



Research Article

Ultra-processed food intake and dietary behaviors in Korean adolescents: a cross-sectional study based on the 2019–2023 Korea National Health and Nutrition Examination Survey

Jin-A Kim¹⁾, Sim-Yeol Lee^{2),†}

¹⁾Adjunct Professor, Department of Home Economics Education, Dongguk University, Seoul, Korea

²⁾Professor, Department of Home Economics Education, Dongguk University, Seoul, Korea

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†Corresponding author:

Sim-Yeol Lee

Department of Home Economics Education, Dongguk University,
30 Pildong-ro 1-gil, Jung-gu, Seoul
04620, Korea

Tel: +82-2-2260-3413

Fax: +82-2-2260-1170

Email: slee@dongguk.edu

Objectives: This study aimed to investigate the intake of ultra-processed foods (UPF) and dietary behaviors in Korean adolescents.

Methods: This study used 24-hour dietary recall data from the Korea National Health and Nutrition Examination Survey (2019–2023). In total, 1,720 adolescents aged 12–18 years were included in this study and categorized into quartiles based on the percentage of energy intake from the UPF. Nutritional status, contributing subgroups of UPF intake, and healthy dietary practices were examined using Health Plan 2030 indicators across quartiles of UPF intake.

Results: The nutrient intake of protein, vitamins (A, B₁, B₂, niacin), and minerals (iron, potassium) was the lowest in the fourth quartile of UPF intake compared with the first quartile (P for trend < 0.001), whereas calcium intake increased across quartiles, from 47.68% in the first quartile to 58.51% in the fourth quartile (P for trend < 0.001). The main contributing subgroups to UPF intake differed across quartiles of UPF intake, and the highest contributing subgroups were ‘instant noodles and dumplings,’ ‘desserts, cakes, and ice cream,’ and ‘sauces and seasonings.’ Healthy dietary practices were the lowest in the fourth quartile (22.18%, P < 0.001), and the proportions of appropriate fat and fruit/vegetable intake were significantly lower in the higher quartiles of UPF intake (P < 0.001).

Conclusion: This study suggests that a lower UPF intake was associated with better nutritional status and healthy dietary practices in Korean adolescents. These findings provide fundamental evidence for promoting healthier food choices and balanced dietary practices.

Keywords: adolescent; ultra-processed foods; nutritional status; health behavior

INTRODUCTION

In recent years, with the development of the food industry and changes in dietary patterns, the consumption of processed foods has increased significantly, owing to their convenience. Along with this trend, the market size and consumption of ultra-processed foods (UPF) have expanded. UPF are industrially manufactured by combining food additives and ingredients derived from foods and include

breakfast cereals, sugary drinks, confectionery, meat and fish products, and various types of convenience foods [1]. Adolescents and young adults in their twenties have the highest proportion of energy intake from UPF among all age groups, and this proportion is expected to continue to increase [2].

Accordingly, several studies have raised concerns that ingredients added during processing, such as sugars, fats, and sodium, may lead to nutritional problems and adverse health effects. Diets with a high proportion of UPF are characterized by lower protein, vitamin, and mineral content and are associated with reduced overall dietary quality [3–5]. Excessive UPF intake has been reported to increase the risk of metabolic disorders such as diabetes [6], dyslipidemia [7], and metabolic syndrome [8]. In particular, a study among U.S. adolescents aged 12–19 years showed that each 5% increase in energy intake from UPF was associated with a 0.13 point decrease in cardiovascular health scores ($P < 0.001$) [9]. Similarly, a study conducted among Brazilian adolescents reported a higher prevalence of metabolic syndrome in groups with higher UPF consumption (prevalence ratio 2.5, $P = 0.012$) [10], suggesting that UPF intake may adversely affect adolescent health. In response, public health authorities in several countries recommend prioritizing unprocessed or minimally processed foods and limiting UPF consumption [11].

Adolescence is a critical period of growth with increased nutrient demands. Establishing healthy dietary habits during this stage is essential for maintaining health into adulthood. However, contemporary adolescents often rely on convenience foods, fast foods, and meals eaten away from home due to academic demands, leading to an excessive intake of sugar, sodium, and fat. Consequently, health problems such as obesity and metabolic syndrome have become increasingly prevalent among adolescents [12].

Previous studies on UPF in Korea have primarily focused on adults and have focused on consumption patterns [2, 13], associations with diet quality [14, 15], and correlations with chronic diseases, including obesity [16].

Although some studies have addressed UPF intake in relation to eating behavior [17], obesity, and metabolic syndrome among adolescents [18], studies investigating dietary behavior according to the level of UPF intake

among adolescents remain limited.

Adolescents showed the highest proportion of UPF intake across all age groups, and there is a need to implement effective management strategies to support health maintenance during this life stage.

Therefore, this study aimed to evaluate dietary behaviors according to UPF intake among Korean adolescents and provide fundamental evidence for promoting healthy food choices and balanced dietary practices.

METHODS

Ethics statement

The 2019–2023 Korea National Health and Nutrition Examination Survey (KNHANES) were approved and conducted by the Institutional Review Board of the Korea Disease Control and Prevention Agency (approval numbers: 2018-01-03-C-A, 2018-01-03-2C-A, 2018-01-03-5C-A, 2018-01-03-4C-A, 2022-11-16-R-A).

1. Study design

This was a cross-sectional analysis of raw data from the KNHANES described in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (<https://www.strobe-statement.org/>).

2. Data and participants

This study used 24-hour dietary recall data from the KNHANES conducted between 2019–2023. During this period, a total of 31,511 individuals participated in the survey. Among them, participants outside the age range of 12–18 years ($n = 29,648$), those with a daily total energy intake of < 500 kcal or $> 5,000$ kcal ($n = 29$), and those with missing values for the variables required for analysis ($n = 114$) were excluded. Consequently, 1,720 adolescents were included in the final analysis.

3. Study methods

1) Ultra-processed food intake and participant classification

The UPFs among the foods consumed by the participants were classified according to the NOVA food classification system [1], utilizing individual 24-hour dietary recall data from the KNHANES. The percentage

of energy intake from UPF was calculated, and participants were categorized into quartiles according to this percentage: Q1 (< 18.94%), Q2 (18.94%–31.48%), Q3 (31.49%–46.27%), and Q4 ($\geq$ 46.28%).

2) General characteristics

Sociodemographic variables, including sex, age, residential area, and household income level, were derived from the KNHANES questionnaires. Age groups were categorized as 12–14 and 15–18 years. Residential areas were classified into metropolitan, urban, and rural regions based on the 17 provinces and administrative divisions (*dong*, *eup*, and *myeon*). Household income was classified into four quartiles (low, lower-middle, upper-middle, and high).

3) Assessment of nutrient intake

Nutrient intake was evaluated as a percentage of the Dietary Reference Intake for Koreans (KDRI) [19]. The nutrients assessed were energy, protein, vitamins A, B₁, B₂, niacin, vitamin C, calcium, phosphorus, sodium, and iron.

4) Contribution of each ultra-processed food subgroup to ultra-processed food energy intake

UPF were categorized into 11 subgroups based on previous studies [20]: ‘instant noodles and dumplings,’ ‘breads and cereals,’ ‘desserts, cakes, and ice cream,’ ‘fast foods,’ ‘beverages,’ ‘processed fish, meats, and eggs,’ ‘savory snacks,’ ‘soy products,’ ‘dairy products,’ ‘processed fruits and vegetables,’ and ‘sauces, spreads, and condiments.’ The contribution of the UPF subgroups to the UPF energy intake in each group was assessed, and the rankings were determined accordingly.

5) Healthy dietary practices

To assess healthy dietary practices, four nutrition-related indicators from the 5th National Health Plan (HP2030) were applied [21]. The indicators were: (1) saturated fat intake < 8% of total daily energy, (2) sodium intake < 2,300 mg/day (chronic disease risk-reduction level), (3) fruit and vegetable intake $\geq$ 500 g/day, and (4) checking nutrition labels when selecting processed foods. Participants who satisfied at least two of the four indicators were classified as having healthy dietary

practices [22].

4. Statistical analysis

The SAS 9.4 (SAS Institute Inc.) was utilized for data analysis. All analyses were performed considering the complex sampling design of the KNHANE. General characteristics according to quartiles of UPF intake are presented as frequencies and percentages, and differences among quartiles were tested using the Rao-Scott chi-square test. Continuous variables are expressed as means and standard errors, and multivariate linear regression analysis was used to compare the quartiles. Logistic regression analysis was conducted to estimate odds ratios (ORs) and 95% confidence intervals (CIs) after adjusting for age, sex, residential area, and household income level. The level of statistical significance was set at P -value < 0.05.

RESULTS

1. General characteristics

The general characteristics of the participants across the UPF intake quartiles are presented in Table 1. In the first quartile, the proportion of boys (62.26%) was higher than that of girls (37.74%), whereas in the fourth quartile, the proportion of girls (51.96%) was higher (P < 0.01). The proportion of participants aged 15–18 years ranged from 56.20% to 62.27% across quartiles, showing no significant difference by age group (P = 0.388). The proportions of participants living in metropolitan, urban, and rural areas were similar across the quartiles (P = 0.667), indicating no significant differences by residential area. The proportion of participants in the lowest household income group was higher in the first quartile (12.14%) than in the fourth quartile (6.18%) (P < 0.05). However, the proportions of participants in the mid-high- and high-income groups were similar across quartiles, indicating no clear trend between UPF intake and household income levels.

2. Nutrient intake across quartiles of ultra-processed food intake

Table 2 presents nutrient intake expressed as percentages of the KDRI across quartiles of UPF intake. Protein intake was the lowest in the fourth quartile (122.47%)

Table 1. General characteristics of participants across quartiles of ultra-processed food intake

Variable	Q1 ¹⁾ (n = 430)	Q2 (n = 437)	Q3(n = 425)	Q4 (n = 428)	P-value ²⁾
Energy intake from ultra-processed food (kcal)	222.12 ± 8.14	506.15 ± 10.40	773.72 ± 17.95	1,154.77 ± 24.59	< 0.001
Sex					
Boys	262 (62.26)	227 (52.55)	225 (51.60)	206 (48.04)	0.002
Girls	168 (37.74)	210 (47.45)	200 (48.40)	222 (51.96)	
Age (year)					
12–14	210 (39.53)	233 (43.80)	217 (40.64)	201 (37.73)	0.388
15–18	220 (60.47)	204 (56.20)	208 (59.36)	227 (62.27)	
Residential area					
Metropolitan	171 (44.25)	185 (45.26)	162 (41.88)	177 (44.28)	0.667
Urban	175 (42.18)	175 (42.03)	187 (47.86)	166 (42.53)	
Rural	68 (13.57)	64 (12.70)	62 (10.26)	72 (13.19)	
Household income level					
Low	49 (12.14)	21 (5.38)	37 (7.45)	30 (6.18)	0.011
Mid-low	105 (22.22)	99 (21.66)	113 (26.26)	132 (29.18)	
Mid-high	143 (35.77)	162 (38.50)	145 (35.81)	134 (31.85)	
High	131 (29.87)	154 (34.50)	128 (30.48)	131 (32.80)	

Mean ± SE or n (weighted %).

¹⁾Levels of ultra-processed food intake were categorized into quartiles of % energy intake from ultra-processed food.²⁾P-value was calculated by the Rao-Scott χ^2 -tests.**Table 2.** % KDRI of nutrient intakes across quartiles of ultra-processed food intake

Variable	Q1 ¹⁾ (n = 430)	Q2 (n = 437)	Q3 (n = 425)	Q4 (n = 428)	P for trend ²⁾
Energy	79.39 ± 1.64	86.08 ± 1.49	87.13 ± 1.74	83.73 ± 1.66	0.140
Protein	141.48 ± 1.71	138.60 ± 1.83	133.51 ± 2.05	122.47 ± 2.11	< 0.001
Vitamin A	52.72 ± 2.02	55.73 ± 2.07	56.39 ± 2.36	45.15 ± 1.89	< 0.001
Vitamin B ₁	123.38 ± 2.60	111.22 ± 2.47	108.97 ± 3.35	85.25 ± 2.09	< 0.001
Vitamin B ₂	108.98 ± 2.48	114.75 ± 2.49	124.14 ± 3.58	125.31 ± 3.26	< 0.001
Niacin	87.17 ± 1.66	84.53 ± 1.86	82.20 ± 2.38	79.21 ± 2.62	< 0.001
Vitamin C	67.46 ± 6.57	68.89 ± 3.90	58.08 ± 3.02	58.90 ± 3.49	0.124
Calcium	47.68 ± 1.39	53.68 ± 1.40	56.61 ± 1.41	58.51 ± 1.49	< 0.001
Phosphorus	93.14 ± 1.07	90.21 ± 1.06	84.91 ± 0.99	78.65 ± 10.97	< 0.001
Sodium	199.36 ± 4.42	198.90 ± 4.18	200.33 ± 4.18	206.56 ± 4.56	0.565
Potassium	71.26 ± 1.46	69.46 ± 1.25	62.75 ± 0.91	55.25 ± 0.86	< 0.001
Iron	72.52 ± 2.61	67.68 ± 2.39	60.10 ± 1.33	56.12 ± 1.34	< 0.001

Mean ± SE.

The multiple linear regression model was adjusted for age, sex, energy intake, and total energy intake for all other nutrients.

KDRI, Dietary Reference Intake for Koreans.

¹⁾Levels of ultra-processed food intake were categorized into quartiles of % energy intake from ultra-processed food.²⁾P for trend value was calculated by the multivariate linear regression tests.

compared with the first quartile (141.48%) (P for trend < 0.001). Intakes of vitamin A, vitamin B₁, niacin, potassium, and iron were also the lowest in the fourth quartile compared with the first quartile (P for trend < 0.001). Vitamin C and sodium did not differ significantly across quartiles. In contrast, calcium intake increased across

quartiles, from 47.68% in the first quartile to 58.51% in the fourth quartile (P for trend < 0.001).

3. Contribution of each ultra-processed food subgroup to ultra-processed food energy intake

Table 3 presents the contribution of each UPF subgroup

Table 3. Contribution of each UPF subgroup to total UPF energy intake across quartiles of ultra-processed food intake

Rank	Q1 ¹⁾ (n = 430)		Q2 (n = 437)		Q3 (n = 425)		Q4 (n = 428)	
	Group	weighted %	Group	weighted %	Group	weighted %	Group	weighted %
1	Desserts, cakes, and ice cream	2.29 ²⁾	Desserts, cakes, and ice cream	5.52	Instant noodles and dumplings	9.23	Instant noodles and dumplings	18.57
2	Sauces, spreads, and condiments	2.24	Instant noodles and dumplings	4.99	Desserts, cakes, and ice cream	9.06	Desserts, cakes, and ice cream	13.63
3	Processed fish, meats, and eggs	1.74	Processed fish, meats, and eggs	3.43	Processed fish, meats, and eggs	4.58	Processed fish, meats, and eggs	7.63
4	Beverages	1.41	Sauces, spreads, and condiments	2.14	Beverages	3.86	Beverages	6.43
5	Instant noodles and dumplings	1.22	Dairy products	2.14	Sauces, spreads, and condiments	3.34	Sauces, spreads, and condiments	3.67
6	Dairy products	1.03	Bread and cereals	1.53	Dairy products	2.53	Dairy products	3.65
7	Bread and cereals	0.66	Beverages	1.43	Bread and cereals	2.52	Bread and cereals	3.05
8	Savory snacks	0.38	Savory snacks	1.36	Savory snacks	2.01	Savory snacks	2.58
9	Soy products	0.15	Fast foods	0.30	Fast foods	0.60	Fast foods	1.17
10	Processed fruits and vegetables	0.04	Soy products	0.27	Soy products	0.33	Soy products	0.32
11	Fast foods	0.03	Processed fruits and vegetables	0.07	Processed fruits and vegetables	0.05	Processed fruits and vegetables	0.08

UPF, ultra-processed food.

¹⁾Levels of ultra-processed food intake were categorized into quartiles of % energy intake from ultra-processed food.²⁾Relative contribution (weighted %) of each ultra-processed food subgroup to total ultra-processed food energy intake.

to UPF energy intake for each group. The cumulative contribution of the top three subgroups accounted for nearly 40% of UPF energy intake in the fourth quartile. The main subgroups contributing to UPF intake differed by group; the highest contributing subgroup was ‘desserts, cakes, and ice cream’ in both the first and second, and ‘instant noodles and dumplings’ in both the third and fourth quartiles.

‘Fast food’ showed low contribution (11th) in the first quartile, but high (9th) in the fourth quartile. ‘Instant noodles and dumplings’ also indicated a comparatively low contribution (5th) in the first quartile and high (1st) in the fourth quartile.

4. Healthy dietary practices across quartiles of ultra-processed food intake

Table 4 shows the prevalence of healthy dietary practices across the quartiles of UPF intake. The proportion of participants satisfying the recommended saturated fat intake was 56.72% in the first quartile and 28.65% in the

fourth quartile ($P < 0.001$). Similarly, the proportion satisfying the fruit and vegetable intake recommendation (≥ 500 g/day) was 21.31% in the first quartile and 3.86% in the fourth quartile ($P < 0.001$). The proportion of adolescents satisfying the criteria for appropriate fat, fruit, and vegetable intake was lower in the high UPF intake group. Overall, healthy dietary practices were also the lowest in the fourth quartile (22.18%) compared to the first quartile (47.27%) ($P < 0.001$). Table 5 shows the ORs (95% CIs) for healthy dietary practices across quartiles of UPF intake. After adjusting for age, residential area, and household income level (Model 2), the ORs for practicing healthy dietary practices were 0.729 (95% CI: 0.535–0.994) in Q2, 0.425 (95% CI: 0.308–0.587) in Q3, and 0.261 (95% CI: 0.184–0.371) in Q4 compared with Q1 (P for trend < 0.001).

DISCUSSION

This study analyzed UPF intake, key contributing sub-

Table 4. Proportion of healthy dietary practices across quartiles of ultra-processed food intake

Characteristics	Q1 ¹⁾ (n = 430)	Q2 (n = 437)	Q3 (n = 425)	Q4 (n = 428)	P-value ²⁾
Adequate fat intake	248 (56.72) ³⁾	210 (51.55)	159 (38.14)	115 (28.65)	< 0.001
Sodium intake < CDRR ⁴⁾	178 (43.65)	154 (35.93)	144 (33.44)	157 (37.87)	0.041
Fruit & vegetable intake ≥ 500 g/day	97 (21.31)	62 (15.50)	43 (9.26)	18 (3.86)	< 0.001
Checking nutrition label information in food selection	105 (25.32)	106 (25.89)	119 (28.46)	119 (28.19)	0.720
Score ≥ 2 ⁵⁾	205 (47.27)	156 (38.33)	126 (29.78)	90 (22.18)	< 0.001

n (weighted %).

CDRR, chronic disease risk reduction intake.

¹⁾Levels of ultra-processed food intake were categorized into quartiles of % energy intake from ultra-processed food.

²⁾P-value was calculated by the Rao-Scott χ^2 -tests.

³⁾n (weighted %) indicates the percentage of participants practicing a healthy diet to the total number of participants, calculated using PROC SURVEY-FREQ.

⁴⁾The CDRR refers to the minimum intake of nutrients that reduces the risk of chronic disease in a healthy population.

⁵⁾The criteria for satisfying healthy dietary practices were for individuals to follow at least 2 out of the 4 specific guidelines.

Table 5. The ORs (95% CIs) of healthy dietary practices across quartiles of ultra-processed food intake

Characteristics	Q1 ¹⁾ (n = 430)	Q2 (n = 437)	Q3 (n = 425)	Q4 (n = 428)	P-value ²⁾
Model 1 ³⁾	1.000 (Ref)	0.723 (0.533–0.981)	0.438 (0.319–0.603)	0.286 (0.204–0.400)	< 0.001
Model 2 ⁴⁾	1.000 (Ref)	0.729 (0.535–0.994)	0.425 (0.308–0.587)	0.261 (0.184–0.371)	< 0.001

ORs (95% CIs).

ORs, odds ratios; CIs, confidence intervals.

¹⁾Levels of ultra-processed food intake were categorized into quartiles of % energy intake from ultra-processed food.

²⁾P for trend value was calculated by the logistic regression tests.

³⁾Model 1 is unadjusted.

⁴⁾Model 2 is adjusted for sex, age, residential area, and household income level.

groups, and healthy dietary practices among Korean adolescents using 2019–2023 KNHANES data. Girls were more prevalent in higher UPF intake groups ($P < 0.05$). A prior study also found more girls in the highest UPF intake group ($P < 0.001$) [17], consistent with this study's findings. Sex should therefore be considered in future nutrition education studies.

The group with lower UPF intake showed a higher % KDRI for protein, vitamins (A, B₁, B₂, and niacin), and minerals (iron and potassium). Calcium intake rose with UPF consumption, while sodium intake showed no significant differences. Similar results were observed in Korean adolescents [23]. These findings indicate that a lower intake of UPF is associated with better nutritional status. Calcium intake increased as the proportion of energy intake from UPF increased, which is consistent with the findings of a previous study that evaluated UPF consumption and diet quality [23]. A study conducted in Brazil [24] reported that higher calcium intake, unlike other micronutrients, was attributable to the high calci-

um content of UPF, such as fast foods, including cheese and sugar-sweetened dairy beverages. Similarly, a study of Korean adults [25] showed that beverages were the major contributors to calcium intake in the UPF group.

Sodium showed no significant differences among the groups, which is consistent with a previous study on Korean adolescents that examined eating behavior according to UPF consumption [23, 26]. Similarly, a study [27] conducted among young adults reported no significant differences in sodium intake between groups. This result was associated with a greater sodium intake from seasonings used in cooking than from processed foods in Korea [23].

In this study, the highest contributing subgroups to UPF intake were 'instant noodles and dumplings,' 'sweets, cakes, and ice cream,' and 'processed fish, meats, and eggs.' This agrees with earlier findings in Korean adolescents [26].

Healthy dietary practices were assessed using four HP2030 indicators: appropriate fat intake, sodium

intake below the chronic disease risk reduction level, consumption of ≥ 500 g/day of fruits and vegetables, and nutrition labeling [22]. In this study, the proportion of adolescents satisfying the criteria for appropriate fat and fruit/vegetable intake decreased with higher levels of UPF intake. Similarly, a study in older Korean adults [28] reported significant decreases in appropriate fat intake ($P < 0.05$) and adequate fruit and vegetable intake ($P < 0.05$) across increasing UPF quartiles, consistent with this study. Nutrition label use did not differ among adolescents. Using labels could encourage more informed, healthier food choices. Higher UPF consumption was associated with lower odds of practicing healthy dietary practices, as shown by the decreasing adjusted ORs across quartiles (Q2: 0.73, Q3: 0.43, Q4: 0.28; P for trend < 0.001). These findings indicate that adolescents with higher UPF intake are significantly less likely to adhere to healthy dietary practices.

This study found that a lower UPF intake among Korean adolescents was associated with better nutritional status and healthy dietary practices. While UPF offers convenience, limiting intake supports a balanced diet. Therefore, targeted nutrition education is needed to support healthier food choices. These findings provide important evidence for developing effective nutrition education and national dietary policies for Korean adolescents.

Limitations

This study had some limitations. Dietary intake was based on a single 24-hour recall, which may not fully represent usual patterns. The NOVA classification system, developed in a Western context, may not perfectly capture the characteristics of all Korean foods, and some degree of subjective judgment by researchers cannot be excluded. Despite these limitations, this study is meaningful in that it analyzed data from the nationally representative KNHANES and provided valuable evidence on dietary behaviors associated with UPF intake among Korean adolescents.

Conclusion

This study aimed to investigate the intake of UPF and dietary behaviors in Korean adolescents. This study demonstrated that a lower UPF intake among Korean

adolescents was associated with better nutritional status and healthy dietary practices. The main contributing subgroups to UPF intake differed across quartiles of UPF intake, and the highest contributing subgroups were 'instant noodles and dumplings,' 'desserts, cakes, and ice cream,' and 'sauces and spreads, and condiments.' These findings suggest that considering both nutrient content and degree of processing when selecting foods may help adolescents adopt healthier and more balanced diets.

CONFLICT OF INTEREST

There are no financial or other issues that might lead to a conflict of interest.

FUNDING

None.

DATA AVAILABILITY

Data supporting the findings of this study are openly available from the KNHANES at <https://knhanes.kdca>.

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