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Research Article

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Total sugar intake and its contributed foods by age groups in Koreans using the 8th (2019–2021) Korea National Health and Nutrition Examination Survey: a cross-sectional study

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

ABSTRACT

Objectives: This study was conducted to investigate the status of total sugar intake and contributing foods in Korea according to age groups.
Methods: This study used 24-hour dietary recall data from the 8th Korea National Health and Nutrition Examination Survey (2019–2021) to investigate the nutritional and total sugar intake status among Koreans. A total of 18,338 research participants (≥3 years old) were included in this study. To analyze the types of foods contributing to total sugar intake, these foods were categorized into 15 types. Moreover, we examined the total sugar intake and ranked the most consumed foods by age groups (3–11 years, 12–18 years, 19–34 years, 35–49 years, 50–64 years, over 65 years). A survey procedure was employed for statistical analysis.
Results: The energy intake ratio from total sugars was approximately 12%–15%, which was within the recommended range. However, the proportion of individuals consuming total sugar exceeding 20% of their total caloric intake is nearly 20%, raising concerns about excessive sugar consumption. Furthermore, the percentage of participants whose intake of sugar from processed foods exceeded 10% of their total calories was highest in the 12–18 age group at 37.1%, followed by the 3–11 age group at 35.2%, and the 19–34 age group at 34.0%. Carbonated drinks, cola, and cider were the primary foods consumed by children and adolescents (3–18 years old) and young adults (19–34 years old). For middle-aged and older adults, mixed coffee with sugar and cream was a prominent contributor to sugar intake.
Conclusions: This study investigated sugar consumption patterns among Koreans, finding the principal foods contributing to this intake. Identifying these contributors is pivotal, given their potential impact on public health.

Keywords: dietary sugars; processed foods; carbonated drinks; Koreans

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Data Availability
The data that support the findings of this study are openly available in KNHANES at https://knhanes.kdca.go.kr/knhanes/sub03/sub03_02_05.do.

INTRODUCTION

Monosaccharides and disaccharides available in foods are collectively known as sugars [1]. Typically, naturally occurring sugars are found in foods, while added sugars, such as syrups, corn syrups, and fruit juice concentrates, are incorporated during food processing or preparation [2]. The intake of naturally occurring or processed sugars from foods provides energy sources through metabolic processes in the body. However, excessive sugar consumption increases the risk of dental caries [3,4]. Numerous studies have documented a heightened prevalence of obesity [5-7] and an elevated risk of metabolic syndrome, potentially leading to diabetes mellitus or cardiovascular diseases [8-10]. However, the direct association between excessive sugar intake and these health issues remains a subject of debate [11,12]. Consequently, many countries recommend reducing sugar consumption to curb the rise in health problems such as obesity and other non-communicable diseases. Specifically, the Dietary Reference Intakes for Koreans (KDRIs) advises limiting total sugar consumption to 10%–20% of total energy intake, with a particular emphasis on restricting added sugars to ≤ 10% of total energy intake [13]. In 2015, the World Health Organization (WHO) recommended reducing daily free sugars intake to < 10% of total calorie intake [14]. Free sugars are defined as sugars added to foods during processing or preparation and include glucose, fructose, and maltose, which can be found in honey, syrups, fruit juices, and fruit juice concentrates.

Over the past decade (2010–2020), the average daily total sugar intake among Koreans was recorded at 70.0 g in 2010, increased to 76.9 g in 2015, and then decreased to 57.2 g by 2020, indicating that intake peaked in 2015 before gradually declining [15]. According to data from the 7th Korea National Health and Nutrition Survey (KNHANES VII-3) in 2018, the average daily sugar consumption was 58.9 g. When compared to other countries, with daily intakes of 106 g in the US, 110 g in Canada, and 75.1–107.1 g in the UK, Korean sugar consumption does not appear relatively excessive [16]. Previous research indicates that total sugar consumption in Korea remains below the levels advised by the KDRIs, though excessive intake primarily derives from added sugars, for which the KDRIs provide separate guidelines. Investigating the intake patterns of sugars, particularly added sugars, in Korea is essential. A study on energy derived from processed foods, excluding milk, revealed a steady increase in added sugar intake from 8.28% in 2010 to 9.92% in 2016. Processed drinks are a significant source of sugar, with high consumption found in fruit or vegetable juices and dairy-based products among children aged 1–5, and carbonated drinks and coffee among individuals aged 6–49 and those over 50, respectively [17]. Therefore, although sugar intake in Korea does not seem to raise concerns currently, as it is below the recommended levels. Consistent monitoring of sugar consumption is crucial due to rising intake from processed foods. Furthermore, it is necessary to explore the primary sources of sugar consumption across different age groups and to conduct targeted research and policy development for specific demographics.

This study aims to analyze the status of total sugar intake by age group and determine food type and commonly consumed foods contributing to sugar intake using comprehensive data from the food intake survey of KNHANES (2019–2021). Subdividing the subjects by age would provide essential data that can be used to determine priorities and future directions for establishing public health policies related to sugar intake.

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METHODS

Ethics statement

The informed written consent was obtained from each participant. The study protocol was approved by the Institutional Review Board of Korea Disease Control and Prevention Agency (approval number: 2018-01-03-C-A, 2018-01-03-2C-A, 2018-01-03-5C-A).

1. Data and participants

This study extracted source data from the 8th KNHANES (2019–2021), focusing on household confirmation surveys and nutrition examinations to investigate the status of sugar intake in Korea. From the total of 22,559 participants in the 8th KNHANES (2019–2021), those aged ≥ 3 years, marking the onset of food preference development, were included. Participants with missing food intake values or total energy intakes of < 500 kcal/day or > 5,000 kcal/day were excluded. Consequently, data from 18,338 participants (6,907 in 2019, 5,628 in 2020, and 5,803 in 2021) were analyzed. Participants were categorized by age according to a life cycle: children (3–11 years: n = 1,879), adolescents (12–18 years: n = 1,149), young adults (19–34 years: n = 2,645), adults (35–49 years: n = 3,791), middle-aged adults (50–64 years: n = 4,333), and older adults (≥ 65 years: n = 4,541).

2. Study methods

1) General characteristics

Variables of the household confirmation survey were extracted and used to examine the general characteristics of participants. Age was based on the international age system, and sex (male/female), area of residence (dong/eup·myeon), and marital status (single·N.A./married) were identified from data of household confirmation survey. Marital status data, specifically not included in total survey (≥ 1 year of age), were collected only from individuals aged ≥ 19 years.

2) Status of nutrient and sugar intake

To assess macronutrient and sugar intake levels in the participants, a 24-hour dietary recall per person from the food intake survey was employed. Furthermore, survey data were utilized to evaluate the status of the top 20 commonly consumed foods that significantly contribute to total sugar intake across different age groups. Nutrient intake per person was analyzed using data from the KNHANES, and an optimal energy intake ratio was calculated to determine macronutrient and sugar intake levels. The KDRIs [13] provide a reference for added sugar intake in addition to total sugar intake. Added sugar intake was determined by calculating the proportion of sugar intake and optimal energy intake from processed foods, incorporating sugars added during food preparation or processing. The category of processed foods used to ascertain added sugar intake includes all food types except fruits and raw food products (e.g., plain milk, unprocessed agricultural, forestry, livestock, and fishery products such as grains, vegetables, and meats). Since fruit, predominantly high in fructose, is a major contributor to sugar intake, it was analyzed separately, rather than being grouped with raw food products.

The KNHANES utilizes the 3rd food code to classify food groups by grouping any food with identical raw materials into a single category. However, the diversity of food intake types consumed should also be considered, even when the raw materials are the same.

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For analyzing food types contributing to sugar intake, the 1st food code was employed to reclassify foods collected from the survey into 15 distinct food groups. These foods were categorized based on prior studies [17,18] and the classification standards of the food code [1]. Initially, foods high in sugars were categorized (e.g., fruits, bread/confectionery/rice cakes, sugar or sugar-processed products, and carbonated drinks). Foods with a clear classification of food groups were also categorized (e.g., pickled food and convenience food). The remaining foods, which were not previously classified, were divided into raw food products (plain milk and unprocessed agricultural, forestry, livestock, and fishery products: grains, vegetables, meats, fish, and eggs, excluding fruit types) and processed agricultural, forestry, livestock, and fishery products (such as processed meat products, bacon, sausages, tofu, processed egg products, and beverages), based on their processing status. Processed food is defined as any prepared, processed, or pre-packaged food that involves adding food or food additives to food ingredients, altering the original form, combining altered forms, or adding food or food additives to these combinations [1]. Among the unclassified foods, dishes such as Bibimbap and Gimbap were categorized under prepared foods. Considering the potential addition of sugar during preparation and processing, this group was included in the processed food category for the analysis of added sugars. Foods that did not fit any of the classifications were assigned to other food types. **Table 1** lists the 15 food groups and the foods included in each group.

3. Statistical analysis

The SAS 9.4 (SAS Institute Inc., Cary, NC, USA) was utilized for data analysis. Given that KNANES employs a complex sampling design, variables such as variance estimation (KSTRATA), clusters (PSU), and weight values for each survey category (WT_NTR) were incorporated into the analysis. The survey procedure calculated results by age group. A *P*-value of < 0.05 was deemed statistically significant. PROC SURVEYREG was employed to assess differences in sugar intake across age groups. For the post hoc test, the Bonferroni test was applied.

Table 1. Classification status of 15 food types

Categories	Food types	Consist of
Unprocessed foods	Raw food products	Plain milk and unprocessed agricultural, forestry, livestock, and fishery products such as grains, vegetables, meats, fish, and eggs (excluding fruit types)
	Fruit types	Foods that consist of edible fruits, whether consumed fresh or preserved by drying.
Processed foods	Processed agricultural, forestry, livestock, and fishery products	Processed products such as bacon, sausages, processed meat products, tofu, processed egg products, alcoholic beverages
	Convenience food types	Cereals, noodles, instant foods, dumplings, etc.
	Bread, confectionery, or rice cakes types	Bread types such as cakes, donuts, snacks, cookies, rice cakes
	Sugar or sugar-processed product types	Sugar, jams, honey, candies, chocolates, jellies, gum, etc.
	Tea, juice, or isotonic drink types	All beverages, excluding carbonated and coffee beverages
	Coffee drink types	Whole bean coffee, mixed coffee with sugar and cream, canned coffee, etc.
	Carbonated drink types	Coke, sprite, flavored carbonated drinks, energy drinks, sparkling water, etc.
	Processed dairy product types	Processed milk, fermented dairy products, butter, cheese, etc.
	Frozen dessert types	Ice cream, sherbet, etc.
	Seasoning types	Sauces, salts, sauces, spices, etc.
	Pickled food types	Kimchi, various salted seafood, etc.
	Cooked food types	Cooked foods like bibimbap, kimbap, fried rice, etc.
	Other food types	Enzymes, propolis, protein supplements, etc.

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RESULTS

1. General characteristics

Table 2 demonstrates the general characteristics of the participants. The mean age was 7.2 years in children (3–11 years), 14.8 years in adolescents (12–18 years), 26.6 years in young adults (19–34 years), 42.4 years in adults (35–49 years), 57.3 years in middle-dated adults (50–64 years), and 73.1 years in older adults (≥ 65 years). There were 3.6% and 5.0% more male participants than female participants in the children (3–11 years) and adolescent (12–18 years) age groups, respectively. In contrast, female participants outnumbered male participants in all other age categories. Notably, the majority of participants across all age groups resided in dong ($P < 0.001$).

2. Intake of essential nutrients

In **Table 3**, the mean daily energy intake per participant was highest among 19–34-year-old adults (2,002.4 kcal) but lowest among ≥ 65-year-old adults (1,563.9 kcal). The percentage of energy intake from carbohydrate, protein, and fat for each age group was in line with the adequate energy intake ratio in the KDRIs (55–65:7–20:15–30), exhibiting a significant difference between age groups. However, the percentage of energy intake from carbohydrates was slightly lower in 19–34-year-old adults (54.0%) compared to the reference intake and other age groups, whereas it was somewhat higher in adults aged 65 years and older (67.3%) relative to the reference intake.

3. Total sugar intake and major food sources

Table 4 shows the distribution of mean daily total sugar intake per person and the percentage of energy intake. A difference in total sugar intake according to age groups was significant. Total sugar intake was highest among 12–18-year-old adolescents (66.4 g), followed by

Table 2. General characteristics of research subjects

Variables	3–11 years (n = 1,879)	12–18 years (n = 1,149)	19–34 years (n = 2,645)	35–49 years (n = 3,791)	50–64 years (n = 4,333)	Over 65 years (n = 4,541)	*P*-value
Age	7.2 ± 0.1	14.8 ± 0.1	26.6 ± 0.1	42.4 ± 0.1	57.3 ± 0.1	73.1 ± 0.1	< 0.001
Sex							< 0.001
Male	973 (51.8)	607 (52.5)	1,221 (45.8)	1,616 (42.6)	1,830 (42.2)	1,944 (43.4)	
Female	906 (48.2)	542 (47.5)	1,424 (54.2)	2,175 (57.4)	2,503 (57.8)	2,597 (56.6)	
Residential district							< 0.001
-Dong	1,586 (88.5)	954 (87.4)	2,331 (91.6)	3,192 (88.2)	3,427 (83.2)	3,150 (73.0)	
-Eup/myeon	293 (11.5)	195 (12.6)	314 (8.4)	599 (11.8)	906 (16.8)	1,391 (27.0)	
Marital status (19 year+)							< 0.001
Single			2,031 (77.3)	479 (12.7)	174 (4.0)	39 (0.9)	
Married			614 (22.7)	3,312 (87.3)	4,159 (96.0)	4,502 (99.1)	

Mean ± SE or n (%) using PROC SURVEYFREQ.

Table 3. Mean daily energy and macronutrient intake according to age groups[1)]

Age groups	Energy	Carbohydrate		Protein		Fat	
	kcal/day	g/day	% Energy	g/day	% Energy	g/day	% Energy
3–11 years (n = 1,879)	1,631.3 ± 18.9$^{a2)}$	239.6 ± 2.8^{a}	59.4 ± 0.3^{a}	59.0 ± 0.8^{a}	14.4 ± 0.1^{a}	47.3 ± 0.8^{a}	25.6 ± 0.2^{a}
12–18 years (n = 1,149)	1,988.5 ± 27.3^{b}	285.2 ± 4.1^{b}	58.2 ± 0.3^{a}	75.2 ± 1.2^{b}	15.1 ± 0.1^{bd}	58.4 ± 1.2^{b}	25.7 ± 0.3^{ab}
19–34 years (n = 2,645)	2,002.4 ± 20.4^{b}	261.3 ± 2.7^{c}	54.0 ± 0.3^{b}	79.3 ± 1.1^{b}	15.8 ± 0.1^{c}	61.3 ± 0.9^{b}	26.7 ± 0.2^{b}
35–49 years (n = 3,791)	1,983.6 ± 17.2^{b}	272.4 ± 2.4^{b}	56.8 ± 0.2^{c}	75.8 ± 0.8^{b}	15.4 ± 0.1^{bc}	52.8 ± 0.7^{c}	23.3 ± 0.2^{c}
50–64 years (n = 4,333)	1,895.1 ± 13.4^{c}	280.8 ± 1.9^{b}	61.0 ± 0.3^{d}	69.8 ± 0.6^{c}	14.8 ± 0.1^{d}	44.4 ± 0.6^{d}	20.6 ± 0.2^{d}
Over 65 years (n = 4,541)	1,563.9 ± 13.1^{a}	257.1 ± 1.9^{c}	67.3 ± 0.2^{e}	55.4 ± 0.6^{d}	14.0 ± 0.1^{e}	30.7 ± 0.5^{e}	16.9 ± 0.2^{e}
P-value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Mean ± SE.
[1)]The difference of intake according to age groups was tested using an analysis of variance.
[2)]Different superscript letter indicates the comparison with significant differences among groups as determined by the Bonferroni test.

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Table 4. Total sugar intake according to age groups

Age groups	Total sugar intake from all food			Total sugar intake from processed food[1)]		
	g/day[2)]	% Energy	≥ 20% of Energy[3)]	g/day	% Energy	≥ 10% of Energy[3)]
3–11 years (n = 1,879)	59.9 ± 1.1[a4)]	14.8 ± 0.2[a]	360 (19.6)	36.1 ± 1.0[a]	8.9 ± 0.2[a]	648 (35.2)
12–18 years (n = 1,149)	66.4 ± 1.7[b]	13.4 ± 0.3[b]	183 (16.3)	47.4 ± 1.5[b]	9.4 ± 0.3[a]	423 (37.1)
19–34 years (n = 2,645)	61.6 ± 1.1[ab]	12.7 ± 0.2[bc]	399 (15.4)	43.9 ± 1.0[b]	8.9 ± 0.2[a]	906 (34.0)
35–49 years (n = 3,791)	59.1 ± 0.9[a]	12.3 ± 0.1[c]	490 (12.3)	36.3 ± 0.7[a]	7.3 ± 0.1[b]	911 (23.7)
50–64 years (n = 4,333)	60.1 ± 0.8[a]	13.0 ± 0.2[bd]	731 (15.8)	29.7 ± 0.5[c]	6.3 ± 0.1[c]	689 (16.3)
Over 65 years (n = 4,541)	49.0 ± 0.8[c]	12.4 ± 0.2[cd]	583 (13.6)	21.2 ± 0.4[d]	5.5 ± 0.1[d]	529 (12.1)
P-value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Mean ± SE or n (%).
[1)]Total amount of sugars contained in processed foods, excluding raw food products and fruits.
[2)]The difference in intake according to age groups was tested using an analysis of variance.
[3)]The proportion according to age groups was significantly different in the χ^2-test.
[4)]Different superscript letter indicates the comparison with significant differences among groups as determined by Bonferroni test.

19–34-year-old adults, 50–64-year-old adults, and 3–11-year-old children (61.6 g, 60.1 g, and 59.9 g, respectively). Importantly, except for the 19–34-year-old adults, adolescents exhibited a significant difference in total sugar intake when compared to other age groups. The lowest total sugar intake was observed in adults aged 65 and above (49.0 g). Additionally, the proportion of total energy derived from sugar was highest in children aged 3–11 years (14.8%) and lowest in adults aged 35–49 years (12.3%). Furthermore, the percentage of intake among 3–11-year-old children differed significantly from other age groups. The highest proportion of participants consuming 20% or more of their total energy intake from sugar was found among 3–11-year-old children (19.6%), followed by adolescents aged 12–18 years and adults aged 50–64 years (16.3% and 15.8%, respectively).

Because sugars are added to foods during preparation and processing, we investigated total sugar intake from processed foods. The percentage of total energy intake from sugars contained in processed foods was highest in 12–18-year-old adolescents (9.4%), followed by 3–11-year-old children and 19–34-year-old young adults (8.9%, 8.9%, respectively). This confirms high proportions of sugar intake from processed foods among all children, adolescents, and young adults. There was no difference in the percentage of total sugar intake from processed foods between children (3–11 years), adolescents (12–18 years), and young adults (19–34 years). However, there was a significant difference in intake ratio between those groups and adults (35–49 years), middle-aged adults (50–64 years), and older adults (≥65 years). The highest proportion of participants consuming 10% or more of their energy intake from total sugars in processed food was observed among those aged 12–18 years (37.1%), followed by those aged 3–11 years (35.2%) and 19–34 years (34.0%). These age groups accounted for a significantly higher proportion than other age brackets.

Foods identified from the food intake survey were reclassified into a total of 15 food groups for analysis (**Table 5**). Regarding the food groups contributing to the total sugar intake among all participants, fruits accounted for the largest percentage (23.43%), followed by unprocessed raw food products such as plain milk and agricultural, forestry, livestock, and fishery products (excluding fruits) (17.84%), sugar or sugar-processed products (9.14%), bread, confectionery, or rice cakes (8.68%), and carbonated drinks (8.60%). The consumption of raw food products and fruits constituted the major contributors to total sugar intake across all age groups. Notably, the intake of carbonated drinks was significantly higher among adolescents aged 12–18 years (16.53%) and young adults aged 19–34 years (17.16%) compared to other age groups, highlighting carbonated drinks as primary sources of sugar. In children aged 3–11 years, sugar or sugar-processed products (11.70%) were the main

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Table 5. Distribution of total sugar intake among 15 food groups by age groups

Food types	Overall (n = 18,338)	3–11 years (n = 1,879)	12–18 years (n = 1,149)	19–34 years (n = 2,645)	35–49 years (n = 3,791)	50–64 years (n = 4,333)	Over 65 years (n = 4,541)
Raw food products	17.84	18.80	15.38	15.81	16.98	18.48	22.32
Fruit types	23.43	20.86	13.32	13.07	21.72	32.08	34.41
Processed agricultural, forestry, livestock, and fishery products	1.36	1.03	1.40	1.70	1.79	1.09	0.67
Convenience food types	1.15	2.06	1.67	1.41	1.11	0.79	0.63
Bread, confectionery, or rice cakes types	8.68	10.53	10.26	11.09	8.57	7.37	5.41
Sugar or sugar-processed product types	9.14	11.70	11.36	10.45	9.57	7.39	6.77
Tea, juice, or isotonic drink types	6.03	7.27	9.07	7.51	5.43	5.11	3.96
Coffee drink types	5.54	0.03	0.48	2.73	7.62	7.99	7.91
Carbonated drink types	8.60	6.82	16.53	17.16	8.59	3.08	1.61
Processed dairy product types	3.14	5.15	3.81	2.83	2.33	3.11	3.58
Frozen dessert types	3.11	9.24	6.17	3.69	2.39	1.44	1.14
Seasoning types	6.64	4.45	6.72	7.88	7.96	5.90	4.92
Pickled food types	5.15	1.84	3.48	4.36	5.71	6.07	6.64
Cooked food types	0.20	0.22	0.35	0.31	0.23	0.10	0.03
Other food types	0.05	0.01	0.02	0.12	0.05	0.03	0.04

n (%).

contributors to sugar intake, followed by bread/confectionery/rice cakes (10.53%) and frozen desserts (9.24%). Adolescents aged 12–18 years saw a similar pattern, with sugar or sugar-processed products (11.36%) leading, followed by bread/confectionery/rice cakes (10.26%) and tea, juice, or isotonic drinks (9.07%). Young adults (19–34 years) showed a similar distribution to adolescents (12–18 years) in major food sources of sugar intake, although the proportion of total sugar intake from seasonings (ssamjang, spices, sauces) was higher in young adults than in adolescents. The proportion of fruit intake was remarkably higher in middle-aged adults and older adults (32.08% and 34.41%, respectively). However, a relatively high percentage of coffee drink intake was observed in those aged ≥ 35 years compared to other age groups.

Total sugar intake from individual foods is illustrated in **Table 6**. The total sugar intake from milk amounted to 5.8 g in children (3–11 years), ranking highest. In adolescents (12–18 years), and young adults (19–34 years), the highest sugar intake was from coke, which were 7.3 g, and 6.7 g, respectively. Thus, carbonated drinks are the predominant source of total sugar intake among adolescents (12–18 years) and young adults (19–34 years). In adults aged 35–49 years, 50–64 years, and ≥ 65 years, the highest sugar intake was from apples, underscoring that fruits contribute significantly to total sugar intake in these age brackets. In these groups, mixed coffee (coffee with sugar and cream) also contributed substantially to total sugar intake, with the second highest contribution observed in individuals aged ≥ 35 years.

DISCUSSION

This study utilized detailed data from the 8th KNHANES food intake survey (2019–2021), stratifying sugar intake status among Koreans by age group throughout various life stages. The highest proportion of daily energy derived from total sugar per individual occurred in children aged 3–11 years (14.8%), while the lowest was observed in adults aged 35–49 years (12.3%). Approximately 13% was the intake proportion across other age groups. Notably, the proportion of participants whose intake surpassed KDRIs (daily total energy ≥ 20%) was greatest in children aged 3–11 years (19.6%), followed by adolescents aged 12–18 years (16.3%). The highest average total sugar intake was observed in adolescents aged 12–18 years (66.4 g), also substantial in those aged 19–34 years and 50–64 years (over 60 g). However,

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Table 6. Top 20 foods highest in daily total sugar intake according to age groups

Rank	3–11 years (n = 1,879)			12–18 years (n = 1,149)			19–34 years (n = 2,645)			35–49 years (n = 3,791)			50–64 years (n = 4,333)			Over 65 years (n = 4,541)		
	Food name	Total sugar (g)	Cumulative % of total sugar	Food name	Total sugar (g)	Cumulative % of total sugar	Food name	Total sugar (g)	Cumulative % of total sugar	Food name	Total sugar (g)	Cumulative % of total sugar	Food name	Total sugar (g)	Cumulative % of total sugar	Food name	Total sugar (g)	Cumulative % of total sugar
1	Milk	5.8	9.6	Coke	7.3	10.7	Coke	6.7	10.8	Apple	3.5	5.9	Apple	6.4	10.6	Apple	5.4	11.1
2	Apple	3.0	14.5	Milk	4.3	17.1	Milk	2.0	14.0	Mixed coffee with sugar and cream (coffee mix)	3.4	11.5	Mixed coffee with sugar and cream (coffee mix)	4.4	17.7	Mixed coffee with sugar and cream (coffee mix)	4.3	20.1
3	Ice cream	2.4	18.5	Ice cream	2.4	20.5	Sprite	1.8	16.9	Coke	3.0	16.6	Steamed sweet potato	2.6	22.0	Steamed sweet potato	2.7	25.7
4	Coke	2.4	22.4	Apple	2.3	23.9	Apple	1.8	19.8	Milk	1.7	19.4	Persimmon	1.9	25.1	persimmon	2.1	30.1
5	Ices	2.3	26.2	Sprite	1.8	26.5	Ice cream	1.4	22.1	Steamed sweet potato	1.4	21.8	Milk	1.7	27.9	Milk	1.8	33.8
6	Cereal	2.1	29.7	Yogurt	1.7	29.0	Cake	1.2	24.1	Kimchi	1.3	23.8	Melon	1.6	30.6	Melon	1.4	36.7
7	Jelly	1.9	32.9	Cereal	1.6	31.4	Yogurt	1.2	25.9	Canned coffee	1.2	25.9	Yogurt	1.5	33.1	Kimchi	1.3	39.5
8	Yogurt	1.8	35.9	Ices	1.5	33.7	Cereal	1.2	27.8	Mandarin	1.2	28.0	Kimchi	1.5	35.6	Yogurt	1.2	41.9
9	Mandarin	1.6	38.4	Jelly	1.4	35.7	Steamed sweet potato	0.9	29.2	Banana	1.0	29.6	Mandarin	1.4	37.9	Mandarin	1.1	44.2
10	Yogurt drink	1.3	40.6	Fruit Juice drink	1.2	37.5	Mixed coffee with sugar and cream (coffee mix)	0.9	30.7	Yogurt	1.0	31.3	Banana	1.3	40.0	Banana	1.1	46.4
11	Banana	1.0	42.2	Cake	1.2	39.2	Canned coffee	0.9	32.1	Sprite	1.0	32.9	Peach	1.1	41.8	Peach	1.0	48.4
12	Steamed sweet potato	0.9	43.7	Soda drink	1.0	40.7	Cafe latte with syrup	0.9	33.5	Melon	0.9	34.4	Pear	1.0	43.5	Soy milk	0.6	49.8
13	Cake	0.9	45.3	Sports drink	0.9	42.0	Kimchi	0.9	34.8	Grape	0.9	35.9	Grape	0.9	45.0	Pear	0.6	51.0
14	Grape	0.9	46.7	Mandarin	0.8	43.2	Banana	0.8	36.2	Peach	0.8	37.3	Coke	0.8	46.4	Multigrain rice	0.6	52.3
15	Pear	0.9	48.2	Kimchi	0.8	44.4	Seasoned chicken	0.7	37.3	Pear	0.8	38.7	Watermelon	0.7	47.6	Grape	0.6	53.5
16	Sprite	0.8	49.6	Banana	0.7	45.5	Mandarin	0.7	38.5	Watermelon	0.8	40.0	Mixed fruit juice	0.6	48.6	Mixed fruit juice	0.5	54.5
17	Cookies	0.8	50.9	Chocolate	0.7	46.5	Lemonade	0.7	39.6	Ice cream	0.8	41.3	Ssam-jang	0.5	49.4	Yogurt drink	0.5	55.5
18	Peach	0.8	52.3	Seasoned chicken	0.7	47.6	Soda drink	0.7	40.7	Persimmon	0.7	42.5	Red bean bread	0.5	50.2	Watermelon	0.5	56.5
19	Orange juice	0.7	53.4	Cookies	0.7	48.6	Sports drink	0.6	41.7	Cake	0.7	43.6	Ice cream	0.5	51.0	Red bean bread	0.4	57.3
20	Watermelon	0.6	54.5	Watermelon	0.6	49.6	Ices	0.6	42.6	Cereal	0.6	44.7	Cake	0.4	51.7	Orange	0.4	58.2

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intake among older adults aged ≥ 65 years was markedly lower compared to other age groups and distinct from all others. A comparative analysis using earlier KNHANES data (2008–2011) revealed the highest total sugar consumption among adolescents aged 12–18 years (69.6 g), succeeded by those aged 19–29 years and 30–49 years (68.4 g and 65.3 g, respectively). The mean sugar intake among older adults aged ≥ 65 years was 39.1 g, which was relatively lower compared to other age groups [18]. Data analysis from the KNHANES VII-3 (2018), conducted by the Korea Disease Control and Prevention Agency, reported that the average daily sugar intake was highest in those aged 10–18 years (70.2 g) and lowest in those aged ≥ 70 years [16]. These results aligned with the observed patterns of intake by age in this study. The average proportion of energy from total sugar intake among participants ranged from 12.4% to 14.8%, falling within the 10%–20% reference intake range recommended by the KDRIs. However, notably, approximately 1/5 of children aged 3–11 years exceeded 20% of their energy intake from total sugar. Furthermore, at least 10% of participants in all other age groups consumed excessive sugar, necessitating ongoing management of sugar intake. In the KDRIs, a specific recommendation suggests limiting the intake of added sugars, which are added to foods during processing, to < 10%. Consequently, the analysis focused on assessing the total sugar intake from processed foods to evaluate the consumption of added sugars. The average proportion of energy intake from total sugars in processed foods was highest among participants aged 12–18 years (9.4%) and did not exceed the reference intake for added sugars. For other age groups, sugar intake also remained within the recommended range. However, as the proportion of energy from total sugars in processed foods is approaching 10% in children and adolescents, careful monitoring of added sugar intake is warranted. Furthermore, the proportions of participants whose intake surpassed the reference intake of added sugars (> 10% of total daily energy from total sugar intake in processed food) were 35.2% for those aged 3–11 years, 37.1% for those aged 12–18 years, and 34.0% for those aged 19–34 years, representing approximately one-third or more. In 2021. Korean government similarly reported that the proportion of individuals exceeding the recommended sugar intake was 25.6% (1 in 4) in the total population and 40.3% (1 in 3) in children (6–11 years) and adolescents (12–18 years), although sugar intake from processed foods across all ages was 34.6 g, within the range recommended by the WHO [19].

Although the added sugar intake of American adults (≥ 19 years) between 2001 and 2018 showed a decreasing trend, sweetened beverages remained a major source of added sugar [20]. In Korea, drinks were the food group with the greatest changes over the last two decades (1998–2018), and their consumption significantly influenced both the total energy and sugar intake [21]. In the present study, carbonated drinks were the predominant contributors to total sugar intake in Korean adolescents aged 12–18 years (16.53%) and young adults aged 19–34 years (17.16%), underscoring their substantial role in sweetened drink consumption. Moreover, the Canadian Community Health Survey in 2014 highlighted that carbonated drinks were a significant source of total sugar intake in adolescents aged 9–18 years (14.3%) and adults aged ≥ 19 years (13.0%). The National Diet and Nutrition Survey in the UK (2008–2012) also noted a high proportion of energy intake from carbonated drinks among those aged 11–18 years. These surveys collectively indicate that carbonated drinks are a primary source of added sugar intake in adolescents [22,23]. A study by Bae assessing sugar intake from snacks found that sugar consumption from drinks was notably high among adults in their 20s [24]. In a survey of beverage consumption among university students in Chungcheongbuk-do and Gwangju, sugar-containing carbonated beverage were ranked first among commonly consumed items [25]. Kim's studies, which analyzed daily beverage consumption by type of sweetened drink among middle school students (12–14 years) and

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high school students (15–18 years) from 2007 to 2015, found that carbonated drinks were the most consumed irrespective of gender [26,27]. In the current study, cola and cider were also among the top five items contributing to total sugar intake in individuals aged 12–34 years. Therefore, it is crucial to be aware of the sugar content in carbonated beverages. Conversely, total sugar intake from mixed coffee was significant among adults, middle-aged individuals, and older adults. Mixed coffee, following apples, was the second most consumed item contributing to sugar intake. According to a 2019 study by Han on beverage consumption among adults aged ≥ 19 years, the average coffee consumption was 107.5 g, the highest recorded [28]. Additionally, Shin *et al.* [29] revealed that most participants (73.8%) consumed mixed coffee. For adults consuming 2,000 kcal daily, drinking one cup of mixed coffee accounts for about 6%–11% of the recommended intake. Special attention is needed for habitual consumers of mixed coffee [29].

Analysis of the status of total sugar intake among Koreans indicated that although total sugar intake has not exceeded the reference intake, the intake from processed foods is nearing the recommended limits. Notably, in the assessment of sugar intake from processed foods, the proportion of participants with sugar intake exceeding ≥ 10% of the recommended reference intake for added sugars was 10% or more across all age groups. This suggests that sugar consumption in Koreans is approaching unsafe levels. Various policies, such as imposing excise taxes on sweetened beverages and restricting advertising for these products, are implemented by countries to curtail sugar consumption [30-32]. Similarly, the Korean government has developed and enacted a comprehensive plan to reduce sugar intake starting in 2016 [33,34]. Ongoing research is essential for developing diverse and effective policies. This study will furnish foundational data for future research and new policies concerning sugar intake.

This study demonstrated that the total sugar intake of the population did not exceed the recommended reference sugar intake. However, the proportion of individuals whose sugar intake from processed foods surpassed the recommended reference intake varied between 12%–35% across age groups, indicating deviations from the reference intake. Notably, the food intake survey utilized in this study, which analyzed dietary habits for only one day, may not accurately reflect usual nutrient and sugar consumption. The household survey suggests consistency in the types and amounts of food intake among members, yet the reported amounts may differ from the actual consumption due to reliance on consumed foods and potential recall inaccuracies. Furthermore, the data from the KNHANES did not clearly differentiate between naturally occurring sugars and added sugars. Although this study focused on added sugar intake by examining sugar consumption from processed foods, it does not preclude the inclusion of raw material forms in the processed food category. Thus, as ingredients of sugar and consumed foods evolve with food trends, it is crucial to establish classification criteria for standardized foods based on sugar contents and types and to develop a database for types of added sugars.

The WHO recently recommends limiting added sugars to < 5% of total energy intake as a conditional recommendation, highlighting health benefits [14]. A study examining the association between the consumption of sweetened beverages among US adults and risk of death [35] found that individuals whose added sugar intake from sweetened beverages exceeded ≥ 10% of daily energy intake had a 1.44-fold increased risk of death from coronary artery diseases compared to those consuming < 5%. While the current study did not directly analyze the status of added sugar intake, further analysis could be undertaken with the development of future databases on added sugars. Research into the sugar intake status among Koreans

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should continue, and conducting in-depth studies to address the limitations will significantly contribute to the data supporting the establishment of public health policy for Koreans.

CONCLUSIONS

This study analyzed comprehensive data from the 8th KNHANES food intake survey (2019–2021), stratifying the sugar intake status among Koreans by age according to life cycle stages. Notably, the mean proportion of individuals whose total sugar intake from processed foods exceeded 10% of the reference intake was 20% or higher. This proportion was particularly elevated in children and adolescents (3–18 years) and young adults (19–34 years), highlighting concerns regarding sugar consumption. Furthermore, the food groups and commonly consumed foods contributing to total sugar intake included carbonated drinks and cola for both adolescents and young adults. For adults, middle-aged adults, and older adults, mixed coffee was the primary contributor to sugar intake. Importantly, this study provides valuable insights for developing nutrition management policies that reflect the unique characteristics of Koreans.

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