Original Article

Fast food consumption alongside socioeconomic status, stress, exercise, and sleep duration are associated with menstrual irregularities in Korean adolescents: Korea National Health and Nutrition Examination Survey 2009–2013

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Background and Objectives: Menstrual irregularities in adolescents are a concern because they are considered a subjective indicator of poor physical and reproductive health. Menstrual regularity is associated with many genetic and mental health factors, and lifestyle changes can markedly influence an individual's level of menstrual regularity. Therefore, we investigated associations between lifestyle factors and menstrual irregularities in Korean adolescents by analysing data collected from the Korea National Health and Nutrition Examination Survey from 2009 to 2013. **Methods and Study Design:** A total of 463 female adolescents aged 15–18 years participated in this study; they were divided into two groups based on their menstrual regularity. We assessed the between-group differences in relation to lifestyle-related factors, fast food consumption, and diet quality. **Results:** The frequencies of consumption of soda, coffee, and fried foods were significantly higher in the irregular menstruation group. However, the nutritional quality index was not significantly different between the two groups. Logistic regression analysis revealed that younger age at menarche (odds ratio [OR]=0.69, 95% confidence interval [CI]=0.54–0.88), higher family income (OR=0.37, 95% CI=0.15–0.91), lack of exercise (OR=10.42, 95% CI=2.73–39.8), and high stress levels (OR=4.18, 95% CI=1.02–17.12) were associated with menstrual irregularity, whereas sufficient sleep (OR=0.49, 95% CI=0.39–0.60) and low frequency of eating out accounted for menstrual regularity. **Conclusions:** Lifestyle factors and stress levels influence menstrual regularity in Korean adolescents. Appropriate and accessible education on lifestyle management is required.

Key Words: adolescent, diet, life habit, menstruation, nutrition surveys

INTRODUCTION

Menarche typically occurs during puberty. After approximately 35 years of menstruation, ovarian function spontaneously degenerates, resulting in menopause. Spontaneous menstruation, a regular physiological process, affects physical and mental development and reproductive functioning. Menstruation is biologically, culturally, socially, and individually significant;[1,2] it is a general physiological phenomenon associated with pubertal maturation in female adolescents. Menstruation strongly influences behavioral patterns and triggers quantitative and qualitative changes in women. The age at menarche is gradually decreasing among Korean teenagers. Menarche occurred at an average age of 12.6 years in the 1990s; early menarche has now become very common, accounting for a rapid increase in precocious puberty. Many factors influence the regularity of menstruation and age at menarche.[3] Presently, adolescents experience more physiological

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stress than in previous years, including factors such as menstrual pain, perceived physical impurity, and premenstrual symptoms. Such stressors affect the reproductive physiology in adulthood. The Korean Society of Obstetrics and Gynecology has recommended dedicated management for teenagers.[4] Irregular menstruation, which is common in adolescents, can trigger reproductive abnormalities and become pathological.[5] The Adolescent Sexual Health Committee of the National Health Insurance Corporation, affiliated with the Korean Society of Obstetrics and Gynecology, reported that the number of women with menstruation disorders increased approximately 3.56-fold (253.0%) from 2000 (incidence rate: approximately 15 million) to 2010 (incidence rate: approximately 53 million).[6] The number of patients with hypermenorrhea, amenorrhea, scanty menstruation, oligomenorrhea, polymenorrhea, and irregular menstruation has increased by 49.3% in the past 6 years. Notably, young women in their teens and twenties account for 48.5% of patients with menstrual disorders, indicating that young women bear the principal physical and mental burdens of such disorders.[6] Increased screen time and reduced physical exercise among Korean adolescents has resulted in body weight polarization and an increase in the number of adolescents with low body weight. Moreover, increases in psychological stress caused by lifestyle changes such as heavy school examination burden and inappropriate eating habits can result in irregular menstruation. However, women with menstrual irregularities often ignore their symptoms because of shyness. Therefore, they may misuse drugs rather than appropriately treating and managing the problem.[7] Many international studies have investigated associations between menstrual irregularities and body mass index (BMI), parental educational levels, ethnicity, parental income, stress levels, smoking status, sleep duration, and nutrition.[8-11] However, most South Korean studies have investigated only premenstrual syndrome and menstrual attitudes; few have evaluated menstruation timing or menstrual regularity.[12,13]

Therefore, menstrual irregularities in Korean adolescents and the associated risk factors require attention. Governments may be able to develop health care initiatives to combat such disorders. We identified associations between lifestyle factors and menstrual irregularities in South Korean adolescents by using a large health care dataset.

METHODS

Ethics

This study was approved by the Korea Centers for Disease Control and Prevention. Additional oversight on the study design was provided by the institutional review board of a university hospital (201503-SB-012).

Study participants

We used data from the Korea National Health And Nutrition Examination Survey (KNHANES) from 2009 to 2013. The KNHANES is an ongoing, population-based, cross-sectional, nationally representative survey conducted by the Division of Chronic Disease Surveillance. The survey adheres to all principles of the Declaration of Helsinki for research involving humans, and all participants provide written informed consent. Data on demographic characteristics, diet, and health-related variables were collected through personal interviews and self-reported questionnaires. The study participants were female adolescents aged 15–18 years, which is older than the average age at menarche in Korea. The KNHANES data of female adolescents in this age group indicated menstrual irregularities. A total of 1918 female adolescents were initially enrolled based on age. Of these, 1623 participants with no history of diseases and who provided information about their menstrual cycles and regularity were selected. Subsequently, we excluded 1160 participants who refused to provide details of their age at menarche; 463 participants were finally enrolled.

Assessment of menstrual regularity

Menstrual status and regularity were assessed through a written questionnaire. The relevant questions were “Do you currently menstruate?” and “Do you have a regular menstrual cycle?” All participants were instructed to consider the preceding 3 months when answering “yes” or “no.” Those who had not experienced menstruation for more than 3 months were classified as having menstrual irregularities. We used the responses to identify participants with regular and irregular menstruation.

Demographic and physical characteristics

Demographic characteristics were determined through questionnaires, and the participants’ height, weight, and waist circumference (WC) were measured. Height was measured in intervals of 0.1 cm. Body weight was measured after correction for the 0.5-kg weight of the disposable gown. WC was measured using a tape measure, from the middle of the iliac crest to the nearest 0.1 cm. BMI was calculated as weight (kg) divided by height (m) squared (kg/m^2); all participants were accordingly categorized into three groups (<18.5: underweight; 18.5-24.9: normal; and ≥25: overweight). Household income was categorized as low, middle–low, middle–high, and high based on parental responses.

Lifestyle factors and fast food consumption

The lifestyle factors evaluated were self-responses to subjective health status, subjective body cognition, attempted dieting in the preceding year, performance of regular exercise, stress levels, average number of sleep hours per night, daily meal skipping, and frequency of eating out. Furthermore, we recorded the consumption of soda, coffee, fried foods, ramen, and hamburgers by using the food frequency method. Although alcohol consumption and smoking are common among adults, we did not explore these parameters because very few of the participants engaged in such behaviors.

Assessment of nutrient intake and diet quality

The appropriateness of nutrient intake and diet quality was assessed. We evaluated the intake of protein, calcium, phosphorus, sodium, potassium, vitamin A, niacin, and vitamin C. The index of nutritional quality (INQ) was used to estimate diet quality.[14] The INQ measures individual differences in energy intake, representing dietary nutrient content corresponding to 1000 kcal as a ratio of

the recommended intake per 1000 kcal. If INQ <1, diet quality is low.

Statistical analysis

The principal outcome variable was menstrual regularity. The participants were divided into two groups based on their levels of menstrual regularity. To identify the factors that differed between the two groups, demographic and lifestyle factors were compared by conducting an independent t test or the Mann–Whitney U test for continuous variables after confirming distribution normality. Furthermore, the equal variance test, chi-squared test, or Fisher's exact test was used for categorical variables. Subsequently, the factors that significantly differed between the two groups were subjected to univariate logistic regression analysis. These factors were included in initial multiple logistic regression and were eliminated in a stepwise manner by using backward selection. The Akaike information criterion (AIC) and Nagelkerke's R^2 statistic were used to assess the fit of the multiple logistic regression model. Sensitivity analyses were performed using the following two steps: 1) multivariate logistic regression analyses of all potential confounders, even those lacking statistical significance in univariate analysis, and 2) regression analyses of data on all participants with missing values. All statistical analyses were conducted using SPSS Version 14.0 (SPSS, Inc., Chicago, IL, USA) and R Version 3.1.3 (R Foundation for Statistical Computing, Vienna, Austria). Two-tailed $p<0.05$ was considered statistically significant.

RESULTS

Demographic characteristics

Table 1 lists the characteristics of all participants based on menstrual regularity. The mean age of the participants was similar in both groups; however, those experiencing irregular menstruation had a younger average age at menarche (11.8±1.3 vs 12.1±1.2 years; $p=0.028$). Although the differences were nonsignificant, WC and BMI were slightly higher in the irregular menstruation group (WC: 70.2±9.6 cm; BMI: 21.7±3.4 kg/m^2) than in the regular menstruation group (WC: 69.4±8.3 cm; BMI: 21.2±3.4 kg/m^2). The family income of approximately 62% of the participants in the regular menstruation group was high or middle–high, whereas that of approximately 56% of the participants in the irregular menstruation group was low or middle–low.

Lifestyle factors

Table 2 lists the answers to the questions related to lifestyle factors. The subjective health status was similar in the two groups, except for body image concerns. Approximately 92% of the participants in the irregular menstruation group considered themselves normal or fat and a significantly higher number of participants (approximately 91%) had attempted to diet to lose weight or maintain a consistent weight in the previous year than those in the regular menstruation group. Irregular menstruation was associated with higher stress levels, less regular walking (3.4% in the irregular group vs. 18.4% in the regular group; $p=0.001$), and less sleep (6.0±1.0 h vs 6.9±1.3 h; $p<0.001$). Skipping breakfast (40.4% in the irregular group vs. 28.9% in the regular menstruation group; $p=0.046$) and frequently eating out were significantly more common in the irregular menstruation group.

Nutrient intake status and dietary quality

Table 3 lists the dietary intake data. Intake of carbohydrate, phosphorus, and vitamin A differed significantly between the two groups. Intake of glucose ($p=0.042$) and phosphorus ($p=0.038$) was significantly higher and that of vitamin A ($p=0.025$) was significantly lower in the irregular menstruation group. No significant between-group differences were observed for diet quality. The intake quality of calcium and iron was less than 1 in both groups.

Fast food consumption

Figure 1 lists the intake frequencies of six typical fast foods. The consumption of soda, coffee, and fried foods differed significantly between the two groups. Approxi-

Table 1. Demographics according to regular menstruation

Variable	Regular menstruation (N=374)	Irregular menstruation (N=89)	Total (N=463)	Comparison (*p*-value)
Age (years)	15.7±1.6	15.8±1.5	15.7±1.6	0.343
Age at menarche (years)	12.1±1.2	11.8±1.3	12.1±1.2	0.028
Waist circumference (cm)	69.4±8.3	70.2±9.6	69.5±8.6	0.526
BMI (kg/m^2)	21.2±3.4	21.7±3.4	21.3±3.4	0.292
Family income				0.02
Low	54 (14.4%)	16 (18.0%)	70 (15.1%)	
Middle-low	90 (24.1%)	34 (38.2%)	124 (26.8%)	
Middle-high	117 (31.3%)	20 (22.5%)	137 (29.6%)	
High	113 (30.2%)	19 (21.3%)	132 (28.5%)	
Obesity†				0.046
Underweight	75 (20.1%)	8 (9.0%)	83 (17.9%)	
Normal	253 (67.6%)	70 (78.7%)	323 (69.8%)	
Overweight	46 (12.3%)	11 (12.4%)	57 (12.3%)	

BMI: body mass index.

†Obesity was classified using the modified World Health Organization criteria (Underweight: BMI <18.5 kg/m^2; Normal: BMI ≥18.5<25; Overweight: BMI ≥25).

Data are presented as mean±standard deviation for continuous variables and as frequency (percentage) for categorical variables.

p-values were calculated using the independent t-test or the Mann–Whitney U-test to compare continuous variables, and the chi-squared test to compare categorical variables.

Table 2. Lifestyle factors according to regular menstruation

Variable	Regular menstruation (N=374)	Irregular menstruation (N=89)	Total (N=463)	Comparison (*p*-value)
Subjective health status				0.862
Good	205 (54.8%)	51 (57.3%)	256 (55.3%)	
Normal	143 (38.2%)	33 (37.1%)	176 (38.0%)	
Bad	26 (7.0%)	5 (5.6%)	31 (6.7%)	
Subjective body image				0.077
Thin or skinny	65 (17.4%)	7 (7.9%)	72 (15.6%)	
Normal	162 (43.3%)	45 (50.6%)	207 (44.7%)	
Chubby or fat	147 (39.3%)	37 (41.6%)	184 (39.7%)	
Attempted to diet during the past 1 year				0.004
To lose weight	214 (57.2%)	58 (65.2%)	272 (58.7%)	
To keep weight constant	63 (16.8%)	23 (25.8%)	86 (18.6%)	
To gain weight	13 (3.5%)	0 (0.0%)	13 (2.8%)	
Did not try	84 (22.5%)	8 (9.0%)	92 (19.9%)	
Regular walking[†]				0.001
Yes	69 (18.4%)	3 (3.4%)	72 (15.6%)	
No	305 (81.6%)	86 (96.6%)	391 (84.4%)	
Stress level				0.001
Too much	12 (3.2%)	12 (13.5%)	24 (5.2%)	
A lot	105 (28.1%)	21 (23.6%)	126 (27.2%)	
A little	217 (58.0%)	48 (53.9%)	265 (57.2%)	
Almost never	40 (10.7%)	8 (9.0%)	48 (10.4%)	
Hours of sleep a night	6.9 ± 1.3	6.0 ± 1.0	6.7 ± 1.3	<0.001
Meals skipped daily				
Breakfast	108 (28.9%)	36 (40.4%)	144 (31.1%)	0.046
Lunch	30 (8.0%)	6 (6.7%)	36 (7.8%)	0.853
Dinner	36 (9.6%)	9 (10.1%)	45 (9.7%)	1
Eating out frequency				0.004
More than twice daily	74 (19.8%)	26 (29.2%)	100 (21.6%)	
Once daily	71 (19.0%)	25 (28.1%)	96 (20.7%)	
Five or six times a week	208 (55.6%)	38 (42.7%)	246 (53.1%)	
Fewer than four times a week	21 (5.6%)	0 (0.0%)	21 (4.5%)	

[†]Regular walking was defined as walking for over 30 min at least 5 days per week.
Data are presented as mean±standard deviation for continuous variables and as frequency (percentage) for categorical variables.
p-values were calculated using the independent t-test or the Mann–Whitney U-test to compare continuous variables and the chi-squared test to compare categorical variables.

mately 35% and 40% of the participants in the irregular menstruation group consumed soda and coffee, respectively, 4–6 times per week. The regular menstruation group consumed ramen more frequently than did the irregular group; however, the difference was nonsignificant.

Logistic regression analysis of factors influencing irregular menstruation

Table 4 shows the results of logistic regression analysis for regular menstruation. The factors that were significantly different between the two groups underwent univariate logistic regression analysis based on menstrual irregularity. The parameters deemed significant in this analysis were subsequently analysed using multiple logistic regression with AIC-based backward selection to eliminate nonsignificant terms. The final model included the demographic characteristics of age at menarche, family income, and lifestyle-related factors (regular exercise and sleep duration). Age at menarche and family income were associated with irregular menstruation. Attempts to diet to lose weight or maintain a consistent weight were associated with threefold higher odds of irregular menstruation (odds ratio [OR]=3.06, 95% confidence interval [CI]=1.26–7.38 and OR=3.74, 95% CI=1.4–10.0, respectively). Participants who did not walk regularly were significantly more likely to experience irregular menstruation (OR=10.42, 95% CI=2.73–39.8). More nighttime sleep was associated with a lower incidence of irregular menstruation (OR=0.46, 95% CI=0.35–0.60). The adjusted ORs indicated positive associations of heightened stress, skipping breakfast, and frequent eating out with irregular menstruation. Two-step sensitivity analysis yielded results that were similar to earlier results (Supplementary tables 1 and 2).

DISCUSSION

We determined the incidence of menstrual irregularities in Korean adolescents and identified the lifestyle factors influencing menstrual irregularity. Baek,[15] another cohort study,[16] and Dharmpel[17] have reported menstrual irregularities in 21%, 29%, and 30.48% of female adolescents, respectively. A lower incidence (19.2%) was observed in our study. Younger age at menarche, low family income, and a high risk of obesity were associated with menstrual irregularities, as reported by Laure[18] and Isaac.[19] Early age at menarche is closely associated with environmental and lifestyle factors.[20] One cohort study[21] recommended that lifestyle factors be managed from childhood. This would ensure normal estrogen levels, which would prevent early menarche and chronic diseases such as obesity, diabetes mellitus, and cardiovascular disease, all of which are associated with various lifestyle factors. Notably,

Table 3. Nutritional assessment according to regular menstruation

Variable	Regular menstruation (N=374)	Irregular menstruation (N=89)	Total (N=463)	Comparison (*p*-value)
Energy (kcal)	1827.21±702.20	1918.93±808.92	1907.15±723.29	0.545
Protein (g)	68.69±34.54 (1.56±0.46)†	65.10±38.43 (1.53±0.41)	68.77±35.28 (1.57±0.45)	0.922 (0.443)
Fat (g)	51.54±29.65	50.32±32.03	51.30±30.09	0.733
Carbohydrate (g)	272.44±109.91	319.35±133.75	305.69±114.91	0.042
Fiber (g)	4.87±2.77	5.51±3.53	4.99±2.94	0.115
Calcium (mg)	458.55±283.57 (0.64±0.36)	477.74±326.75 (0.62±0.35)	462.24±292.08 (0.63±0.36)	0.578 (0.793)
Phosphorous (mg)	916.31±520.89 (1.42±0.37)	1156.61±435.48 (1.61±0.34)	1003.16±452.96 (1.47±0.36)	0.038 (0.282)
Iron (mg)	11.25±7.18 (0.76±0.48)	11.58±7.01 (0.74±0.38)	11.32±7.14 (0.76±0.46)	0.696 (0.684)
Sodium (mg)	3524.29±2034.56 (1.01±1.09)	3821.15±2365.91 (1.23±2.26)	3581.35±2102.84 (1.12±1.39)	0.232 (0.405)
Potassium (mg)	2307.14±1062.07 (1.35±0.69)	2623.85±1575.58 (1.39±0.70)	2368.03±1182.86 (1.36±0.69)	0.074 (0.619)
Vitamin A (μgRAE)	687.95±721.85 (1.10±0.56)	597.71±1042.57 (1.14±0.58)	639.44±792.64 (1.10±0.57)	0.025 (0.491)
Vitamin B-1 (mg)	1.26±0.68	1.38±0.75	1.28±0.70	0.130
Vitamin B-2 (mg)	1.23±0.67	1.22±0.76	1.23±0.69	0.877
Niacin (mgNE)	14.75±7.47 (1.12±0.38)	15.41±9.88 (1.11±0.39)	14.88±7.99 (1.11±0.38)	0.481 (0.834)
Vitamin C (mg)	89.95±96.43 (1.00±1.11)	103.25±123.23 (1.20±1.27)	94.43±102.39 (1.04±1.14)	0.098 (0.155)

†In parentheses data are presented as mean±standard deviation and significance for index of nutritional quality.
Data are presented as mean±standard deviation for continuous variables.
p-values were calculated using the independent t-test or the Mann–Whitney U-test to compare continuous variables

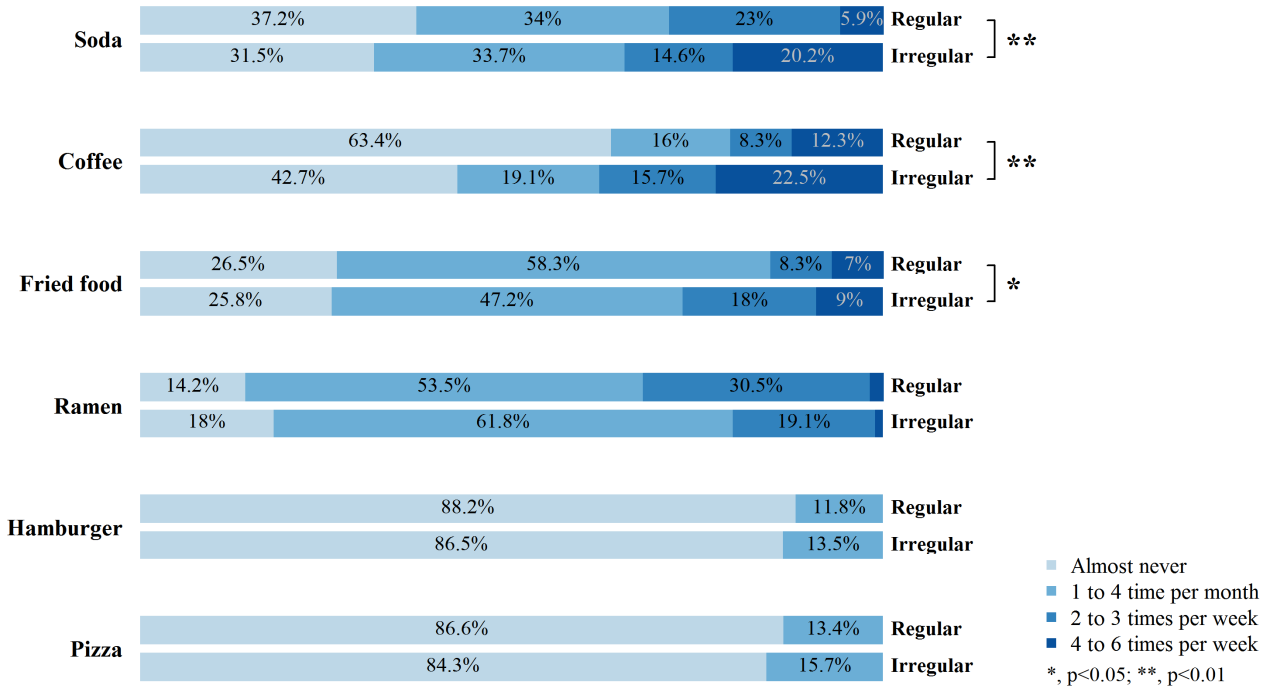

Figure 1. Fast food consumption according to regular menstruation

39.7% of our participants considered themselves chubby or fat, despite only 12.3% being overweight. The National Statistical Office of Korea reported that the major concerns of Koreans aged 15–18 years were their studies (performing well in school) first and their appearance second.[22] Consequently, excessive dieting and cosmetic surgery have become major concerns in recent years among adolescents who dislike their appearance and feel inferior.[23] In the present study, the mean BMIs of both groups were within the normal range and the obesity rates were only 12.3% in the regular menstruation group and 12.4% in the irregular menstruation group; however, 39.3% and 41.6%, respectively, considered themselves obese. In the irregular menstrual group, the percentage of underweight participants (9.0%) was significantly lower and that of participants attempting to lose weight was

Table 4. Logistic regression analysis for regular menstruation

Variable	Univariate		Multivariate	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Age at menarche	0.76 (0.62, 0.92)	0.006	0.69 (0.54, 0.88)	0.003
Family income				
Low	1.00 (Reference)		1.00 (Reference)	
Middle-low	1.28 (0.64, 2.53)	0.486	0.94 (0.41, 2.19)	0.889
Middle-high	0.58 (0.28, 1.2)	0.141	0.36 (0.15, 0.87)	0.024
High	0.57 (0.27, 1.19)	0.133	0.37 (0.15, 0.91)	0.031
Obesity†				
Underweight	0.39 (0.18, 0.84)	0.016		
Normal	1.00 (Reference)			
Overweight	0.86 (0.43, 1.76)	0.687		
Attempted to diet in the past 1 year				
To lose weight	2.85 (1.3, 6.21)	0.009	3.06 (1.26, 7.38)	0.013
To stay at existing weight	3.83 (1.61, 9.13)	0.002	3.74 (1.4, 10)	0.008
To gain weight	0 (0, Infinite)	0.983	0 (0, Infinite)	0.991
Did not try	1.00 (Reference)		1.00 (Reference)	
Regular walking‡				
Yes	1.00 (Reference)		1.00 (Reference)	
No	6.49 (1.99, 21.11)	0.002	10.42 (2.73, 39.8)	<0.001
Stress level				
Too much	5 (1.66, 15.06)	0.004	4.18 (1.02, 17.12)	0.047
A lot	1 (0.4098, 2.4401)	1	0.53 (0.17, 1.61)	0.26
A little	1.11 (0.49, 2.51)	0.81	0.8 (0.29, 2.22)	0.673
Almost never	1.00 (Reference)		1.00 (Reference)	
Hours of sleep a night	0.53 (0.43, 0.67)	<0.001	0.46 (0.35, 0.6)	<0.001
Skipping breakfast	1.67 (1.04, 2.7)	0.035	1.54 (0.85, 2.79)	0.153
Eating out frequency				
More than twice daily	1.00 (Reference)		1.00 (Reference)	
Once daily	1.00 (0.53, 1.90)	0.995	0.68 (0.31, 1.5)	0.344
Five or six times a week	0.52 (0.3, 0.91)	0.023	0.43 (0.21, 0.87)	0.018
Fewer than four times a week	0 (0, Infinite)	0.985	0 (0, Infinite)	0.986

OR: odds ratio; CI: confidence interval.
†Obesity was classified using the modified World Health Organization criteria (Underweight: BMI <18.5 kg/m^2; Normal: BMI ≥18.5<25; Overweight: BMI ≥25).
‡Regular walking was defined as walking for over 30 min at least 5 days per week.

much higher (65.2%) than that regular menstruation group. An in-depth comparative analysis is necessary to instill positive body image attitudes in adolescents and minimize inappropriate weight loss attempts.

Stress increases sympathoadrenomedullary activation in the premenstrual phase, aggravates premenstrual symptoms,[24,25] and hinders emotional development. Mari[26] examined teenage girls and reported positive associations between menstrual irregularities and depressive moods, low self-esteem, and somatic preoccupation. In the present study, the participants who exhibited excessive stress had a 4.18-fold higher risk of menstrual irregularities than did those who almost never experienced stress. Stress affects the menstrual cycle and irregular menstruation can cause stress. Stress in female adolescents markedly affects mental health and delinquency; therefore, addressing the internal and external causes of stress is crucial.

In this study, menstrual regularity had significant associations with regular exercise and sleep duration. One previous study demonstrated that appropriate aerobic exercise reduced arginine vasopressin and relieved premenstrual tension symptoms.[27] Recently, the average sleep duration of Korean adolescents decreased to 6 h, which is insufficient and 2 h less than that of adolescents in other countries on average. The consumption of fast foods and carbonated drinks and rates of obesity and skipping breakfast are increasing.[28] As reported in many studies, sleep quality deteriorates as adolescents progress through formal education. Continuous and cumulative fatigue caused by lack of sleep reduces cognitive functioning and competence in daily activities.[29,30]

In the irregular menstrual group, the dietary intake of carbohydrate and phosphorus was higher and that of calcium and iron intake was lower. Calcium and iron are essential nutrients in adolescence. Approximately 45% of skeletal growth occurs during adolescence, and for this sufficient calcium is required. Moreover, because girls aged 15–18 years who are menstruating exhibit rapid increases in iron requirement, they must be encouraged to consume appropriate foods. We documented nutrient insufficiencies in some Korean female adolescents and observed that government policies and appropriate management are required. The participants with irregular menstruation tended to consume more soda, coffee, and fried foods than did those with regular menstruation. Therefore, programs promoting healthier lifestyles with sufficient sleep, limits on eating out, a balanced diet, and regular to moderately intense physical activity during adolescence are required.

Our study adopted a cross-sectional design; therefore, we could not draw cause-and-effect conclusions. One limitation of this study was that menstrual regularity was self-reported through questionnaires. Recall bias may be present in terms of age at menarche and frequency of ex-

ercise and eating out. However, we considered the inclusion of such factors appropriate because they are relevant to menstrual irregularities. Lifestyle patterns are typically stable, and the time from menarche to questionnaire completion was short in our study. Dietary factors possibly affecting menstrual regularity were not analyzed based on food groups and dietary patterns. Furthermore, only fast food items were analyzed in detail. Future studies are recommended to validate the various dietary factors identified in the present study. One advantage of our study was the use of a large dataset, namely the KNHANES.

Conclusion

Among all the examined Korean adolescents, 19.4% reported menstrual irregularities. Age at menarche, family economic status, extent of body weight control, amount of regular exercise, stress level, and sleep duration significantly influenced menstrual regularity. Notably, menstrual regularity in female adolescents is crucial for achieving a healthy adulthood. Irregularities should be prevented by managing lifestyle factors. Further studies are required to develop family programs for the enhancement of female health that can be executed in different stages of life.

AUTHOR DISCLOSURES

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Supplementary table 1. Sensitivity analysis I: The various version of multivariate logistic regression analysis for regular menstruation

Variable	Multivariate 1		Multivariate 2	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Age at menarche	0.7 (0.55, 0.89)	0.004	0.69 (0.54, 0.88)	0.003
Family income				
Low	1.00 (Reference)		1.00 (Reference)	
Middle-low	0.93 (0.4, 2.16)	0.863	0.94 (0.41, 2.19)	0.889
Middle-high	0.34 (0.14, 0.85)	0.02	0.36 (0.15, 0.87)	0.024
High	0.37 (0.15, 0.91)	0.031	0.37 (0.15, 0.91)	0.031
Obesity†				
Underweight	0.45 (0.16, 1.26)	0.13		
Normal	1.00 (Reference)			
Overweight	0.84 (0.35, 2)	0.69		
Attempted to diet in the past 1 year				
To lose weight	2.61 (1.02, 6.63)	0.044	3.06 (1.26, 7.38)	0.013
To stay at existing weight	4.01 (1.47, 10.95)	0.007	3.74 (1.4, 10)	0.008
To gain weight	0 (0, Infinite)	0.992	0 (0, Infinite)	0.991
Did not try	1.00 (Reference)		1.00 (Reference)	
Regular walking‡				
Yes	1.00 (Reference)		1.00 (Reference)	
No	10.3 (2.72, 39.2)	<0.001	10.4 (2.73, 39.8)	<0.001
Stress level				
Too much	4.34 (1.04, 18.1)	0.044	4.18 (1.02, 17.1)	0.047
A lot	0.59 (0.19, 1.85)	0.367	0.53 (0.17, 1.61)	0.26
A little	0.86 (0.31, 2.4)	0.771	0.8 (0.29, 2.22)	0.673
Almost never	1.00 (Reference)		1.00 (Reference)	
Hours of sleep a night	0.45 (0.34, 0.59)	<0.001	0.46 (0.35, 0.6)	<0.001
Skipping breakfast	1.47 (0.81, 2.67)	0.209	1.54 (0.85, 2.79)	0.153
Eating out frequency				
More than twice daily	1.00 (Reference)		1.00 (Reference)	
Once daily	0.66 (0.3, 1.46)	0.31	0.68 (0.31, 1.5)	0.344
Five or six times a week	0.43 (0.21, 0.87)	0.018	0.43 (0.21, 0.87)	0.018
Fewer than four times a week	0 (0, Infinite)	0.986	0 (0, Infinite)	0.986

OR: odds ratio; CI: confidence interval.
†Obesity was classified using the modified World Health Organization criteria (Underweight: BMI <18.5 kg/m^2; Normal: BMI ≥18.5<25; Overweight: BMI ≥25).
‡Regular walking was defined as walking for over 30 min at least 5 days per week.
Multivariate 1 model includes all the confounders.
Multivariate 2 model was eliminated by backward selection and the same result in the Table 3.

Supplementary table 2. Sensitivity analysis II: Logistic regression analysis for regular menstruation including subjects with missing values

Variable	Univariate		Multivariate	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Age at menarche	0.79 (0.65, 0.95)	0.011	0.74 (0.6, 0.9)	0.003
Family income				
Low	1.00 (Reference)		1.00 (Reference)	
Middle-low	0.95 (0.49, 1.82)	0.869	0.82 (0.42, 1.61)	0.56
Middle-high	0.44 (0.22, 0.87)	0.019	0.37 (0.18, 0.77)	0.008
High	0.38 (0.18, 0.79)	0.01	0.34 (0.16, 0.73)	0.005
Obesity†				
Underweight	0.44 (0.21, 0.92)	0.029	0.44 (0.21, 0.93)	0.032
Normal	1.00 (Reference)		1.00 (Reference)	
Overweight	0.87 (0.44, 1.76)	0.707	0.8 (0.38, 1.67)	0.555
Attempted to diet in the past 1 year				
To lose weight	0.94 (0.54, 1.62)	0.814		
To stay at existing weight	1.13 (0.57, 2.25)	0.727		
To gain weight	0 (0, Infinite)	0.982		
Did not try	1.00 (Reference)			
Regular walking‡				
Yes	1.00 (Reference)		1.00 (Reference)	
No	2.25 (1.09, 4.65)	0.028	2.27 (1.08, 4.79)	0.031
Stress level				
Too much	1.31 (0.31, 5.62)	0.714		
A lot	1.28 (0.55, 3.01)	0.569		
A little	1.24 (0.56, 2.76)	0.601		
Almost never	1.00 (Reference)			
Hours of sleep a night	0.94 (0.8, 1.11)	0.471		
Skipping breakfast	1.08 (0.65, 1.77)	0.773		
Eating out frequency				
More than twice daily	1.00 (Reference)		1.00 (Reference)	
Once daily	0.68 (0.34, 1.35)	0.267	0.53 (0.26, 1.11)	0.093
Five or six times a week	0.75 (0.43, 1.3)	0.301	0.56 (0.31, 1)	0.051
Fewer than four times a week	0.13 (0.02, 0.98)	0.048	0.08 (0.01, 0.62)	0.016

OR: odds ratio; CI: confidence interval.
†Obesity was classified using the modified World Health Organization criteria (Underweight: BMI <18.5 kg/m^2; Normal: BMI ≥18.5<25; Overweight: BMI ≥25).
‡Regular walking was defined as walking for over 30 min at least 5 days per week.