b	Report category boundaries when continuous variables were	20-22
18			categorized	
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21		#16c	If relevant, consider translating estimates of relative risk into	20-22
22			absolute risk for a meaningful time period	
23				
24	Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and	16-19
25			interactions, and sensitivity analyses	
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28	Key results	#18	Summarise key results with reference to study objectives	22
29				
30	Limitations	#19	Discuss limitations of the study, taking into account sources of	24-25
31			potential bias or imprecision. Discuss both direction and	
32			magnitude of any potential bias.	
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36	Interpretation	#20	Give a cautious overall interpretation considering objectives,	22-24
37			limitations, multiplicity of analyses, results from similar studies,	
38			and other relevant evidence.	
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41	Generalisability	#21	Discuss the generalisability (external validity) of the study	25
42			results	
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45	Funding	#22	Give the source of funding and the role of the funders for the	26
46			present study and, if applicable, for the original study on which	
47			the present article is based	
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BMJ Open

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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Primary Subject Heading:	Public health
Secondary Subject Heading:	Nutrition and metabolism, Epidemiology
Keywords:	NUTRITION & DIETETICS, PUBLIC HEALTH, PREVENTIVE MEDICINE

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4 1 **The association between sleep duration, quality and food**
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10 3 **the Korea Youth Risk Behavior Web-based Survey**
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4 31 **ABSTRACT**

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6 32 Objective: This study examined the relationship between sleep duration and quality and food
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9 33 consumption among adolescents.

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11 34 Design: Cross-sectional study.

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14 35 Setting: Data from the 2014 and 2015 Korea Youth Risk Behavior Web-based Survey were
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16 36 used.

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19 37 Participants: Participants of 12-18 years old (n = 118,462 [59,431 males, 59,031 females])
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21 38 were selected.

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24 39 Primary and secondary outcome measures: Sleep duration, sleep quality and the frequencies
25
26 40 of fruits, soda, soft drinks, fast food, instant noodle, confectionaries, vegetables, and milk
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28 41 consumption.

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31 42 Results: Short sleep durations (< 6 h) were associated with higher soft drinks and
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33 43 confectionaries intake than longer sleep durations (9+ h) (adjusted odds ratios, AORs [95%
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35 44 confidence intervals, CIs] for ≥ 5 times a week for soft drinks, 1.73 [1.57-1.91] and
36
37 45 confectionaries, 1.32 [1.20-1.46]; $P < 0.001$). Poor sleep quality, with 7-8 h of sleep, was
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39 46 associated with a lower intake of fruits, vegetables and milk (AORs [95% CIs] for ≥ 5 times a
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41 47 week for fruits, 0.71 [0.65-0.77]; vegetables, 0.66 [0.58-0.75]; and milk, 0.80 [0.74-0.86];
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43 48 each $P < 0.001$), and higher intake of soda, soft drinks, fast food, instant noodle and
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45 49 confectionaries (AORs [95% CIs] for ≥ 5 times a week for soda, 1.55 [1.40-1.70]; soft drinks,
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47 50 1.58 [1.43-1.73]; fast food, 1.97 [1.65-2.35]; instant noodle, 1.55 [1.37-1.76]; and
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49 51 confectionaries, 1.30 [1.18-1.43]; each $P < 0.001$) than good sleep quality of the same
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51 52 duration.
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4 53 Conclusion: Short sleep durations and poor sleep quality might be associated with higher
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6 54 consumption of unhealthier foods, such as sugar-sweetened beverages, fast food, instant
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8 55 noodle and confectionaries, and associated with lower consumption of fruits, vegetables and
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10 56 milk.

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13 57 Key words: sleep duration, sleep quality, food consumption, food frequency, sugar-sweetened
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15 58 beverages, fast food, fruits, vegetables, adolescents, Korean

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4 61 **STRENGTHS AND LIMITATIONS OF THIS STUDY**

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6 62 ♦ Our study was conducted on a representative population of Korean adolescents.
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9 63 ♦ We considered numerous socio-economic status variables as confounding factors to
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11 64 investigate the independent relationship between sleep status and food consumption.
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14 65 ♦ We considered not only sleep duration but also sleep quality in explaining sleep
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16 66 status.
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19 67 ♦ Our study was based on secondary data and it has some limitations in providing
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21 68 specific information.
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24 69 ♦ Because the data were collected based on a self-reported questionnaire, the precision
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26 70 of the information may be low.
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72 INTRODUCTION

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

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

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4 95 In Korea, the prevalence of childhood obesity in males and females was 15.3% and 11.1%
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6 96 in 2016, respectively and it increased steadily since 2010.¹⁸ Lee, who performed a study
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8 97 using the Korea Youth Risk Behavior Web-based Survey (KYRBWS), reported that < 7 h of
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10 98 sleep per night in high school students was associated with increased cracker consumption.¹⁹
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13 99 Meanwhile, studies of sleep deprivation should consider not only sleep duration but also
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15 100 sleep quality. However, few studies have investigated the relationship between sleep duration,
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17 101 along with sleep quality, and the intake of various foods while also adjusting for the
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19 102 numerous confounding factors among adolescents in population-based datasets. Lee utilized
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21 103 KYRBWS data which is population-based datasets with containing numerous variables, she
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23 104 did not consider the sleep quality.¹⁹ The aim of our study was to identify the associations
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25 105 between sleep duration and quality and food intake among adolescents by using KYRBWS
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27 106 datasets. We utilized the data of the participants' level of recovery from fatigue after sleeping
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29 107 as sleep quality. We obtained consistent results for assessing the associations between sleep
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31 108 duration and quality, and the consumption of fruits, soda, soft drinks, fast food, instant noodle,
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33 109 confectionaries, vegetables, and milk with previous studies.^{13-15 19}
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40 111 **MATERIALS AND METHODS**

41 112 **Data collection**

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45 113 The Institutional Review Board (IRB) of the Centers for Disease Control and Prevention of
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47 114 Korea (KCDC) approved this study (2014-06EXP-02-P-A). Written, informed consent was
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49 115 obtained from each participant prior to the survey. Because this web-based survey was
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51 116 performed at schools and included a large number of participants, informed consent from
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4 117 their parents was exempted. This consent procedure was approved by the IRB of KCDC.
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7 118 This was a cross-sectional study using data from the KYRBWS, covering only Korea and
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9 119 using statistical methods based on a designed sampling method and adjusted, weighted values.
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11 120 The results from the KYRBWS conducted in 2014 and 2015 were analyzed. The data were
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13 121 collected by the KCDC.
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17 18 19 123 **Public Involvement**

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21 124 The survey consists of 125 questions assessing demographic characteristics and health-related
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23 125 behaviors. Korean adolescents from the 7th through 12th grade completed the self-
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25 126 administered questionnaire voluntarily and anonymously. Using 43 regions (considering
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27 127 administrative districts, geographic accessibility, the number of schools, and population size)
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29 128 and the school participants attended, the mother population was stratified into 129 levels to
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31 129 identify the sample distribution. Groups were then selected using stratified, two-stage
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33 130 (schools and classes) clustered sampling based on data from the Education Ministry.
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35 131 Sampling was weighted by statisticians, who performed a post-stratification step and
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37 132 considered non-response rates and extreme values. Detailed methods are described at the
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39 133 KYRBWS website (<https://yhs.cdc.go.kr/new/pages/main.asp>).
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43 134 Of a total of 140,103 participants, we excluded the following participants from analysis in
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45 135 this study; participants who slept less than 3 h or more than 12 h per night or who had no
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47 136 sleep records (18,594 participants); participants who did not give their age (403 participants);
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49 137 and participants without height or weight data (2,644 participants). Finally, 118,462
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51 138 participants (84.5% of total participants; 59,431 males; 59,031 females; 12 to 18 years old)
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4 139 were included in this study (Figure 1).
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9 141 **Sleep duration and quality**

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12 142 The times at which participants fall asleep and wake up were recorded to within 10 min. The
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14 143 participants were asked the time they fall asleep and the time they wake up for the 7 most
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16 144 recent days classified into weekdays and weekends. Sleep duration was calculated by
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18 145 subtracting the time they fall asleep from the time they wake up. The mean daily sleep
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20 146 duration was calculated by adding weekday and weekend sleep durations with weights of 5/7
21
22 147 and 2/7, respectively. Sleep duration was divided into five groups: < 6 h (6(-) h), ≥ 6 h and <
23
24 148 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
25
26 149 asked about their recovery from fatigue after sleeping for the 7 most recent days (quality of
27
28 150 sleep). The answer options were very good, good, moderate, poor, and very poor. We
29
30 151 regrouped answers into three groups of sleep quality to simplify the categories: good (very
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32 152 good and good), moderate, and poor (poor and very poor). We analyzed the association
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34 153 between sleep quality and food consumption only in the 7 h and 8 h groups as sleep duration
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36 154 was closely related to its quality (S1 Table).
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43 156 **Food intake frequency**

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46 157 The KCDC collected the participants' certain food intake frequencies in the 7 most recent
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48 158 days. The foods were fruits (not fruit juice), soda, soft drinks (including sports drinks, coffee-
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50 159 based beverages, and fruit drinks; excluding soda), fast food (such as pizza, hamburgers, or
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52 160 chicken), instant noodle, confectionaries, vegetables and milk. The data were divided into 4
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4 161 groups: ≥ 5 times a week, 3-4 times a week, 1-2 times a week, and 0 time a week.
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9 163 **Health examination and socio-economic status**
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12 164 The participants were asked their weight (kg) and height (cm). Obesity levels were
13
14 165 categorized into 4 groups according to the Centers for Disease Control and Prevention
15
16 166 guidelines regarding body mass index (BMI, kg/m^2) for children and teens²⁰ as follows:
17
18 167 obese, $\geq 95^{\text{th}}$ percentile; overweight, $\geq 85^{\text{th}}$ percentile and $< 95^{\text{th}}$ percentile; healthy weight, \geq
19
20 168 5^{th} percentile and $< 85^{\text{th}}$ percentile; and underweight, $< 5^{\text{th}}$ percentile. The region of residence
21
22 169 was divided into 3 groups by administrative district: large city, small city, and rural area.
23
24 170 Subjective self-assessments of health were divided into 5 groups, from very good to very bad.
25
26 171 The stress level of participants was divided into 5 groups: severe, moderate, mild, a little, and
27
28 172 no stress. Self-reported economic level was grouped into 5 levels, from the highest to lowest.
29
30 173 Parent educational level was divided into 4 groups: graduated college or higher, graduated
31
32 174 high school, graduated middle school or below, unknown, and no parents. The participants
33
34 175 who did not know the educational level of their parents or who had no parents were not
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36 176 excluded as this could have increased the number missing values for participants of relatively
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38 177 lower economic levels.
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47 179 **Statistical Analysis**
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49 180 Differences in the general characteristics according to sleep duration were calculated using
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51 181 linear regression analysis with complex sampling for age. The rate differences in relation to
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53 182 sex, region of residence, economic level, educational level of parents, stress level, food
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4 183 consumption, and quality of sleep were compared using chi-square tests with Rao-Scott
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6 184 corrections.

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8
9 185 Adjusted odd ratios (AORs) for sleep duration in relation to food consumption were
10
11 186 calculated using multinomial logistic regression analysis with complex sampling for adjusted
12
13 187 covariates (age, sex, obesity, region of residence, stress level, economic level, and
14
15 188 educational level of parents).

16
17
18 189 AORs for sleep quality in relation to food consumption were calculated using
19
20 190 multinomial logistic regression analysis with complex sampling for adjusted covariates in the
21
22 191 7 h and 8 h groups.

23
24
25 192 Two-tailed analyses were conducted. P-values lower than 0.05 were considered to
26
27 193 indicate significance, and 95% confidence intervals (CIs) were calculated. The weighted
28
29 194 values recommended by the KYRBWS were applied, and all results are presented as
30
31 195 weighted values. The results were analyzed using SPSS ver. 21.0 (IBM, Armonk, NY, USA).

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34 196

35 36 37 197 **RESULTS**

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40 198 Analysis of the general characteristics of the study participants shows that an older age, being
41
42 199 female, reporting being healthy, living in a large city, feeling severe or moderate stress, being
43
44 200 at a lower economic level, and having higher parental educational levels were associated with
45
46 201 shorter sleep durations (all P values < 0.001, Table 1).

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49 202

50
51 203 **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	118,4	27,409	29,773	30,254	20,743	10,283	
	62						
%	100	23.1	25.1	25.5	17.5	8.7	
Mean Age (year,	15.0	16.1	15.5	14.7	13.9	14.0	<0.001*
SD)	(1.7)	(1.5)	(1.6)	(1.6)	(1.5)	(1.6)	
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	

1							
2							
3							
4	Mild	43.8	39.9	45.1	45.8	44.8	42.8
5							
6	A little	16.6	10.1	14.3	18.8	23.0	21.9
7							
8	No	3.3	1.9	2.3	3.3	5.2	6.6
9							
10	Economic Level (%)						<0.001†
11							
12	Highest	8.1	7.3	6.9	7.9	9.5	11.1
13							
14	Middle High	26.5	26.7	25.5	25.7	28.1	27.7
15							
16	Middle	48.3	46.9	48.9	49.5	48.3	46.3
17							
18	Middle Low	14.0	15.2	15.2	13.9	11.8	11.9
19							
20	Lowest	3.2	3.9	3.5	3.0	2.3	3.0
21							
22							
23	Educational level,						<0.001†
24							
25	Father (%)						
26							
27	Unknown	19.7	12.8	16.0	21.9	26.6	28.5
28							
29	Middle School	2.7	2.6	2.8	2.8	2.4	2.6
30							
31	High School	29.2	28.8	30.5	30.3	27.5	26.9
32							
33	College, or over	48.4	55.8	50.8	45.0	43.6	42.0
34							
35							
36	Educational level,						<0.001†
37							
38	Mother (%)						
39							
40	Unknown	18.9	12.0	15.2	21.0	25.8	28.1
41							
42	Middle School	2.3	2.3	2.5	2.3	2.0	2.2
43							
44	High School	37.1	39.1	39.3	37.1	33.7	31.8
45							
46	College, or over	41.7	46.7	43.0	39.6	38.5	37.9
47							
48							

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

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

206

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

211 **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	

1								
2								
3								
4	Fast food (%)							<0.001*
5								
6	≥5 times a week	2.5	2.8	2.6	2.2	2.2	2.7	
7								
8	3-4 times a week	11.9	12.6	12.8	11.7	10.6	10.7	
9								
10	1-2 times a week	59.8	60.0	60.7	60.5	58.8	56.2	
11								
12	0 time a week	25.8	24.6	23.8	25.5	28.3	30.3	
13								
14	Instant noodle (%)							<0.001*
15								
16	≥5 times a week	4.6	4.4	4.3	4.8	4.8	5.4	
17								
18	3-4 times a week	17.6	15.0	16.9	18.6	19.7	18.6	
19								
20	1-2 times a week	51.6	49.8	51.9	52.4	52.6	51.3	
21								
22	0 time a week	26.2	30.8	26.9	24.2	22.9	24.6	
23								
24								
25	Confectionaries (%)							<0.001*
26								
27	≥5 times a week	10.7	12.2	11.1	9.9	9.7	9.7	
28								
29	3-4 times a week	26.4	27.1	26.9	26.4	25.5	24.4	
30								
31	1-2 times a week	45.4	44.3	45.6	45.9	45.9	45.6	
32								
33	0 time a week	17.6	16.5	16.5	17.8	18.9	20.3	
34								
35								
36	Vegetables (%)							<0.001*
37								
38	≥5 times a week	56.6	57.3	55.4	55.4	57.8	58.7	
39								
40	3-4 times a week	24.1	23.8	24.5	25.1	23.2	22.6	
41								
42	1-2 times a week	15.7	15.0	16.4	16.1	15.6	14.9	
43								
44	0 time a week	3.6	4.0	3.7	3.4	3.4	3.8	
45								
46								
47	Milk (%)							<0.001*
48								
49	≥5 times a week	41.9	36.7	38.4	42.9	48.4	50.4	
50								
51	3-4 times a week	20.0	20.3	20.4	20.2	19.6	18.2	
52								
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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

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

213

214 Short sleep durations (< 6 h) were associated with a higher intake of soft drinks (AOR
 215 [95% CI] for ≥ 5 times a week, 1.73 [1.57-1.91]; $P < 0.001$) and with a higher intake of
 216 confectionaries (AOR [95% CI] for ≥ 5 times a week, 1.32 [1.20-1.46]; $P < 0.001$). Soda and
 217 fast food intake showed an increasing trend in the group getting < 6 h of sleep. However, it
 218 was not definite. Fruits, instant noodle, vegetables, and milk intake did not show an evident
 219 association with getting < 6 h of sleep per night despite the significant association with sleep
 220 duration overall (Table 3). Unadjusted model was also analyzed (S2 Table).

221

222

223 **Table 3. Adjusted odd ratios of sleep duration for food consumption using multiple logistic regression analysis with complex sampling**
 224 **(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	

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5	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	
6							
7	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	
8							
9	Fast food (%)						<0.001*
10							
11	≥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	
12							
13	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	
14							
15	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	
16							
17							
18	Instant noodle (%)						<0.001*
19							
20	≥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	
21							
22	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	
23							
24	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	
25							
26							
27	Confectionaries (%)						<0.001*
28							
29	≥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	
30							
31	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	
32							
33	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	
34							
35	Vegetables (%)						<0.001*
36							
37							

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≥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

228 Sleep quality was also associated with the frequency of food intake. Poor quality of sleep
 229 was associated with a lower intake of fruits, vegetables, and milk (AOR [95% CI] for ≥ 5
 230 times a week for fruits, 0.71 [0.65-0.77]; vegetables, 0.66 [0.58-0.75]; and milk, 0.80 [0.74-
 231 0.86]; each $P < 0.001$). Poor sleep quality was also related with a higher intake of soda, soft
 232 drinks, fast food, instant noodle, and confectionaries (AOR [95% CI] for ≥ 5 times a week for
 233 soda, 1.55 [1.40-1.70]; soft drinks, 1.58 [1.43-1.73]; fast food, 1.97 [1.65-2.35]; instant
 234 noodle, 1.55 [1.37-1.76]; and confectionaries, 1.30 [1.18-1.43]; each $P < 0.001$, Table 4).

235

236 **Table 4. Adjusted odd ratios of quality of sleep for food consumption using multiple**
 237 **logistic regression analysis with complex sampling (Reference of food frequency = 0 time**
 238 **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*

1					
2					
3					
4	≥5 times a week	1	1.24 (1.15-1.35)	1.58 (1.43-1.73)	
5					
6	3-4 times a week	1	1.21 (1.13-1.29)	1.36 (1.26-1.46)	
7					
8	1-2 times a week	1	1.09 (1.03-1.16)	1.10 (1.03-1.18)	
9					
10	Fast food (%)				<0.001*
11					
12	≥5 times a week	1	1.26 (1.07-1.49)	1.97 (1.65-2.35)	
13					
14	3-4 times a week	1	1.28 (1.19-1.38)	1.49 (1.37-1.62)	
15					
16	1-2 times a week	1	1.11 (1.06-1.17)	1.18 (1.11-1.25)	
17					
18	Instant noodle (%)				<0.001*
19					
20	≥5 times a week	1	1.29 (1.14-1.45)	1.55 (1.37-1.76)	
21					
22	3-4 times a week	1	1.27 (1.19-1.36)	1.31 (1.22-1.42)	
23					
24	1-2 times a week	1	1.14 (1.09-1.20)	1.11 (1.05-1.18)	
25					
26	Confectionaries (%)				<0.001*
27					
28	≥5 times a week	1	1.13 (1.03-1.23)	1.30 (1.18-1.43)	
29					
30	3-4 times a week	1	1.12 (1.04-1.19)	1.08 (1.01-1.17)	
31					
32	1-2 times a week	1	1.05 (0.99-1.12)	1.00 (0.93-1.07)	
33					
34	Vegetables (%)				<0.001*
35					
36	≥5 times a week	1	0.97 (0.86-1.10)	0.66 (0.58-0.75)	
37					
38	3-4 times a week	1	1.14 (1.00-1.30)	0.78 (0.68-0.89)	
39					
40	1-2 times a week	1	1.30 (1.14-1.49)	0.98 (0.85-1.12)	
41					
42	Milk (%)				<0.001*
43					
44	≥5 times a week	1	0.89 (0.83-0.95)	0.80 (0.74-0.86)	
45					
46	3-4 times a week	1	1.01 (0.94-1.09)	0.86 (0.79-0.93)	
47					
48	1-2 times a week	1	0.99 (0.92-1.06)	0.91 (0.84-0.99)	
49					
50					
51					
52					
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54	239				* Significance at P < 0.05
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240

241 **DISCUSSION**

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

248 Along with these outcomes, sleep duration in association with sleep quality might affect
249 one's appetite and even be related to health problems such as obesity²¹ and diabetes.²² A
250 short sleep duration or poor sleep quality is associated with appetite-related hormonal
251 changes such as lower leptin and higher ghrelin levels in previous studies. These results were
252 also associated with greater energy intake and a higher BMI.^{16 17} Baron et al. reported that
253 people who fall asleep later sleep less and consume more calories than people who fall asleep
254 earlier. Moreover, consuming calories after 8 pm was associated with a higher BMI.²¹
255 Rudnicka et al. reported that shorter sleep durations in children were associated with a higher
256 prevalence of risk factors for type 2 diabetes, such as increases in the fat mass index, insulin
257 resistance and fasting glucose level.²² Meanwhile, Doo et al. reported that participants with
258 shorter sleep durations and a higher consumption of dietary antioxidant vitamins had a lower
259 risk of obesity than those with a lower consumption of dietary antioxidant vitamins.²³ In
260 summary, a short sleep duration in association with poor sleep quality could affect dietary
261 habits and appetite, which could result in health problems. Nevertheless, people who sleep for
262 shorter durations can reduce the risks of health problems by consuming foods rich in

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4 263 micronutrients such as vitamins.
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6 264 Although nutrient profiles were not available in our study, sugar-sweetened beverages
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8 265 such as soda and soft drinks, confectionaries, fast food, and instant noodle have higher energy
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10 266 levels but less micronutrients than fruits, vegetables, and milk. Sugar-sweetened beverages
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12 267 contain mainly liquid calories provided by sugars and have very few of other nutrients. A
13
14 268 potential biological mechanism for sugar-sweetened beverages leading to obesity is that
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16 269 liquid calories may result in decreased satiety, leading to the consumption of more sugar-
17
18 270 sweetened beverages with subsequent weight gain.²⁴
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22 271 Fast food, confectionaries, and instant noodle contain high energy densities, with calories
23
24 272 derived from carbohydrates and fats and with minimal amounts of other nutrients.
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26 273 Nevertheless, humans have a weak innate ability to recognize energy density, so humans fail
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28 274 to down-regulation the consumption of most of these foods accordingly.²⁵ Obesity is one of
29
30 275 the risk factors of type 2 diabetes because it is related to an increase in insulin resistance.²⁶
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32 276 In fact, previous studies reported that sugar-sweetened beverage and fast food consumption
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34 277 were associated with not only changes in bodyweight but also increased insulin resistance.²⁴
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36 278 ²⁷Hence, consumption of these foods could be a potential mechanistic link between sleep
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38 279 duration in association with quality and health problems, including obesity and type 2
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40 280 diabetes in adolescents.
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44 281 On the other hand, food intake might affect sleep duration and sleep quality. Fruits,
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46 282 vegetables, and milk are sources of vitamins and minerals. Grandner et al. reported that sleep
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48 283 symptoms such as difficulty falling asleep, difficulty maintaining sleep, non-restorative sleep,
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50 284 and daytime sleepiness were associated with a lower intake of calcium, potassium, selenium,
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52 285 vitamin C, vitamin D, alpha-carotene, and lycopene.²⁸ Although mechanistic links between
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4 286 vitamin intake and sleep quality are unclear, previous studies have verified the relationship
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6 287 between sleep duration and vitamin intake.^{29,30} In addition, Grandner et al. reported that
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8 288 sleep symptoms associated with poor sleep quality were associated with a higher intake of
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10 289 salt²⁸, and fast food and instant noodle intake are associated with salt intake. In accordance
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12 290 with the Korean food composition table, the sodium content of cooked hamburger is 498
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14 291 mg/100 g, and that of cheese pizza is 447 mg/100 g. Instant noodle seasoning contains 2,225
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16 292 mg of sodium in one portion (10.5 g).³¹ Excessive salt (and therefore sodium) intake leads to
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18 293 elevated blood pressure, whereas calcium and potassium lower blood pressure.³² Fereidoun
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20 294 et al. reported that providing 0.05 g/kg of salt to participants resulted in poor sleep quality.³³
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22 295 According to a study by Javaheri et al., poor sleep quality in adolescents was associated with
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24 296 prehypertension.³⁴ The findings of previous studies and those of our study show that
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26 297 consuming foods with high levels of salt and low levels of other micronutrients might result
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28 298 in reduced sleep durations and poor sleep quality.
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33 299 The limitations of our study are as follows. First, our study was based on data collected
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35 300 by the KYRBWS, and as secondary data, it has some limitations in providing specific
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37 301 information. For example, the dataset did not have information on nutrient contents or the
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39 302 quantity of food consumed to go along with intake frequency data. In addition, data on other
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41 303 confounding factors such as school examination periods or the timing of food intake across
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43 304 the 24 h were not present. Second, because the data were collected based on a self-reported
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45 305 questionnaire including weight and height, the precision of the information may be low such
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47 306 as BMI have possibility of underestimation.³⁵ Third, the validity of questionnaires of sleep
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49 307 duration, sleep quality and food intake frequencies is unclear. Hence, the responses on the
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51 308 questionnaire may not represent the usual sleep duration, sleep quality or food intake
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4 309 frequency of each participant. To collect usual sleep duration, sleep quality and food intake
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6 310 data, the validity and reliability of the questionnaire should be evaluated in a further study.
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8 311 Finally, because of the cross-sectional design, the causal relationship between sleep duration
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10 312 and quality and food intake frequency is unclear. Longitudinal, randomized, controlled
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12 313 studies should be conducted to determine the causal relationship.
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15 314 Nevertheless, our findings provide valuable information for the following reasons. First,
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17 315 our study was conducted on a representative population of Korean adolescents. Second, we
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19 316 considered numerous socio-economic status variables as confounding factors to investigate
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21 317 the independent relationship between sleep status and food consumption. Third, we
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23 318 considered not only sleep duration but also sleep quality in explaining sleep status. Finally,
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25 319 we investigated the intake frequency of various foods to show the relationship between sleep
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27 320 status and food consumption.
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33 322 **CONCLUSION**

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36 323 A short sleep duration was related to a higher frequency of soft drinks and confectionaries
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38 324 intake. Additionally, poor sleep quality with a normal sleep duration was related to a lower
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40 325 frequency of fruits, vegetables and milk intake, and a higher frequency of soda, soft drinks,
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42 326 fast food, instant noodle and confectionaries intake in adolescents. Hence, we demonstrate
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44 327 that short sleep durations and poor sleep quality might be associated with unhealthy food
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46 328 consumption, such as consuming more sugar-sweetened beverages, fast food, instant noodle
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48 329 and confectionaries, and fewer fruits, vegetables and milk. Further studies with a longitudinal,
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50 330 randomized, controlled design are needed to elucidate the specific causal relationship
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52 331 between sleep status and food consumption in adolescents.
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10
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13 336 survey and providing the data.
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19 338 **DATA SHARING STATEMENT**

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22 339 No additional data are available.
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27 341 **FUNDING STATEMENT**

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30 342 This research was supported by Hallym University Research Fund.
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35 344 **COMPETING INTERESTS STATEMENT**

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38 345 There are no competing interests for any author.
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44 347 **CONTRIBUTORS**

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47 348 CM wrote the manuscript. HJK designed the study. ISP performed the data processing. BP
48
49 349 performed the data interpretation. JHK analyzed the data. SS gave statistical techniques and
50
51 350 reviewed the manuscript. HGC conceptualized the study and wrote and reviewed the
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53 351 manuscript.
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4 466 **FIGURE**

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6 467 **Figure 1. A schematic illustration of the participant selection.** From a total of 140,103
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8 468 participants, those getting < 3 h or > 12 h of sleep per night or with no sleep records (n =
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10 469 18,594), without a record of their age (403) or without height or weight data (2,644) were
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12 470 excluded. The data for the 118,462 participants from whom complete records were obtained
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14 471 were analyzed.
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21 473 **SUPPLEMENTARY FILES**

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23 474 **S1 Table. Quality of sleep rates of participants according to sleep duration.** * Chi-square
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25 475 test with Rao-Scott correction, Significance at $P < 0.05$
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28 476 **S2 Table. Unadjusted odd ratios of sleep duration for food consumption using multiple**
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30 477 **logistic regression analysis with complex sampling (Reference of food frequency = 0 time**
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32 478 **a week).** * Significance at $P < 0.05$
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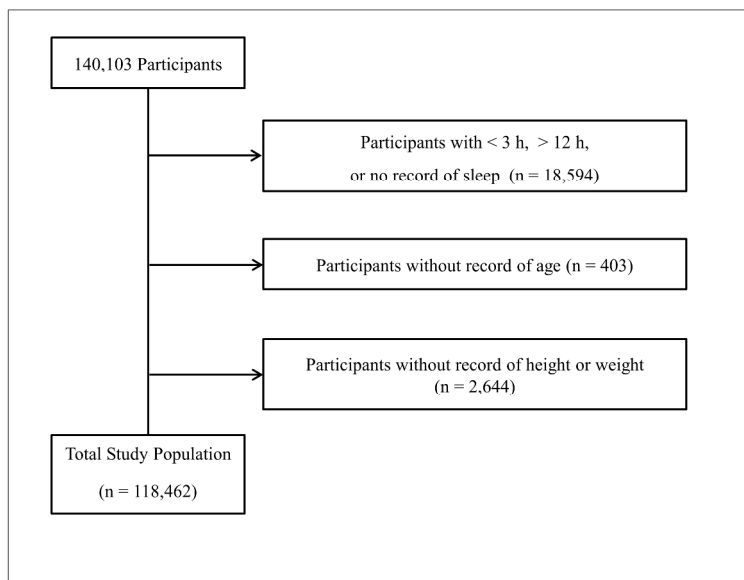


Figure 1. A schematic illustration of the participant selection.

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 (1.05-1.25)	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 (0.84-0.98)	0.98 (0.91-1.06)	1.03 (0.96-1.12)	1.05 (0.96-1.14)	1

* Significance at P < 0.05

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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

1		#7	Clearly define all outcomes, exposures, predictors, potential	8-10
2			confounders, and effect modifiers. Give diagnostic criteria, if	
3			applicable	
4				
5				
6	Data sources /	#8	For each variable of interest give sources of data and details of	8-10
7	measurement		methods of assessment (measurement). Describe	
8			comparability of assessment methods if there is more than one	
9			group. Give information separately for for exposed and	
10			unexposed groups if applicable.	
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14	Bias	#9	Describe any efforts to address potential sources of bias	9-10
15				
16				
17	Study size	#10	Explain how the study size was arrived at	8
18				
19	Quantitative	#11	Explain how quantitative variables were handled in the	8
20	variables		analyses. If applicable, describe which groupings were chosen,	
21			and why	
22				
23				
24	Statistical	#12a	Describe all statistical methods, including those used to control	10-11
25	methods		for confounding	
26				
27				
28		#12b	Describe any methods used to examine subgroups and	8-10
29			interactions	
30				
31				
32		#12c	Explain how missing data were addressed	8
33				
34				
35		#12d	If applicable, describe analytical methods taking account of	8
36			sampling strategy	
37				
38				
39		#12e	Describe any sensitivity analyses	10-11
40				
41	Participants	#13a	Report numbers of individuals at each stage of study—eg	11-12
42			numbers potentially eligible, examined for eligibility, confirmed	
43			eligible, included in the study, completing follow-up, and	
44			analysed. Give information separately for for exposed and	
45			unexposed groups if applicable.	
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49		#13b	Give reasons for non-participation at each stage	8
50				
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52		#13c	Consider use of a flow diagram	8
53				
54	Descriptive data	#14a	Give characteristics of study participants (eg demographic,	11-15
55			clinical, social) and information on exposures and potential	
56			confounders. Give information separately for exposed and	
57			unexposed groups if applicable.	
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1		#14b	Indicate number of participants with missing data for each	11-15
2			variable of interest	
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4				
5	Outcome data	#15	Report numbers of outcome events or summary measures.	11-13
6			Give information separately for exposed and unexposed	
7			groups if applicable.	
8				
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10	Main results	#16a	Give unadjusted estimates and, if applicable, confounder-	20-22
11			adjusted estimates and their precision (eg, 95% confidence	
12			interval). Make clear which confounders were adjusted for and	
13			why they were included	
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17		#16b	Report category boundaries when continuous variables were	20-22
18			categorized	
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21		#16c	If relevant, consider translating estimates of relative risk into	20-22
22			absolute risk for a meaningful time period	
23				
24	Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and	16-19
25			interactions, and sensitivity analyses	
26				
27				
28	Key results	#18	Summarise key results with reference to study objectives	22
29				
30				
31	Limitations	#19	Discuss limitations of the study, taking into account sources of	24-25
32			potential bias or imprecision. Discuss both direction and	
33			magnitude of any potential bias.	
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36	Interpretation	#20	Give a cautious overall interpretation considering objectives,	22-24
37			limitations, multiplicity of analyses, results from similar studies,	
38			and other relevant evidence.	
39				
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41	Generalisability	#21	Discuss the generalisability (external validity) of the study	25
42			results	
43				
44				
45	Funding	#22	Give the source of funding and the role of the funders for the	26
46			present study and, if applicable, for the original study on which	
47			the present article is based	
48				
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BMJ Open

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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Primary Subject Heading:	Public health
Secondary Subject Heading:	Nutrition and metabolism, Epidemiology
Keywords:	NUTRITION & DIETETICS, PUBLIC HEALTH, PREVENTIVE MEDICINE

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4 1 **The association between sleep duration, quality and food**
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10 3 **the Korea Youth Risk Behavior Web-based Survey**
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4 31 **ABSTRACT**

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6 32 Objective: This study examined the relationship between sleep duration and quality and food
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8 33 consumption among adolescents.

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11 34 Design: Cross-sectional study.

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14 35 Setting: Data from the 2014 and 2015 Korea Youth Risk Behavior Web-based Survey were
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16 36 used.

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19 37 Participants: Participants of 12-18 years old (n = 118,462 [59,431 males, 59,031 females])
20
21 38 were selected.

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23
24 39 Primary and secondary outcome measures: Sleep duration, sleep quality and the frequencies
25
26 40 of fruits, soda, soft drinks, fast food, instant noodle, confectionaries, vegetables, and milk
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28 41 consumption.

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31 42 Results: Short sleep durations (< 6 h) were associated with higher soft drinks and
32
33 43 confectionaries intake than longer sleep durations (9+ h) (adjusted odds ratios, AORs [95%
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35 44 confidence intervals, CIs] for ≥ 5 times a week for soft drinks, 1.73 [1.57-1.91] and
36
37 45 confectionaries, 1.32 [1.20-1.46]; $P < 0.001$). Poor sleep quality, with 7-8 h of sleep, was
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39 46 associated with a lower intake of fruits, vegetables and milk (AORs [95% CIs] for ≥ 5 times a
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41 47 week for fruits, 0.71 [0.65-0.77]; vegetables, 0.66 [0.58-0.75]; and milk, 0.80 [0.74-0.86];
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43 48 each $P < 0.001$), and higher intake of soda, soft drinks, fast food, instant noodle and
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45 49 confectionaries (AORs [95% CIs] for ≥ 5 times a week for soda, 1.55 [1.40-1.70]; soft drinks,
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47 50 1.58 [1.43-1.73]; fast food, 1.97 [1.65-2.35]; instant noodle, 1.55 [1.37-1.76]; and
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49 51 confectionaries, 1.30 [1.18-1.43]; each $P < 0.001$) than good sleep quality of the same
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51 52 duration.
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4 53 Conclusion: Short sleep durations and poor sleep quality might be associated with higher
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6 54 consumption of unhealthier foods, such as sugar-sweetened beverages, fast food, instant
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8 55 noodle and confectionaries, and associated with lower consumption of fruits, vegetables and
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10 56 milk.

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13 57 Key words: sleep duration, sleep quality, food consumption, food frequency, sugar-sweetened
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15 58 beverages, fast food, fruits, vegetables, adolescents, Korean

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4 61 **STRENGTHS AND LIMITATIONS OF THIS STUDY**

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6 62 ♦ Our study was conducted on a representative population of Korean adolescents.
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9 63 ♦ We considered numerous socio-economic status variables as confounding factors to
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11 64 investigate the independent relationship between sleep status and food consumption.
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14 65 ♦ We considered not only sleep duration but also sleep quality in explaining sleep
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16 66 status.
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19 67 ♦ Our study was based on secondary data and it has some limitations in providing
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21 68 specific information.
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24 69 ♦ Because the data were collected based on a self-reported questionnaire, the precision
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26 70 of the information may be low.
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72 INTRODUCTION

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

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

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4 95 In Korea, the prevalence of childhood obesity in males and females was 15.3% and 11.1%
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6 96 in 2016, respectively and it increased steadily since 2010.¹⁸ Lee, who performed a study
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8 97 using the Korea Youth Risk Behavior Web-based Survey (KYRBWS), reported that < 7 h of
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10 98 sleep per night in high school students was associated with increased cracker consumption.¹⁹
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13 99 Meanwhile, studies of sleep deprivation should consider not only sleep duration but also
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15 100 sleep quality. However, few studies have investigated the relationship between sleep duration,
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17 101 along with sleep quality, and the intake of various foods while also adjusting for the
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19 102 numerous confounding factors among adolescents in population-based datasets. Lee utilized
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21 103 KYRBWS data which is population-based datasets with containing numerous variables, but
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23 104 she did not consider the sleep quality.¹⁹ The aim of our study was to identify the associations
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25 105 between sleep duration and quality and food intake among adolescents by using KYRBWS
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27 106 datasets. We utilized the data of the participants' level of recovery from fatigue after sleeping
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29 107 as sleep quality.
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36 109 **MATERIALS AND METHODS**

39 110 **Data collection**

41 111 The Institutional Review Board (IRB) of the Centers for Disease Control and Prevention of
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43 112 Korea (KCDC) approved this study (2014-06EXP-02-P-A). Written, informed consent was
44
45 113 obtained from each participant prior to the survey. Because this web-based survey was
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47 114 performed at schools and included a large number of participants, informed consent from
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49 115 their parents was exempted. This consent procedure was approved by the IRB of KCDC.
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53 116 This was a cross-sectional study using data from the KYRBWS, covering only Korea and
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4 117 using statistical methods based on a designed sampling method and adjusted, weighted values.

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6 118 The results from the KYRBWS conducted in 2014 and 2015 were analyzed. The data were

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8 119 collected by the KCDC.

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12 121 **Patient and Public Involvement**

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16 122 The survey consists of 125 questions assessing demographic characteristics and health-related

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18 123 behaviors. Korean adolescents from the 7th through 12th grade completed the self-

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20 124 administered questionnaire voluntarily and anonymously. Using 43 regions (considering

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22 125 administrative districts, geographic accessibility, the number of schools, and population size)

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24 126 and the school participants attended, the mother population was stratified into 129 levels to

25
26 127 identify the sample distribution. Groups were then selected using stratified, two-stage

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28 128 (schools and classes) clustered sampling based on data from the Education Ministry.

29
30 129 Sampling was weighted by statisticians, who performed a post-stratification step and

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32 130 considered non-response rates and extreme values. Detailed methods are described at the

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34 131 KYRBWS website (<https://yhs.cdc.go.kr/new/pages/main.asp>).

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38 132 Of a total of 140,103 participants, we excluded the following participants from analysis in

39
40 133 this study; participants who slept less than 3 h or more than 12 h per night or who had no

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42 134 sleep records (18,594 participants); participants who did not give their age (403 participants);

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44 135 and participants without height or weight data (2,644 participants). Finally, 118,462

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46 136 participants (84.5% of total participants; 59,431 males; 59,031 females; 12 to 18 years old)

47
48 137 were included in this study (Figure 1).

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4 139 **Sleep duration and quality**

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6 140 The times at which participants fall asleep and wake up were recorded to within 10 min. The
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8 141 participants were asked the time they fall asleep and the time they wake up for the 7 most
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10 142 recent days classified into weekdays and weekends. Sleep duration was calculated by
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12 143 subtracting the time they fall asleep from the time they wake up. The mean daily sleep
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14 144 duration was calculated by adding weekday and weekend sleep durations with weights of 5/7
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16 145 and 2/7, respectively. Sleep duration was divided into five groups: < 6 h (6(-) h), ≥ 6 h and <
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18 146 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
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20 147 asked about their recovery from fatigue after sleeping for the 7 most recent days (quality of
21
22 148 sleep). The answer options were very good, good, moderate, poor, and very poor. We
23
24 149 regrouped answers into three groups of sleep quality to simplify the categories: good (very
25
26 150 good and good), moderate, and poor (poor and very poor). We analyzed the association
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28 151 between sleep quality and food consumption only in the 7 h and 8 h groups as sleep duration
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30 152 was closely related to its quality (S1 Table).
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38 154 **Food intake frequency**

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41 155 The KCDC collected the participants' certain food intake frequencies in the 7 most recent
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43 156 days. The foods were fruits (not fruit juice), soda, soft drinks (including sports drinks, coffee-
44
45 157 based beverages, and fruit drinks; excluding soda), fast food (such as pizza, hamburgers, or
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47 158 chicken), instant noodle, confectionaries, vegetables and milk. The data were divided into 4
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49 159 groups: ≥ 5 times a week, 3-4 times a week, 1-2 times a week, and 0 time a week.
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4 161 **Health examination and socio-economic status**
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6 162 The participants were asked their weight (kg) and height (cm). Obesity levels were
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8 163 categorized into 4 groups according to the Centers for Disease Control and Prevention
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10 164 guidelines regarding body mass index (BMI, kg/m²) for children and teens²⁰ as follows:
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12 165 obese, $\geq 95^{\text{th}}$ percentile; overweight, $\geq 85^{\text{th}}$ percentile and $< 95^{\text{th}}$ percentile; healthy weight, \geq
13
14 166 5^{th} percentile and $< 85^{\text{th}}$ percentile; and underweight, $< 5^{\text{th}}$ percentile. The region of residence
15
16 167 was divided into 3 groups by administrative district: large city, small city, and rural area.
17
18 168 Subjective self-assessments of health were divided into 5 groups, from very good to very bad.
19
20 169 The stress level of participants was divided into 5 groups: severe, moderate, mild, a little, and
21
22 170 no stress. Self-reported economic level was grouped into 5 levels, from the highest to lowest.
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24 171 Parent educational level was divided into 4 groups: graduated college or higher, graduated
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26 172 high school, graduated middle school or below, unknown, and no parents. The participants
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28 173 who did not know the educational level of their parents or who had no parents were not
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30 174 excluded as this could have increased the number missing values for participants of relatively
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32 175 lower economic levels.
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40 177 **Statistical Analysis**
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43 178 Differences in the general characteristics according to sleep duration were calculated using
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45 179 linear regression analysis with complex sampling for age. The rate differences in relation to
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47 180 sex, region of residence, economic level, educational level of parents, stress level, food
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49 181 consumption, and quality of sleep were compared using chi-square tests with Rao-Scott
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51 182 corrections.
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4 183 Adjusted odd ratios (AORs) for sleep duration in relation to food consumption were
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6 184 calculated using multinomial logistic regression analysis with complex sampling for adjusted
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8 185 covariates (age, sex, obesity, region of residence, stress level, economic level, and
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10 186 educational level of parents).

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13 187 AORs for sleep quality in relation to food consumption were calculated using
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15 188 multinomial logistic regression analysis with complex sampling for adjusted covariates in the
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17 189 7 h and 8 h groups.

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20 190 Two-tailed analyses were conducted. P-values lower than 0.05 were considered to
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22 191 indicate significance, and 95% confidence intervals (CIs) were calculated. The weighted
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24 192 values recommended by the KYRBWS were applied, and all results are presented as
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26 193 weighted values. The results were analyzed using SPSS ver. 21.0 (IBM, Armonk, NY, USA).

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32 195 **RESULTS**

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35 196 Analysis of the general characteristics of the study participants shows that an older age, being
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37 197 female, reporting being healthy, living in a large city, feeling severe or moderate stress, being
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39 198 at a lower economic level, and having higher parental educational levels were associated with
40
41 199 shorter sleep durations (all P values < 0.001, Table 1).

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46 201 **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	118,4	27,409	29,773	30,254	20,743	10,283	
	62						
%	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	

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3							
4	No	3.3	1.9	2.3	3.3	5.2	6.6
5							
6	Economic Level (%)						<0.001†
7							
8	Highest	8.1	7.3	6.9	7.9	9.5	11.1
9							
10	Middle High	26.5	26.7	25.5	25.7	28.1	27.7
11							
12	Middle	48.3	46.9	48.9	49.5	48.3	46.3
13							
14	Middle Low	14.0	15.2	15.2	13.9	11.8	11.9
15							
16	Lowest	3.2	3.9	3.5	3.0	2.3	3.0
17							
18							
19	Educational level,						<0.001†
20							
21	Father (%)						
22							
23	Unknown	19.7	12.8	16.0	21.9	26.6	28.5
24							
25	Middle School	2.7	2.6	2.8	2.8	2.4	2.6
26							
27	High School	29.2	28.8	30.5	30.3	27.5	26.9
28							
29	College, or over	48.4	55.8	50.8	45.0	43.6	42.0
30							
31							
32	Educational level,						<0.001†
33							
34	Mother (%)						
35							
36	Unknown	18.9	12.0	15.2	21.0	25.8	28.1
37							
38	Middle School	2.3	2.3	2.5	2.3	2.0	2.2
39							
40	High School	37.1	39.1	39.3	37.1	33.7	31.8
41							
42	College, or over	41.7	46.7	43.0	39.6	38.5	37.9
43							
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202 * Linear regression analysis with complex sampling, Significance at $P < 0.05$

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

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

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

209 **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	

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

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5 212 Short sleep durations (< 6 h) were associated with a higher intake of soft drinks (AOR
6 [95% CI] for ≥ 5 times a week, 1.73 [1.57-1.91]; $P < 0.001$) and with a higher intake of
7 213 confectionaries (AOR [95% CI] for ≥ 5 times a week, 1.32 [1.20-1.46]; $P < 0.001$). Soda and
8 214 fast food intake showed an increasing trend in the group getting < 6 h of sleep. However, it
9 215 was not definite. Fruits, instant noodle, vegetables, and milk intake did not show an evident
10 216 association with getting < 6 h of sleep per night despite the significant association with sleep
11 217 duration overall (Table 3). Unadjusted model was also analyzed (S2 Table).
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221 **Table 3. Adjusted odd ratios of sleep duration for food consumption using multiple logistic regression analysis with complex sampling**
 222 **(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*

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≥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

226 Sleep quality was also associated with the frequency of food intake. Poor quality of sleep
 227 was associated with a lower intake of fruits, vegetables, and milk (AOR [95% CI] for ≥ 5
 228 times a week for fruits, 0.71 [0.65-0.77]; vegetables, 0.66 [0.58-0.75]; and milk, 0.80 [0.74-
 229 0.86]; each $P < 0.001$). Poor sleep quality was also related with a higher intake of soda, soft
 230 drinks, fast food, instant noodle, and confectionaries (AOR [95% CI] for ≥ 5 times a week for
 231 soda, 1.55 [1.40-1.70]; soft drinks, 1.58 [1.43-1.73]; fast food, 1.97 [1.65-2.35]; instant
 232 noodle, 1.55 [1.37-1.76]; and confectionaries, 1.30 [1.18-1.43]; each $P < 0.001$, Table 4).

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234 **Table 4. Adjusted odd ratios of quality of sleep for food consumption using multiple**
 235 **logistic regression analysis with complex sampling (Reference of food frequency = 0 time**
 236 **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*

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4	≥5 times a week	1	1.24 (1.15-1.35)	1.58 (1.43-1.73)	
5					
6	3-4 times a week	1	1.21 (1.13-1.29)	1.36 (1.26-1.46)	
7					
8	1-2 times a week	1	1.09 (1.03-1.16)	1.10 (1.03-1.18)	
9					
10	Fast food (%)				<0.001*
11					
12	≥5 times a week	1	1.26 (1.07-1.49)	1.97 (1.65-2.35)	
13					
14	3-4 times a week	1	1.28 (1.19-1.38)	1.49 (1.37-1.62)	
15					
16	1-2 times a week	1	1.11 (1.06-1.17)	1.18 (1.11-1.25)	
17					
18	Instant noodle (%)				<0.001*
19					
20					
21	≥5 times a week	1	1.29 (1.14-1.45)	1.55 (1.37-1.76)	
22					
23	3-4 times a week	1	1.27 (1.19-1.36)	1.31 (1.22-1.42)	
24					
25	1-2 times a week	1	1.14 (1.09-1.20)	1.11 (1.05-1.18)	
26					
27	Confectionaries (%)				<0.001*
28					
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30	≥5 times a week	1	1.13 (1.03-1.23)	1.30 (1.18-1.43)	
31					
32	3-4 times a week	1	1.12 (1.04-1.19)	1.08 (1.01-1.17)	
33					
34	1-2 times a week	1	1.05 (0.99-1.12)	1.00 (0.93-1.07)	
35					
36	Vegetables (%)				<0.001*
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39	≥5 times a week	1	0.97 (0.86-1.10)	0.66 (0.58-0.75)	
40					
41	3-4 times a week	1	1.14 (1.00-1.30)	0.78 (0.68-0.89)	
42					
43	1-2 times a week	1	1.30 (1.14-1.49)	0.98 (0.85-1.12)	
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45	Milk (%)				<0.001*
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48	≥5 times a week	1	0.89 (0.83-0.95)	0.80 (0.74-0.86)	
49					
50	3-4 times a week	1	1.01 (0.94-1.09)	0.86 (0.79-0.93)	
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52	1-2 times a week	1	0.99 (0.92-1.06)	0.91 (0.84-0.99)	

237 * Significance at P < 0.05

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239 **DISCUSSION**

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

248 Along with these outcomes, sleep duration in association with sleep quality might affect
249 one's appetite and even be related to health problems such as obesity²¹ and diabetes.²² A
250 short sleep duration or poor sleep quality is associated with appetite-related hormonal
251 changes such as lower leptin and higher ghrelin levels in previous studies. These results were
252 also associated with greater energy intake and a higher BMI.^{16 17} Baron et al. reported that
253 people who fall asleep later sleep less and consume more calories than people who fall asleep
254 earlier. Moreover, consuming calories after 8 pm was associated with a higher BMI.²¹
255 Rudnicka et al. reported that shorter sleep durations in children were associated with a higher
256 prevalence of risk factors for type 2 diabetes, such as increases in the fat mass index, insulin
257 resistance and fasting glucose level.²² Meanwhile, Doo et al. reported that participants with
258 shorter sleep durations and a higher consumption of dietary antioxidant vitamins had a lower
259 risk of obesity than those with a lower consumption of dietary antioxidant vitamins.²³ In
260 summary, a short sleep duration in association with poor sleep quality could affect dietary

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4 261 habits and appetite, which could result in health problems. Nevertheless, people who sleep for
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6 262 shorter durations can reduce the risks of health problems by consuming foods rich in
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8 263 micronutrients such as vitamins.
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11 264 Although nutrient profiles were not available in our study, sugar-sweetened beverages
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13 265 such as soda and soft drinks, confectionaries, fast food, and instant noodle have higher energy
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15 266 levels but less micronutrients than fruits, vegetables, and milk. Sugar-sweetened beverages
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17 267 contain mainly liquid calories provided by sugars and have very few of other nutrients. A
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19 268 potential biological mechanism for sugar-sweetened beverages leading to obesity is that
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21 269 liquid calories may result in decreased satiety, leading to the consumption of more sugar-
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23 270 sweetened beverages with subsequent weight gain.²⁴
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27 271 Fast food, confectionaries, and instant noodle contain high energy densities, with calories
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29 272 derived from carbohydrates and fats and with minimal amounts of other nutrients.
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31 273 Nevertheless, humans have a weak innate ability to recognize energy density, so humans fail
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33 274 to down-regulation the consumption of most of these foods accordingly.²⁵ Obesity is one of
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35 275 the risk factors of type 2 diabetes because it is related to an increase in insulin resistance.²⁶
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37 276 In fact, previous studies reported that sugar-sweetened beverage and fast food consumption
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39 277 were associated with not only changes in bodyweight but also increased insulin resistance.²⁴
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41 278 ²⁷Hence, consumption of these foods could be a potential mechanistic link between sleep
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43 279 duration in association with quality and health problems, including obesity and type 2
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45 280 diabetes in adolescents.
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49 281 On the other hand, food intake might affect sleep duration and sleep quality. Fruits,
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51 282 vegetables, and milk are sources of vitamins and minerals. Grandner et al. reported that sleep
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53 283 symptoms such as difficulty falling asleep, difficulty maintaining sleep, non-restorative sleep,
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4 284 and daytime sleepiness were associated with a lower intake of calcium, potassium, selenium,
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6 285 vitamin C, vitamin D, alpha-carotene, and lycopene.²⁸ Although mechanistic links between
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8 286 vitamin intake and sleep quality are unclear, previous studies have verified the relationship
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10 287 between sleep duration and vitamin intake.^{29 30} In addition, Grandner et al. reported that
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12 288 sleep symptoms associated with poor sleep quality were associated with a higher intake of
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14 289 salt²⁸, and fast food and instant noodle intake are associated with salt intake. In accordance
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16 290 with the Korean food composition table, the sodium content of cooked hamburger is 498
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18 291 mg/100 g, and that of cheese pizza is 447 mg/100 g. Instant noodle seasoning contains 2,225
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20 292 mg of sodium in one portion (10.5 g).³¹ Excessive salt (and therefore sodium) intake leads to
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22 293 elevated blood pressure, whereas calcium and potassium lower blood pressure.³² Fereidoun
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24 294 et al. reported that providing 0.05 g/kg of salt to participants resulted in poor sleep quality.³³
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26 295 According to a study by Javaheri et al., poor sleep quality in adolescents was associated with
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28 296 prehypertension.³⁴ The findings of previous studies and those of our study show that
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30 297 consuming foods with high levels of salt and low levels of other micronutrients might result
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32 298 in reduced sleep durations and poor sleep quality.
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37 299 The limitations of our study are as follows. First, our study was based on data collected
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39 300 by the KYRBWS, and as secondary data, it has some limitations in providing specific
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41 301 information. For example, the dataset did not have information on nutrient contents or the
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43 302 quantity of food consumed to go along with intake frequency data. In addition, data on other
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45 303 confounding factors such as school examination periods or the timing of food intake across
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47 304 the 24 h were not present. Second, because the data were collected based on a self-reported
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49 305 questionnaire including weight and height, the precision of the information may be low such
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51 306 as BMI have possibility of underestimation.³⁵ Third, the validity of questionnaires of sleep
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4 307 duration, sleep quality and food intake frequencies is unclear. Hence, the responses on the
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6 308 questionnaire may not represent the usual sleep duration, sleep quality or food intake
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8 309 frequency of each participant. To collect usual sleep duration, sleep quality and food intake
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10 310 data, the validity and reliability of the questionnaire should be evaluated in a further study.
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12 311 Finally, because of the cross-sectional design, the causal relationship between sleep duration
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14 312 and quality and food intake frequency is unclear. Longitudinal, randomized, controlled
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16 313 studies should be conducted to determine the causal relationship.
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19 314 Nevertheless, our findings provide valuable information for the following reasons. First,
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21 315 our study was conducted on a representative population of Korean adolescents. Second, we
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23 316 considered numerous socio-economic status variables as confounding factors to investigate
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25 317 the independent relationship between sleep status and food consumption. Third, we
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27 318 considered not only sleep duration but also sleep quality in explaining sleep status. Finally,
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29 319 we investigated the intake frequency of various foods to show the relationship between sleep
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31 320 status and food consumption.
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38 322 **CONCLUSION**

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41 323 A short sleep duration was related to a higher frequency of soft drinks and confectionaries
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43 324 intake. Additionally, poor sleep quality with a normal sleep duration was related to a lower
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45 325 frequency of fruits, vegetables and milk intake, and a higher frequency of soda, soft drinks,
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47 326 fast food, instant noodle and confectionaries intake in adolescents. Hence, we demonstrate
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49 327 that short sleep durations and poor sleep quality might be associated with unhealthy food
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51 328 consumption, such as consuming more sugar-sweetened beverages, fast food, instant noodle
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53 329 and confectionaries, and fewer fruits, vegetables and milk. Further studies with a longitudinal,
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4 330 randomized, controlled design are needed to elucidate the specific causal relationship
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6 331 between sleep status and food consumption in adolescents.
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24 338 **DATA SHARING STATEMENT**
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27 339 No additional data are available.
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44 345 There are no competing interests for any author.
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49 347 **CONTRIBUTORS**
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52 348 CM wrote the manuscript. HJK designed the study. ISP performed the data processing. BP
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349 performed the data interpretation. JHK analyzed the data. SS gave statistical techniques and
350 reviewed the manuscript. HGC conceptualized the study and wrote and reviewed the
351 manuscript.

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4 466 **FIGURE**

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6 467 **Figure 1. A schematic illustration of the participant selection.** From a total of 140,103
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8 468 participants, those getting < 3 h or > 12 h of sleep per night or with no sleep records (n =
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10 469 18,594), without a record of their age (403) or without height or weight data (2,644) were
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12 470 excluded. The data for the 118,462 participants from whom complete records were obtained
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14 471 were analyzed.
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21 473 **SUPPLEMENTARY FILES**

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23 474 **S1 Table. Quality of sleep rates of participants according to sleep duration.** * Chi-square
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25 475 test with Rao-Scott correction, Significance at $P < 0.05$
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28 476 **S2 Table. Unadjusted odd ratios of sleep duration for food consumption using multiple**
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30 477 **logistic regression analysis with complex sampling (Reference of food frequency = 0 time**
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32 478 **a week).** * Significance at $P < 0.05$
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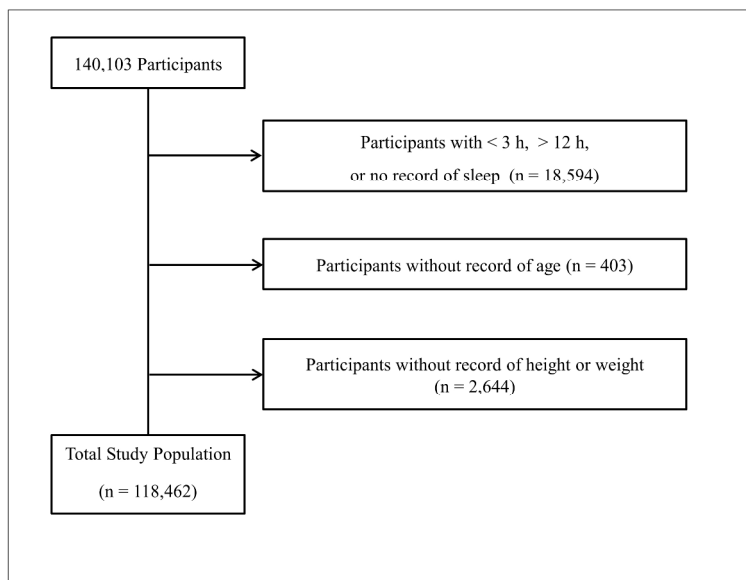


Figure 1. A schematic illustration of the participant selection.

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 (1.05-1.25)	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	

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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 (0.84-0.98)	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, Gotsche 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

1		#7	Clearly define all outcomes, exposures, predictors, potential	8-10
2			confounders, and effect modifiers. Give diagnostic criteria, if	
3			applicable	
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6	Data sources /	#8	For each variable of interest give sources of data and details of	8-10
7	measurement		methods of assessment (measurement). Describe	
8			comparability of assessment methods if there is more than one	
9			group. Give information separately for for exposed and	
10			unexposed groups if applicable.	
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14	Bias	#9	Describe any efforts to address potential sources of bias	9-10
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17	Study size	#10	Explain how the study size was arrived at	8
18				
19	Quantitative	#11	Explain how quantitative variables were handled in the	8
20	variables		analyses. If applicable, describe which groupings were chosen,	
21			and why	
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24	Statistical	#12a	Describe all statistical methods, including those used to control	10-11
25	methods		for confounding	
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28		#12b	Describe any methods used to examine subgroups and	8-10
29			interactions	
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32		#12c	Explain how missing data were addressed	8
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35		#12d	If applicable, describe analytical methods taking account of	8
36			sampling strategy	
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39		#12e	Describe any sensitivity analyses	10-11
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41	Participants	#13a	Report numbers of individuals at each stage of study—eg	11-12
42			numbers potentially eligible, examined for eligibility, confirmed	
43			eligible, included in the study, completing follow-up, and	
44			analysed. Give information separately for for exposed and	
45			unexposed groups if applicable.	
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49		#13b	Give reasons for non-participation at each stage	8
50				
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52		#13c	Consider use of a flow diagram	8
53				
54	Descriptive data	#14a	Give characteristics of study participants (eg demographic,	11-15
55			clinical, social) and information on exposures and potential	
56			confounders. Give information separately for exposed and	
57			unexposed groups if applicable.	
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1		#14b	Indicate number of participants with missing data for each	11-15
2			variable of interest	
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5	Outcome data	#15	Report numbers of outcome events or summary measures.	11-13
6			Give information separately for exposed and unexposed	
7			groups if applicable.	
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10	Main results	#16a	Give unadjusted estimates and, if applicable, confounder-	20-22
11			adjusted estimates and their precision (eg, 95% confidence	
12			interval). Make clear which confounders were adjusted for and	
13			why they were included	
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17		#16b	Report category boundaries when continuous variables were	20-22
18			categorized	
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21		#16c	If relevant, consider translating estimates of relative risk into	20-22
22			absolute risk for a meaningful time period	
23				
24	Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and	16-19
25			interactions, and sensitivity analyses	
26				
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28	Key results	#18	Summarise key results with reference to study objectives	22
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31	Limitations	#19	Discuss limitations of the study, taking into account sources of	24-25
32			potential bias or imprecision. Discuss both direction and	
33			magnitude of any potential bias.	
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36	Interpretation	#20	Give a cautious overall interpretation considering objectives,	22-24
37			limitations, multiplicity of analyses, results from similar studies,	
38			and other relevant evidence.	
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41	Generalisability	#21	Discuss the generalisability (external validity) of the study	25
42			results	
43				
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45	Funding	#22	Give the source of funding and the role of the funders for the	26
46			present study and, if applicable, for the original study on which	
47			the present article is based	
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 52 made by the [EQUATOR Network](#) in collaboration with [Penelope.ai](#)
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