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Association between Soft Drink Consumption and Metabolic Syndrome among Korean Adults: Data from the 2007-2011 Korea National Health and Nutrition Examination Survey

한국 성인의 탄산음료 섭취와
대사증후군의 관련성:
2007-2011 국민건강영양조사 자료를 이용하여

2015 년 8 월

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Abstract

Association between Soft Drink Consumption and Metabolic Syndrome among Korean Adults: Data from the 2007-2011 Korea National Health and Nutrition Examination Survey

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As consumption of processed foods has increased, consumption of sugar-sweetened beverage (SSB) including soft drinks has increased worldwide. Accordingly, a positive relationship between SSB consumption and metabolic disease has been consistently reported in Western populations.

In Korea, it has been reported that SSB is a major source of sugar intake from processed foods and sugar intake from soft drinks is the highest among all types of beverages. However, few studies have assessed to investigate the association between SSB intake and metabolic disease in Korean populations.

To examine the association between SSB consumption and metabolic syndrome risk factors in Korean adults, this study used data from 13,972 participants (5,432 men and 8,540 women) aged ≥30 years, from the 2007–2011 Korea National Health and Nutrition Examination Survey. The subjects were divided into six groups based on their soft drink consumption levels from a food frequency questionnaire. In addition, total sugar intake from 24-hour dietary recall data was categorized into quintiles for comparison of associations of soft drink consumption and total sugar intake with metabolic syndrome. Nutrient intake was compared among groups using the 24-hour dietary recall data.

The highest soft drink consumption frequency category was ≥4 times per week, observed in 4.6% of men and 1.7% of women. The percentage of energy from sugar in processed foods increased with increased soft drink consumption. In the highest soft drink consumption group, the percentage of energy from sugar in processed foods was 8.9% in men and 11.0% in women. The percentage of energy from sugar in milk and fruits significantly decreased with increased soft drink consumption in women. In contrast, the percentage of energy from sugar in different food sources significantly increased with total sugar intake in both men and women.

After adjusting for potential confounding variables, greater consumption of soft drinks was positively associated with all of the components of metabolic syndrome, except the high density lipoprotein (HDL) cholesterol level, in women only. Women who consumed soft drinks ≥4 times per week had a 74% higher risk of metabolic syndrome compared to those who consumed soft drinks infrequently (OR: 1.74; 95% CI: 1.00-3.03; *P* for trend <0.0001). However, total sugar intake was negatively associated with metabolic syndrome components in men and women.

In conclusion, high levels of soft drink consumption might constitute an important determinant of metabolic syndrome and its components in Korean adult women.

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Keywords: soft drinks, sugar intake, metabolic syndrome, Korean adults

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LIST OF ABBREVIATIONS

SSB: sugar-sweetened beverage

SBP: systolic blood pressure

DBP: diastolic blood pressure

HDL: high density lipoprotein

BMI: body mass index

GI: glycemic index

GL: glycemic load

KNHANES: Korea National Health and Nutrition Examination Survey

Ⅰ. Introduction

Consumption of processed foods has increased in parallel with development of food industry and trade liberalization (1). Processed foods are convenient to have, however, they are high in refined sugar, sodium, saturated fat, or trans-fat which have linked with chronic diseases (2).

In recent years, sales and consumption of beverages have increased worldwide (3, 4). Most of beverages such as soft drinks contain high added sugar and are considered to have identical characteristics, thus a new term for these beverages, sugar-sweetened beverage (SSB) has emerged. Even though the definition of SSB is different by studies, they generally include soft drinks, fruit and vegetable drinks, sports drinks, or energy drinks.

According to the definition of U.S. Department of Agriculture, added sugars are “all sugars used as ingredients in processed and prepared foods such as breads, cakes, soft drinks, jams, chocolates, and ice cream, and sugars eaten separately or added to foods at the table” and include sugars, syrup, such as high fructose corn syrup and maple syrup, sweetener, and honey (5).

General soft drinks contain 25g to 35g of added sugar per 250mL. World Health Organization (WHO) has recently reported a guideline to limit the sugar intake from processed foods less than 10% of total energy intake, which is approximately 50g of added sugar for a 2,000 kcal diet per day (6). Therefore, we can easily exceed the half of recommendation level for added sugar with consumption of only one 250mL can of soft drink.

Added sugars are known that they have adverse effects on human body. In particular, when we consume added sugars in liquid, they are rapidly absorbed in a body and could not lead to satiety, thus, cause additional food intake. Therefore, consumption of added sugar in liquid is linked to increased energy intake and weight gain, and development of several diseases (7). Because of this adverse health effect of added sugars, numerous studies have been conducted to examine the adverse association between added sugars and several diseases instead of total sugars which refer to all types of sugars such as added sugars and sugars in milk and fruits.

Metabolic syndrome is a cluster of abnormal metabolic conditions, such as abdominal obesity, hypertension, dyslipidemia, and hyperglycemia, and has been linked with obesity, type 2 diabetes, and cardiovascular diseases. Several recent large-scale cohort studies have found that SSBs are positively associated with an increased risk of type 2 diabetes and cardiovascular disease (8). American adult men in the top quartile of SSB intake have been found to have a 24% higher risk of type 2 diabetes (9) and a 20% higher risk of coronary heart disease (10) relative to those in the bottom quartile. Furthermore, compared with individuals who did not consume SSBs, those who consumed one or more servings per day had a 16% higher risk of any stroke (11). In European adults, one 12-ounce daily increment in SSB intake was associated with a 22% increase in the risk of type 2 diabetes (12).

A meta-analysis of the association between SSBs and metabolic syndrome that included three studies found that individuals in the highest quartile of

SSB intake had a 20% higher relative risk of developing metabolic syndrome than those in the lowest quartile (13).

Although most epidemiological investigations of the link between SSBs and metabolic diseases have been conducted in Western populations, a few have considered Asian populations. A study of Japanese men found that those who consumed one or more servings of SSB per day had a 35% higher risk of developing type 2 diabetes than those who rarely or never consumed SSBs; however, the difference was not statistically significant (14). A study in Taiwanese boys and girls found that high SSB consumption was associated with a 1.9 and 2.7 times, respectively, higher risk of metabolic syndrome (15).

SSB consumption has been steadily increasing worldwide. In the United States, the energy intake from SSBs increased almost three fold from 3.9% of total calories in the late 1970s to 9.2% in 2001 (16, 17). A similar trend has been documented in Mexico (16). Furthermore, 25% of Americans consume approximately 200 kcal a day from SSBs, which corresponds to more than one 12-ounce can of soft drink, and 5% of the population consumes more than 567 kcal a day, which is the equivalent of four 12-ounce cans of soft drink (18). In addition, the major source of added sugar intake was SSB in the United States, and soft drink was the top source of added sugar intake among SSBs (19).

SSB consumption is on the rise among Asians, although it remains lower than that in Western populations. As Asian populations adapt to the Western lifestyle, the traditional dietary practice consisting primarily of rice or grains as staples and plenty of vegetables has gradually come to include meat and sweet foods such as desserts and beverages.

According to the 2013 Korea National Health and Nutrition Examination Survey (KNHANES) report, most frequently consumed foods among Koreans were rice (17.8 times/week), Kimchi (17.7 times/week), and beverages (15.6 times/week) (20). Moreover, beverage intake has been increased about 4 times from 45.3 g/day in 1998 to 167.3 g/day in 2013 (20). Energy intake from beverage has also increased over the past decade. The average energy intake from SSBs in adolescents and young adults has increased from 22.3 and 20.0 kcal a day in 1998 to 35.1 and 29.4 kcal a day in 2009, respectively (21). A recent Korean study found that all beverages, including SSBs, coffee, and tea, were a major source of sugar intake from processed foods. Furthermore, sugar intake from soft drinks is the highest among all types of beverages (22).

Although SSB consumption and the prevalence of metabolic syndrome in Korean adults are increasing (23), no study has investigated the associations between SSB consumption and metabolic syndrome in a large sample of Korean adults. In addition, it is necessary to prove the adverse effect of added sugar intake compared to total sugar intake in Korean population because studies conducted in Korea have focused on the association of total sugar intake and chronic diseases (24).

Therefore, this study aimed to examine and compare the associations of metabolic syndrome with soft drink consumption and total sugar intake in Korean adults using data from the 2007–2011 KNHANES.

The specific objectives of this study were as follows:

1. To examine total sugar intake and soft drink consumption level of Korean adults
2. To assess sugar intake from major sugar sources of Korean adults according to total sugar intake and soft drink consumption
3. To analyze and compare the associations of total sugar intake and soft drink consumption with metabolic syndrome

Ⅱ. Methods

2.1. Study subjects

The KNHANES is an ongoing nationwide survey conducted by the Korea Centers for Disease Control and Prevention to collect data on the health and nutritional status of the Korean population. This survey uses a complex multistage, probability-sampling design to select nationally representative non-institutionalized Korean participants aged 1 year or older (25).

Of the 37,836 2007–2011 KNHANES participants, those who were <30 years old (n = 13,196), were pregnant or lactating women (n = 224), reported implausible energy intake (<500 or >5000 kcal/day, n = 349), diagnosed with or receiving medication for hypertension, dyslipidemia, stroke, myocardial infarction, angina, or diabetes (n = 7,920), had missing information on height and weight and food frequency questionnaire (n = 1,695), and had not fasted ≥8 hours before a day preceding the examination (n = 480) were excluded. The final study sample consisted of 13,972 participants.

The survey protocols were approved by the Korea Centers for Disease Control and Prevention Institutional Review Board, and written informed consent was obtained from each participant.

2.2. Dietary assessment

The KNHANES included a dietary questionnaire and a single 24-h dietary recall method. The dietary questionnaire assessed general dietary behaviors and the intake of 63 food items on the food-frequency questionnaire. The 24-hour dietary recall method was administered in a face-to-face interview conducted by a trained staff member (25).

Soft drink consumption was estimated by the question "How often do you consume soft drinks (carbonated beverages, e.g., Cola and Sprite)?" on the food-frequency questionnaire. The initial response options were "rarely," "6–11 times/year," "once a month," "2–3 times/month," "once a week," "2–3 times/week," "4–6 times/week," "once a day," "2 times/day," and "3 times/day." However, it was found that few individuals were in the high-consumption group; thus, the categories were revised to "rarely," "≤1 time/month," "2–3 times/month," "1 time/week," "2–3 times/week," and "≥4 times/week."

The 24-hour dietary recall method was used to assess nutrient intake. The KNHANES dietary survey did not specifically assess sugar intake; thus, a sugar database was developed, which has been described in detail elsewhere (22). In brief, the sugar database was based on data from Release 25 of the US Department of Agriculture National Nutrient Database for Standard Reference, the total sugar database of the Ministry of Food and Drug Safety in Korea, and nutrition information on the labels of processed foods. The sugar database was linked to the KNHANES 24-hour dietary recall data.

The sugar database contained the total sugar content of 4,928 foods, covering 96.5% of the 5,105 foods in the KNHANES food list. After the database was linked to the 24-hour dietary recall data, the dietary sugar intake was estimated by multiplying sugar content of each food per 1 gram by the amount of the food intake. Based on this total sugar intake data, participants also were divided to quintiles.

To evaluate the major food sources of dietary sugar intake, all food items were categorized into four groups (22): milk, fruits, processed foods, and commodity-type foods. Milk referred to white milk only and did not include flavored milk. Fruits referred to fresh fruits including 100% fruit juice, but not fruit drinks. Processed foods included all types of drinks containing sugar or syrup, coffee (without sugar), tea (e.g., tea bag), flavored milk and soymilk, dressings and seasonings, salted or pickled foods, breads/snacks/rice cakes, ice cream/frozen confections, and candies/chocolates/gums/jams. Commodity-type foods included grains, vegetables, fish, and meat.

2.3. Definition and measurements of metabolic syndrome

The definition of metabolic syndrome was based on the criteria of the National Cholesterol Education Program Adult Treatment Panel III (26), except that waist circumference was based on the World Health Organization ethnicity-specific cut-off values for the Asian population (27). The metabolic syndrome diagnosis requires the presence of three or more of following components: waist circumference ≥90 cm for men and ≥80 cm for women, systolic blood pressure (SBP) ≥130 mmHg or diastolic blood pressure (DBP) ≥85 mmHg, high density lipoprotein (HDL) cholesterol levels <40 mg/dL for men and <50 mg/dL for women, triglyceride levels ≥150 mg/dL, and fasting plasma glucose levels ≥100 mg/dL. All anthropometric and clinical data, such as blood pressure and blood tests, were measured using standardized examinations or laboratory assays.

2.4. Confounding variables

The covariates were sociodemographic and health behavior variables obtained from the general questionnaire. The sociodemographic variables included age, sex, family income, and education level. Family income was categorized as “lowest,” “lower middle,” “upper middle,” and “highest,” and education level was categorized as “≤elementary school,” “middle school,” “high school,” and “≥college.” The health behavior variables, which included alcohol consumption, current smoking status, and physical activity, were self-reported. Alcohol consumption status was based on the question, "How often during the last year have you had an alcoholic drink?" and response options were categorized as "never or rarely," "1–4 times/month," and "≥2 times/week." Smoking status was categorized as "current smoker" or "non-smoker." Physical activity was assessed by the time spent walking. The participants were considered physically active if they walked ≥5 times a week for ≥30 min each time.

2.5. Statistical analyses

All statistical tests were conducted using SAS 9.3 (SAS Institute, Cary, NC, USA). Sampling weights were used in the statistical analyses to take into account the complex sampling design of the national survey, and all analyses were conducted using the SAS survey procedure.

The general characteristics were compared according to sex, and other dietary intake variables and the associations of total sugar intake and soft drink consumption with metabolic syndrome components were assessed across quintiles of total sugar intake and soft drink consumption groups.

The χ^2 test was used to compare categorical variables, Student's *t*-test was used to compare continuous variables, and regression models were used to examine linear trends in the continuous variables. The associations of total sugar intake and soft drink consumption with the metabolic syndrome components were tested using a logistic regression analysis, with the lowest quintile or the lowest consumption group as the reference group. All multivariate analyses were adjusted for age, family income, education level, alcohol consumption, current smoking status, physical activity, and total energy intake.

Ⅲ. Results

3.1. General characteristics of participants

3.1.1. Sociodemographic variables and health behaviors of participants

The sociodemographic variables and health behaviors of participants are shown in Table 1. The 13,972 participants included 8,540 women (mean age, 46.2 ± 0.2) and 5,432 men (mean age, 45.5 ± 0.2). The family income distribution was similar for men and women. Men were more likely than women to have a high level of education, to drink alcohol frequently, and to smoke.

Table 1. Sociodemographic variables and health behaviors[a] of participants according to sex

	n	Men	Women	*P*-value[b]
Total (*n*, %)	13,972	5,432 (48.7)	8,540 (51.3)	0.0001
Age (mean ± SE)	13,972	45.5 ± 0.2	46.2 ± 0.2	0.0006
Family income (%)				0.0203
Lowest	2,234	11.4	13.0	
Lower middle	3,449	26.0	26.4	
Upper middle	4,069	32.1	30.6	
Highest	3,987	30.5	30.0	
Education level (%)				<0.0001
≤Elementary school	3,169	12.0	19.6	
Middle school	1,642	11.0	12.0	
High school	4,831	36.5	39.9	
≥College	4,206	40.6	28.5	
Alcohol consumption[c] (%)				<0.0001
Never or rarely	6,451	24.1	57.1	
1-4/month	4,455	36.6	32.5	
≥2/week	2,925	39.4	10.4	
Smoking status (%)				<0.0001
Yes	2,800	48.0	5.7	
No	11,069	52.0	94.3	
Physical activity[d] (%)				0.0886
<5 times/week	8,093	58.5	60.2	
≥5 times/week	5,698	41.5	39.8	

[a] All values reflected the complex sampling design of the national survey, and appropriate sampling weights were used.

[b] *P*-values were derived from the χ^2 test for categorical variables and Student's *t*-test for continuous variables.

[c] Alcohol consumption was based on the question "How often during the last year have you had an alcoholic drink?"

[d] Physical activity was defined as walking ≥30 min each time.

3.1.2. Total sugar intake and soft drink consumption status

Total sugar intake was higher in men (mean intake, 66.4±0.9g) than in women (mean intake, 59.3±0.9g) as shown in Figure 1 ($P < 0.0001$). In addition, soft drink consumption was significantly different between men and women (Figure 1). A high percentage of women consumed soft drinks rarely (44.5%) or less than once a month (29.1%) compared with men (27.9 and 26.0%, respectively). Furthermore, men were 2.7 times more likely than women to consume soft drinks ≥4 times/week. In light of these findings, the following analyses were conducted according to sex, and total sugar intake and soft drink consumption.

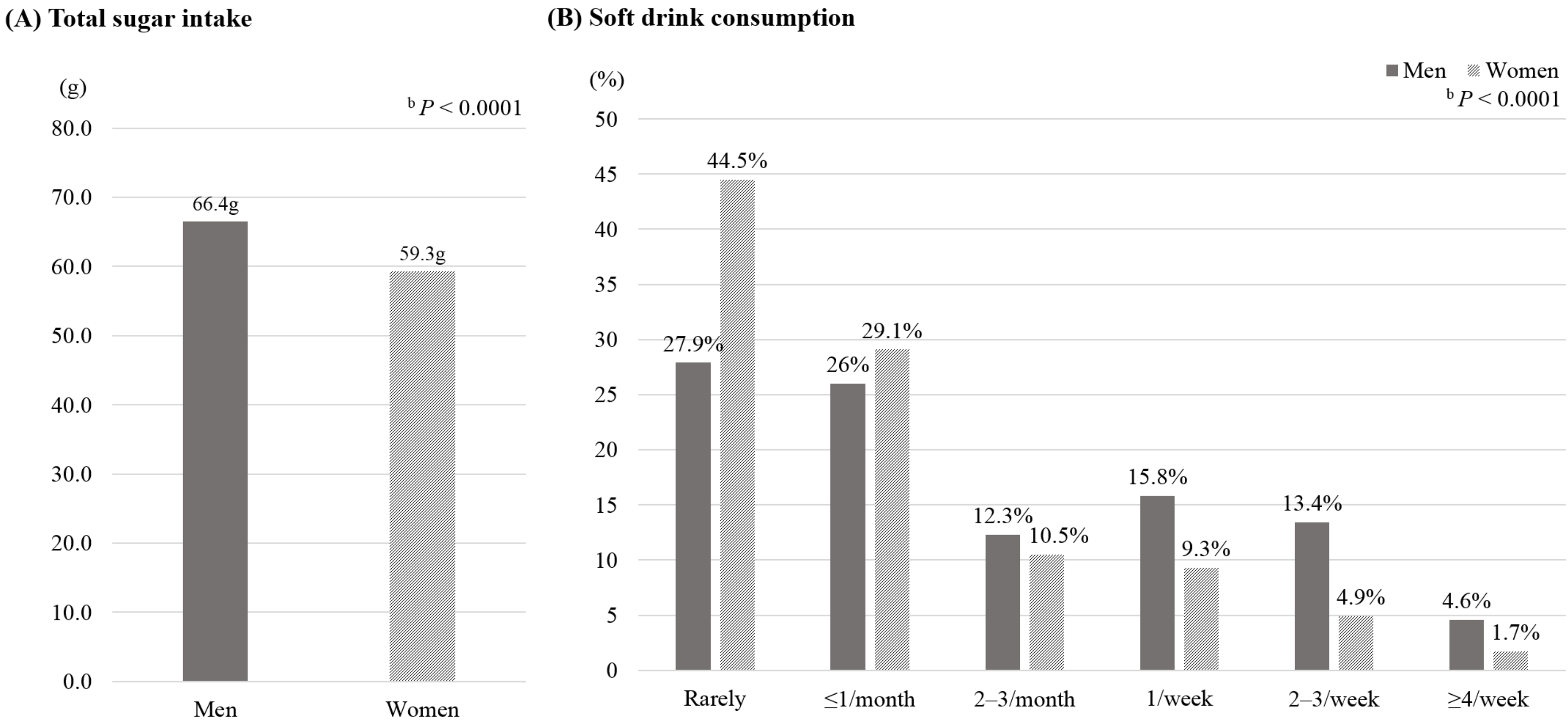

Figure 1. Total sugar intake[a] (A) and soft drink consumption[a] (B) status of participants according to sex

[a] All values reflected the complex sampling design of the national survey, and appropriate sampling weights were used.
[b] P-values were derived from the χ^2 test for categorical variables and Student's t-test for continuous variables.

3.2. Dietary intake according to total sugar intake and soft drink consumption

3.2.1. Major nutrient and dietary sugar intake according to total sugar intake

Table 2 shows major nutrient intake according to quintiles of total sugar intake. Energy and carbohydrate intake was positively associated with total sugar intake in men and women (*P* for trend < 0.0001). However, the increment in carbohydrate intake across quintiles of total sugar intake was greater in men (Q1, 339.4; Q5, 422.1 g/day) than in women (Q1, 271.2; Q5, 306.7 g/day). Conversely, protein intake was negatively associated with total sugar intake in men and women (*P* for trend = 0.0041 and < 0.0001, respectively). Calcium, iron, and vitamin C intake was positively associated with total sugar intake in men and women (*P* for trend < 0.0001).

Table 2. Major nutrient intake[a] according to quintiles of total sugar intake

	Quintiles of total sugar intake					*P* for trend[a]
	Q1 (1.4-26.5g)	**Q2 (26.6-43.1g)**	**Q3 (43.1-62.6g)**	**Q4 (62.6-90.6g)**	**Q5 (90.6-445.6g)**	
Men (*n* = 5,432)						
Energy[b] (kcal/day)	1710.2 ± 25.0	2036.7 ± 25.5	2256.4 ± 26.5	2441.8 ± 26.8	2881.3 ± 28.2	<0.0001[b]
Carbohydrate (g/day)	339.4 ± 3.3	348.3 ± 2.9	365.7 ± 2.9	380.1 ± 2.7	422.1 ± 3.0	<0.0001
Protein (g/day)	85.8 ± 1.2	88.9 ± 1.0	86.6 ± 0.9	85.1 ± 0.9	83.6 ± 1.1	0.0041
Fat (g/day)	46.5 ± 0.9	49.4 ± 0.9	48.5 ± 0.8	48.8 ± 0.8	46.3 ± 0.9	0.2303
Calcium (mg/day)	485.8 ± 12.4	549.4 ± 9.9	576.0 ± 10.4	613.5 ± 10.6	679.1 ± 14.9	<0.0001
Iron (mg/day)	15.1 ± 0.4	17.0 ± 0.4	16.7 ± 0.3	17.2 ± 0.3	20.4 ± 0.6	<0.0001
Vitamin C (mg/day)	82.8 ± 2.4	96.1 ± 2.1	111.2 ± 2.4	130.9 ± 3.0	166.7 ± 4.6	<0.0001

Table 2. (Continued)

	Quintiles of total sugar intake					*P* for trend[a]
	Q1 (1.6-23.2g)	**Q2 (23.2-38.7g)**	**Q3 (38.7-56.2g)**	**Q4 (56.2-84.3g)**	**Q5 (84.3-762.3g)**	
Women (*n* = 8,540)						
Energy[b] (kcal/day)	1262.4 ± 20.1	1468.8 ± 21.9	1638.4 ± 24.6	1836.3 ± 25.7	2236.3 ± 27.3	<0.0001[b]
Carbohydrate (g/day)	271.2 ± 2.3	272.6 ± 1.9	275.8 ± 2.3	277.3 ± 1.9	306.7 ± 2.1	<0.0001
Protein (g/day)	61.2 ± 0.5	62.9 ± 0.6	61.2 ± 0.6	61.1 ± 0.6	55.0 ± 0.7	<0.0001
Fat (g/day)	33.2 ± 0.8	33.4 ± 0.7	34.1 ± 0.9	35.1 ± 0.6	30.4 ± 0.7	0.0295
Calcium (mg/day)	382.2 ± 8.2	428.9 ± 7.2	466.0 ± 8.3	498.4 ± 8.7	518.1 ± 11.0	<0.0001
Iron (mg/day)	11.9 ± 0.3	12.8 ± 0.4	12.9 ± 0.2	13.0 ± 0.2	15.1 ± 0.4	<0.0001
Vitamin C (mg/day)	63.9 ± 1.8	77.4 ± 1.6	94.0 ± 2.1	114.3 ± 2.7	157.2 ± 4.3	<0.0001

[a] All values (adjusted means ± standard errors) and *P* for trend were obtained from a multivariate regression model accounting for the complex sampling design of the national survey. Appropriate sampling weights were used after adjustment for total energy intake (except the energy intake[b]), age, family income, education level, alcohol consumption, current smoking status, and physical activity.

Dietary sugar intake by major sugar sources according to quintiles of total sugar intake is shown in Figure 2. The percentage of energy from total sugar, and sugar in milk, fruits, processed foods, and commodity-type foods significantly increased across quintiles of total sugar intake in men and women (*P* for trend <0.0001). In women, the percentage of energy from the total sugar was higher than men, however, the percentage of energy from the sugar in fruits was almost 2 times higher than that of men, and higher (13.0%) than the percentage of energy from sugar in processed foods (11.2%) in the highest quintile. By contrast, the percentage of energy from sugar in processed foods (11.6%) was still higher than the percentage of energy from sugar in fruits (7.4%) in the highest quintile in men.

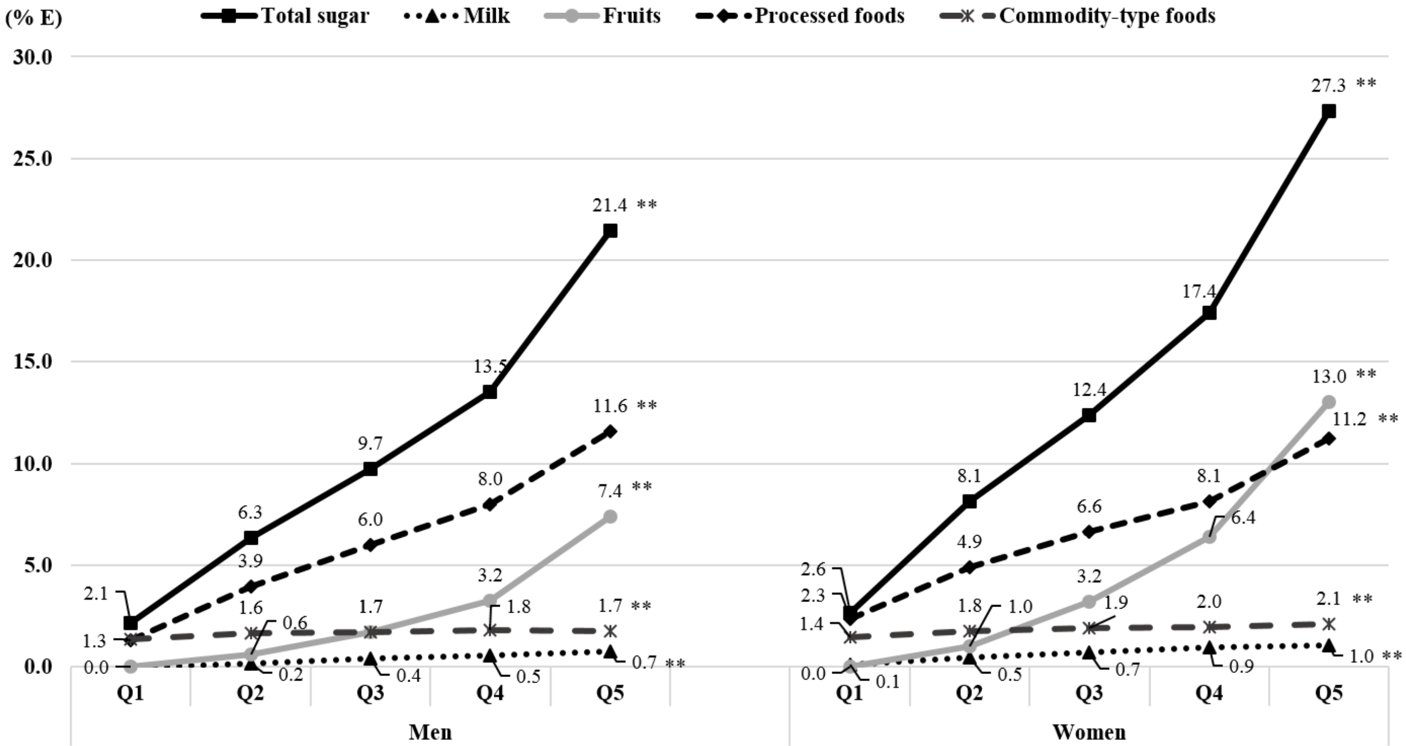

Figure 2. Dietary sugar intake by major sugar sources[a] according to quintiles of total sugar intake

[a] All values and *P* for trend were obtained from a multivariate regression model accounting for the complex sampling design of the national survey. Appropriate sampling weights were used after adjustment for total energy intake, age, family income, education level, alcohol consumption, current smoking status, and physical activity. ** *P* for trend <0.0001

3.2.2. Major nutrient and dietary sugar intake according to soft drink consumption

Table 3 shows major nutrient intake according to soft drink consumption. Energy intake was positively associated with soft drink consumption in men and women (*P* for trend <0.0001). However, the increment in energy intake across soft drink consumption levels was greater in men (rarely, 2247.8; ≥4/week, 2575.8 kcal/day) than in women (rarely, 1637.6; ≥4/week, 1779.0 kcal/day). Soft drink consumption was positively associated with protein and fat (*P* for trend = 0.0114 and 0.0002, respectively), but not carbohydrate (*P* for trend = 0.4895) intake in men. Conversely, soft drink consumption was negatively associated with carbohydrate intake in women (*P* for trend = 0.0086), although the difference between the lowest and the highest groups was not substantially different. Soft drink consumption was positively associated with fat (*P* for trend = 0.0175), but not protein (*P* for trend = 0.6023) intake in women. Calcium intake was negatively associated with soft drink consumption in men (*P* for trend = 0.0017), and calcium and iron intake in women (*P* for trend = 0.0003 and 0.0002, respectively).

Table 3. Major nutrient intake[a] according to soft drink consumption

	Soft drink consumption						*P* for trend[a]
	Rarely	≤1/month	2–3/month	1/week	2–3/week	≥4/week	
Men (*n* = 5,432)							
Energy[b] (kcal/day)	2247.8 ± 23.4	2315.9 ± 27.7	2283.6 ± 37.5	2320.5 ± 34.4	2373.0 ± 43.0	2575.8 ± 71.8	<0.0001[b]
Carbohydrate (g/day)	371.2 ± 2.7	376.5 ± 2.7	376.8 ± 3.8	380.9 ± 3.3	373.9 ± 3.5	369.0 ± 6.7	0.4895
Protein (g/day)	85.0 ± 0.9	84.8 ± 0.8	86.3 ± 1.3	86.1 ± 1.1	87.3 ± 1.2	91.8 ± 3.7	0.0114
Fat (g/day)	46.6 ± 0.7	47.1 ± 0.7	47.0 ± 0.9	49.0 ± 0.9	51.1 ± 1.1	50.5 ± 2.1	0.0002
Calcium (mg/day)	611.3 ± 10.5	592.0 ± 11.9	595.8 ± 13.9	578.8 ± 12.7	573.6 ± 14.3	533.3 ± 20.1	0.0017
Iron (mg/day)	17.9 ± 0.5	17.7 ± 0.3	17.6 ± 0.5	16.8 ± 0.4	17.2 ± 0.5	17.5 ± 1.1	0.1896
Vitamin C (mg/day)	122.1 ± 2.5	122.5 ± 2.9	121.4 ± 3.7	121.0 ± 3.7	124.3 ± 4.2	111.9 ± 8.0	0.6125

Table 3. (Continued)

	Soft drink consumption						*P* for trend[a]
	Rarely	**≤1/month**	**2–3/month**	**1/week**	**2–3/week**	**≥4/week**	
Women (n = 8,540)							
Energy[b] (kcal/day)	1637.6 ± 17.1	1698.9 ± 17.0	1714.4 ± 29.6	1741.4 ± 30.3	1720.0 ± 42.0	1779.0 ± 60.0	<0.0001[b]
Carbohydrate (g/day)	282.5 ± 2.0	280.4 ± 1.6	280.1 ± 2.5	277.8 ± 2.5	275.7 ± 3.3	272.0 ± 5.8	0.0086
Protein (g/day)	60.5 ± 0.5	60.2 ± 0.5	60.6 ± 0.8	59.7 ± 0.7	59.9 ± 1.2	61.4 ± 1.7	0.6023
Fat (g/day)	32.8 ± 0.7	33.1 ± 0.5	32.9 ± 0.8	34.7 ± 0.8	35.1 ± 1.1	34.9 ± 2.1	0.0175
Calcium (mg/day)	467.2 ± 6.6	469.7 ± 7.9	431.4 ± 9.7	437.6 ± 11.1	437.2 ± 12.9	439.1 ± 26.8	0.0003
Iron (mg/day)	13.7 ± 0.2	12.8 ± 0.2	13.1 ± 0.3	12.3 ± 0.3	12.5 ± 0.4	12.3 ± 0.5	0.0002
Vitamin C (mg/day)	103.2 ± 2.1	101.5 ± 2.2	98.7 ± 3.4	95.1 ± 3.5	104.1 ±7.7	88.5 ± 8.9	0.1088

[a] All values (adjusted means ± standard errors) and *P* for trend were obtained from a multivariate regression model accounting for the complex sampling design of the national survey. Appropriate sampling weights were used after adjustment for total energy intake (except the energy intake[b]), age, family income, education level, alcohol consumption, current smoking status, and physical activity.

Dietary sugar intake by major sugar sources according to soft drink consumption is shown in Figure 3. The percentage of energy from total sugar significantly increased across soft drink consumption levels (*P* for trend <0.0001) in men and showed a weak positive tendency (*P* for trend = 0.0692) in women. The percentage of energy from the sugar in processed foods was significantly greater in the highest soft drink consumption group than in the lowest group in both men and women. Moreover, the percentage of energy from the sugar in processed foods in women who consumed soft drinks ≥4 times/week (11.0%) was almost twice that of women who rarely consumed soft drinks (6.0%), and was higher than that of men. In contrast, the percentage of energy from sugar in milk and fruits decreased with rising soft drink consumption in women (*P* for trend = 0.0042 and <0.0001, respectively), particularly the energy intake from sugar in fruits, which decreased markedly from 4.9% in the lowest soft drink consumption group to 2.5% in the highest group. In men, the percentage of energy from sugar in milk and fruits showed a non-significant tendency (*P* for trend = 0.6198 and 0.1053, respectively).

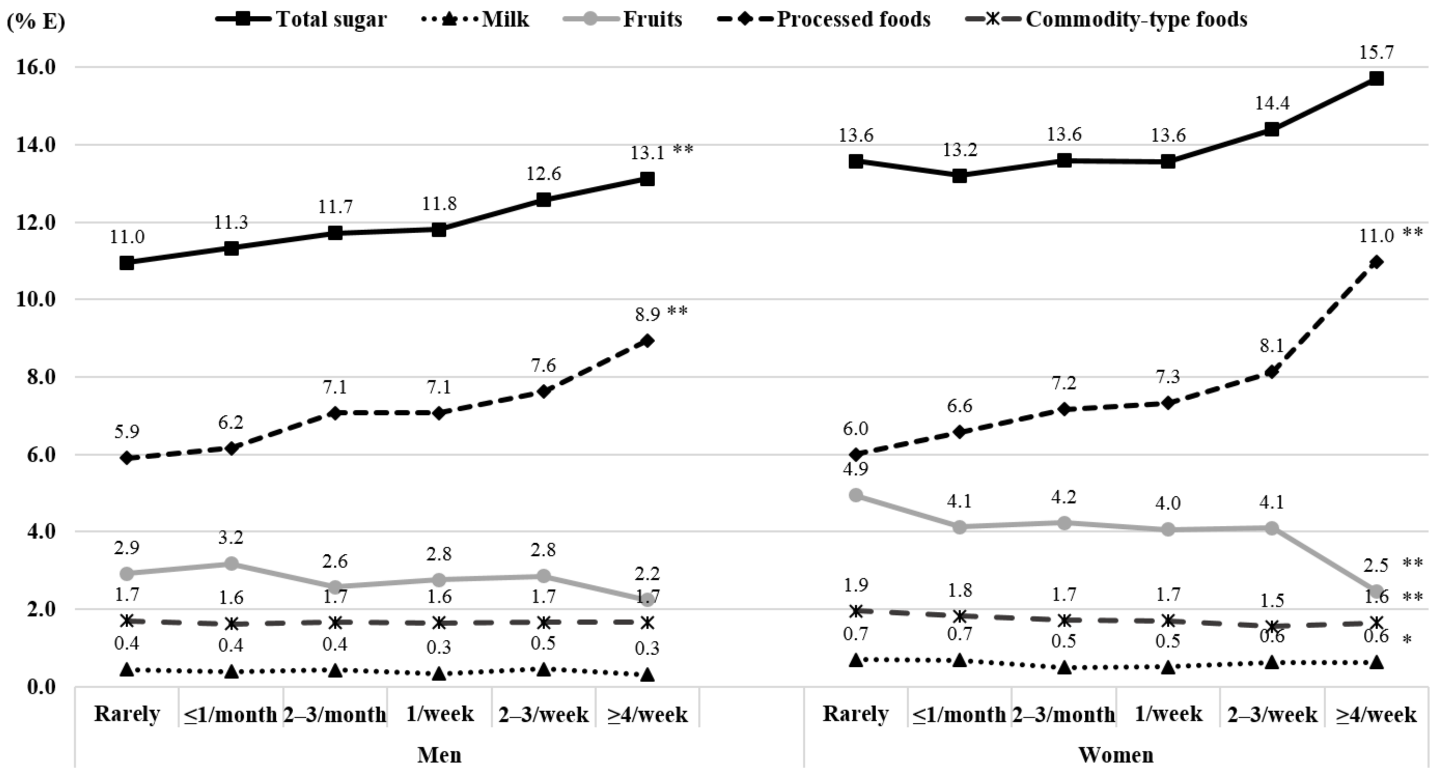

Figure 3. Dietary sugar intake by major sugar sources[a] according to soft drink consumption

[a] All values and *P* for trend were obtained from a multivariate regression model accounting for the complex sampling design of the national survey. Appropriate sampling weights were used after adjustment for total energy intake, age, family income, education level, alcohol consumption, current smoking status, and physical activity * *P* for trend <0.005, ** *P* for trend <0.0001

3.2.3 Sugar-sweetened beverage intake according to soft drink consumption

Sugar-sweetened beverage (SSB) intake and energy intake from SSB is presented in Table 4. SSB includes soft drink (carbonated beverages and artificially sweetened carbonated beverages), fruit and vegetable drink (excluding 100% fruit juice), coffee and tea drink (containing sugar or syrup), and other drinks such as sports drink, iced tea, and milk shake. The overall SSB intake and energy intake from SSB of men was higher than those of women. The SSB intake and energy intake from SSB of highest soft drink consumption group was 195.4±26.0g/day and 128.2±12.2 kcal/day in men and 185.8±29.0g/day and 127.0±17.7 kcal/day in women. The amount of SSB intake and energy intake from SSB increased with rising soft drink consumption frequency in men and women (*P* for trend < 0.0001). Energy intake from soft drink was also positively associated with soft drink consumption in men and women (*P* for trend < 0.0001). In addition, energy intake from fruit and vegetable drink and coffee and tea drink were positively associated with soft drink consumption in men (*P* for trend = 0.0493 and 0.0201, respectively) and women (*P* for trend = 0.0207 and <0.0001, respectively).

Table 4. Sugar-sweetened beverage[a] (SSB) intake[b,c] and energy intake[b] from SSB according to soft drink consumption[d]

	Soft drink consumption						*P* for trend[b]
	Rarely	≤1/month	2–3/month	1/week	2–3/week	≥4/week	
Men (*n* = 5,432)							
SSB intake (g/day)	61.5 ± 5.7	67.9 ± 5.5	101.8 ± 9.8	93.2 ± 8.0	125.1 ± 11.2	195.4 ± 26.0	<0.0001
SSB intake (kcal/day)	64.1 ± 3.1	69.0 ± 3.2	80.5 ± 5.0	81.3 ± 4.7	95.8 ± 5.7	128.2 ± 12.2	<0.0001
Soft drink	3.3 ± 0.7	4.3 ± 0.8	10.4 ± 1.6	13.2 ± 1.9	22.2 ± 2.9	45.0 ± 7.1	<0.0001
Fruit and vegetable drink	11.8 ± 1.4	12.7 ± 1.5	15.5 ± 2.5	14.2 ± 2.1	15.4 ± 2.5	21.5 ± 6.0	0.0493
Coffee and tea drink	44.3 ± 2.4	48.0 ± 2.6	48.9 ± 3.9	49.9 ± 3.3	54.4 ± 4.0	55.3 ± 7.7	0.0201
Others	4.6 ± 1.2	4.0 ± 0.7	5.7 ± 1.3	4.1 ± 1.1	3.9 ± 1.1	6.5 ± 2.9	0.9050

Table 4. (Continued)

	Soft drink consumption						*P* for trend[b]
	Rarely	**≤1/month**	**2–3/month**	**1/week**	**2–3/week**	**≥4/week**	
Women (*n* = 8,540)							
SSB intake (g/day)	37.8 ± 3.3	47.3 ± 3.1	61.4 ± 6.1	61.2 ± 5.8	86.2 ± 8.7	185.8 ± 29.0	<0.0001
SSB intake (kcal/day)	46.5 ± 2.2	54.8 ± 2.2	59.9 ± 3.8	67.1 ± 3.8	73.4 ± 5.1	127.0 ± 17.7	<0.0001
Soft drink	2.8 ± 0.7	5.0 ± 1.0	6.8 ± 1.3	12.5 ± 2.1	16.3 ± 2.7	38.8 ± 8.1	<0.0001
Fruit and vegetable drink	7.5 ± 1.2	9.6 ± 0.9	9.7 ± 1.7	7.9 ± 1.4	10.1 ± 2.5	28.5 ± 9.0	0.0207
Coffee and tea drink	34.2 ± 1.5	37.9 ± 1.7	38.4 ± 2.4	44.8 ± 2.6	44.3 ± 4.1	56.2 ± 12.0	<0.0001
Others	2.1 ± 0.4	2.2 ± 0.4	5.1 ± 1.4	1.8 ± 0.5	2.6 ± 0.8	3.5 ± 1.3	0.0941

[a] Sugar-sweetened beverage (SSB) includes soft drink(carbonated beverages and artificially sweetened carbonated beverages), fruit and vegetable drink(excluding 100% fruit juice), coffee and tea drink(containing sugar or syrup), and other drinks such as sports drink, iced tea, and milk shake.

[b] All values (adjusted means ± standard errors) and *P*-value were obtained from a multivariate regression model accounting for the complex sampling design of the national survey. Appropriate sampling weights were used after adjustment for total energy intake, age, family income, education level, alcohol consumption, current smoking status, and physical activity.

[c] SSB intake was estimated using 24-hour dietary recall data from the 2007-2011 KNHANES

[d] Soft drink consumption was estimated using food frequency questionnaire from the 2007-2011 KNHANES

Sugar intake from SSB is presented in Table 5. Sugar intake from all SSB and soft drink increased with rising soft drink consumption frequency in men and women (*P* for trend <0.0001). Sugar intake from coffee and tea drink was positively associated with soft drink consumption in men and women (*P* for trend = 0.0127 and 0.0001, respectively), and fruit and vegetable drink and other SSB were also positively associated with soft drink consumption in women (*P* for trend = 0.0493 and 0.0201, respectively). Although energy intake from coffee and tea drink was higher than energy intake from soft drink, sugar intake from soft drink was higher than sugar intake from coffee and tea drink in the highest soft drink consumption group in men (11.1±1.7 and 6.2±0.9 g/day, respectively) and women (9.5±2.0 and 6.3±1.3 g/day, respectively).

Table 5. Sugar intake[b,c] from sugar-sweetened beverage[a] (SSB) according to soft drink consumption[d]

	Soft drink consumption						*P* for trend[b]
	Rarely	≤1/month	2–3/month	1/week	2–3/week	≥4/week	
Men (*n* = 5,432)							
Sugar from SSB (g/day)	9.6 ± 0.5	10.4 ± 0.6	13.3 ± 0.9	13.1 ± 0.8	16.4 ± 1.1	23.8 ± 2.6	<0.0001
Soft drink	0.8 ± 0.2	1.0 ± 0.2	2.5 ± 0.4	3.2 ± 0.5	5.4 ± 0.7	11.1 ± 1.7	<0.0001
Fruit and vegetable drink	2.7 ± 0.3	3.0 ± 0.4	3.6 ± 0.6	3.2 ± 0.5	3.4 ± 0.6	4.9 ± 1.5	0.0807
Coffee and tea drink	5.2 ± 0.3	5.6 ± 0.3	6.1 ± 0.5	5.8 ± 0.4	6.7 ± 0.5	6.2 ± 0.9	0.0127
Others	0.9 ± 0.3	0.8 ± 0.1	1.2 ± 0.3	0.8 ± 0.2	0.9 ± 0.3	1.5 ± 0.7	0.7264
% Energy from							
Sugar from SSB (% E)	1.6 ± 0.1	1.8 ± 0.1	2.3 ± 0.2	2.2 ± 0.1	2.8 ± 0.2	4.0 ± 0.4	<0.0001

Table 5. (Continued)

	Soft drink consumption						*P* for trend[b]
	Rarely	≤1/month	2–3/month	1/week	2–3/week	≥4/week	
Women (*n* = 8,540)							
Sugar from SSB (g/day)	6.6 ± 0.4	8.0 ± 0.4	9.2 ± 0.7	9.9 ± 0.6	12.0 ± 0.9	22.9 ± 3.2	<0.0001
Soft drink	0.5 ± 0.1	1.1 ± 0.2	1.6 ± 0.3	2.5 ± 0.4	3.9 ± 0.7	9.5 ± 2.0	<0.0001
Fruit and vegetable drink	1.7 ± 0.3	2.1 ± 0.2	2.2 ± 0.4	1.8 ± 0.3	2.4 ± 0.6	6.3 ± 2.0	0.0163
Coffee and tea drink	4.0 ± 0.2	4.4 ± 0.2	4.5 ± 0.3	5.2 ± 0.3	5.1 ± 0.5	6.3 ± 1.3	0.0001
Others	0.4 ± 0.1	0.4 ± 0.1	1.0 ± 0.3	0.3 ± 0.1	0.5 ± 0.2	0.7 ± 0.3	0.0336
% Energy from							
Sugar from SSB (% E)	1.6 ± 0.1	2.0 ± 0.1	2.2 ± 0.1	2.4 ± 0.1	3.0 ± 0.3	5.0 ± 0.6	<0.0001

[a] Sugar-sweetened beverage (SSB) includes soft drink(carbonated beverages and artificially sweetened carbonated beverages), fruit and vegetable drink(excluding 100% fruit juice), coffee and tea drink(containing sugar or syrup), and other drinks such as sports drink, iced tea, and milk shake.

[b] All values (adjusted means ± standard errors) and *P*-value were obtained from a multivariate regression model accounting for the complex sampling design of the national survey. Appropriate sampling weights were used after adjustment for total energy intake, age, family income, education level, alcohol consumption, current smoking status, and physical activity.

[c] Sugar intake was estimated using 24-hour dietary recall data from the 2007-2011 KNHANES

[d] Soft drink consumption was estimated using food frequency questionnaire from the 2007-2011 KNHANES

3.3. Association of total sugar intake and soft drink consumption with metabolic syndrome

3.3.1. Association of total sugar intake with metabolic syndrome

Association of total sugar intake with metabolic syndrome is shown in Table 6. Total sugar intake was negatively associated with diastolic blood pressure (DBP), triglyceride, and fasting glucose level in men (*P* for trend = 0.0345, 0.0028 and 0.0206, respectively), and systolic blood pressure (SBP), DBP, triglyceride, and fasting glucose level in women (*P* for trend = 0.0001, 0.0107, 0.0011 and 0.0006, respectively). However, total cholesterol and high density lipoprotein (HDL) cholesterol level was positively associated with total sugar intake in women (*P* for trend = 0.0010 and 0.0099, respectively).

Table 6. Metabolic syndrome components[a] according to quintiles of total sugar intake

	Quintiles of total sugar intake					*P* for trend[a]
	Q1 (1.4-26.5g)	**Q2 (26.6-43.1g)**	**Q3 (43.1-62.6g)**	**Q4 (62.6-90.6g)**	**Q5 (90.6-445.6g)**	
Men (*n* = 5,432)						
Waist circumference (cm)	84.3 ± 0.4	83.9 ± 0.3	83.7 ± 0.4	83.2 ± 0.3	83.6 ± 0.3	0.2078
SBP (mmHg)	117.3 ± 0.6	116.9 ± 0.5	115.8 ± 0.5	116.6 ± 0.5	115.6 ± 0.5	0.0601
DBP (mmHg)	78.1 ± 0.4	78.1 ± 0.4	77.5 ± 0.4	77.6 ± 0.4	77.0 ± 0.4	0.0345
Total cholesterol (mg/dL)	187.2 ± 1.5	190.4 ± 1.4	189.6 ± 1.3	192.2 ± 1.4	190.9 ± 1.4	0.1518
HDL cholesterol (mg/dL)	45.6 ± 0.5	45.0 ± 0.3	45.6 ± 0.4	45.3 ± 0.4	45.2 ± 0.4	0.7998
Triglyceride (mg/dL)	158.6 ± 5.6	147.7 ± 4.5	142.1 ± 3.8	147.2 ± 5.9	134.8 ± 3.9	0.0028
Fasting glucose (mg/dL)	96.7 ± 0.8	96.3 ± 0.7	94.9 ± 0.7	94.5 ± 0.6	94.6 ± 0.6	0.0206

Table 6. (Continued)

	Quintiles of total sugar intake					*P* for trend[a]
	Q1 (1.6-23.2g)	Q2 (23.2-38.7g)	Q3 (38.7-56.2g)	Q4 (56.2-84.3g)	Q5 (84.3-762.3g)	
Women (*n* = 8,540)						
Waist circumference (cm)	77.7 ± 0.3	77.4 ± 0.3	77.4 ± 0.3	76.6 ± 0.3	77.0 ± 0.3	0.0827
SBP (mmHg)	112. 4 ± 0.5	112.6 ± 0.5	111.9 ± 0.5	110.4 ± 0.4	110.5 ± 0.5	0.0001
DBP (mmHg)	72.7 ± 0.3	73.2 ± 0.3	72.6 ± 0.3	72.0 ± 0.3	72.0 ± 0.3	0.0107
Total cholesterol (mg/dL)	184.2 ± 1.1	187.9 ± 1.0	186.3 ± 1.0	186.3 ± 1.0	190.7 ± 1.2	0.0010
HDL cholesterol (mg/dL)	51.2 ± 0.4	51.8 ± 0.3	51.8 ± 0.3	52.2 ± 0.3	52.6 ± 0.4	0.0099
Triglyceride (mg/dL)	115.2 ± 3.0	112.5 ± 2.5	106.8 ± 2.1	104.2 ± 2.2	105.0 ± 2.4	0.0011
Fasting glucose (mg/dL)	92.6 ± 0.5	91.9 ± 0.4	92.5 ± 0.5	91.7 ± 0.4	90.6 ± 0.4	0.0006

[a] All values (adjusted means ± standard errors) and *P* for trend were obtained from a multivariate regression model accounting for the complex sampling design of the national survey. Appropriate sampling weights were used after adjustment for total energy intake, age, family income, education level, alcohol consumption, current smoking status, and physical activity.

Abbreviation: SBP, systolic blood pressure; DBP, diastolic blood pressure; HDL, high density lipoprotein.

3.3.2. Association of soft drink consumption with metabolic syndrome

Soft drink consumption was positively associated with all metabolic syndrome components in women with the exception of HDL cholesterol level. By contrast, soft drink consumption was not associated with metabolic syndrome components in men (Table 7).

Table 7. Metabolic syndrome components[a] according to soft drink consumption

	Soft drink consumption						*P* for trend[a]
	Rarely	≤1/month	2–3/month	1/week	2–3/week	≥4/week	
Men (n = 5,432)							
Waist circumference (cm)	83.4 ± 0.3	83.6 ± 0.3	84.2 ± 0.5	83.4 ± 0.4	84.1 ± 0.4	84.8 ± 0.7	0.0691
SBP (mmHg)	116.4 ± 0.4	115.9 ± 0.5	116.6 ± 0.7	115.7 ± 0.6	116.9 ± 0.6	118.3 ± 1.1	0.2532
DBP (mmHg)	77.8 ± 0.3	77.6 ± 0.3	77.3 ± 0.5	77.2 ± 0.5	77.7 ± 0.5	78.7 ± 0.9	0.9779
Total cholesterol (mg/dL)	188.6 ± 1.2	191.1 ± 1.2	190.9 ± 1.6	190.6 ± 1.5	191.8 ± 1.6	188.7 ± 2.5	0.3231
HDL cholesterol (mg/dL)	45.6 ± 0.3	45.5 ± 0.3	45.0 ± 0.4	45.2 ± 0.5	45.1 ± 0.4	44.9 ± 0.7	0.2305
Triglyceride (mg/dL)	148.1 ± 4.9	145.2 ± 3.9	140.3 ± 4.5	144.3 ± 5.3	143.2 ± 5.1	148.2 ± 7.8	0.5787
Fasting glucose (mg/dL)	94.6 ± 0.5	95.2 ± 0.5	94.8 ± 0.6	94.3 ± 0.6	97.5 ± 1.3	97.3 ± 1.9	0.0677

Table 7. (Continued)

	Soft drink consumption						*P* for trend[a]
	Rarely	**≤1/month**	**2–3/month**	**1/week**	**2–3/week**	**≥4/week**	
Women (*n* = 8,540)							
Waist circumference (cm)	76.5 ± 0.2	77.2 ± 0.2	77.6 ± 0.4	78.6 ± 0.4	79.0 ± 0.6	78.3 ± 0.9	<0.0001
SBP (mmHg)	110.9 ± 0.3	111.5 ± 0.4	111.9 ± 0.6	112.9 ± 0.6	113.1 ± 0.9	113.5 ± 1.4	<0.0001
DBP (mmHg)	72.2 ± 0.2	72.5 ± 0.3	72.5 ± 0.4	73.1 ± 0.4	73.1 ± 0.6	73.4 ± 1.1	0.0245
Total cholesterol (mg/dL)	185.5 ± 0.8	186.9 ± 0.8	188.4 ± 1.4	189.7 ± 1.3	189.8 ± 1.9	197.3 ± 4.2	<0.0001
HDL cholesterol (mg/dL)	52.2 ± 0.3	51.6 ± 0.3	51.9 ± 0.4	51.7 ± 0.5	51.7 ± 0.6	53.3 ± 1.1	0.5674
Triglyceride (mg/dL)	105.7 ± 1.9	108.6 ± 2.2	107.9 ± 2.4	117.0 ± 3.1	113.2 ± 3.5	121.7 ± 6.6	<0.0001
Fasting glucose (mg/dL)	91.2 ± 0.3	92.4 ± 0.4	91.9 ± 0.6	92.4 ± 0.5	92.8 ± 0.7	92.1 ± 1.0	0.0057

[a] All values (adjusted means ± standard errors) and *P* for trend were obtained from a multivariate regression model accounting for the complex sampling design of the national survey. Appropriate sampling weights were used after adjustment for total energy intake, age, family income, education level, alcohol consumption, current smoking status, and physical activity.

Abbreviation: SBP, systolic blood pressure; DBP, diastolic blood pressure; HDL, high density lipoprotein.

3.3.3. Risk of metabolic syndrome according to total sugar intake

Table 8 shows risk of metabolic syndrome components according to quintiles of total sugar intake. Metabolic syndrome components were negatively associated with total sugar intake in men and women. Men and women in the highest quintile of total sugar intake had a 30% (OR: 0.70; 95% CI: 0.55-0.88; *P* for trend = 0.0136) and a 23% (OR: 0.77; 95% CI: 0.60-0.99; *P* for trend = 0.0329) lower risk of elevated triglyceride than did those in the lowest quintile, respectively. Women in the highest quintile of total sugar intake had a 35% lower risk of elevated blood pressure (OR: 0.65; 95% CI: 0.50-0.86; *P* for trend = 0.0003) and a 19% lower risk of reduced HDL cholesterol level (OR: 0.81; 95% CI: 0.67-0.99; *P* for trend = 0.0384) than did those in the lowest quintile. In addition, risk of metabolic syndrome in the highest quintile was 36% lower than the lowest quintile in women (OR: 0.64; 95% CI: 0.49-0.82; *P* for trend = 0.0015).

Table 8. Multivariate adjusted odds ratios and 95% CI values[a] for metabolic syndrome components[b] according to quintiles of total sugar intake

	Quintiles of total sugar intake					*P* for trend[a]
	Q1 (1.4-26.5g)	Q2 (26.6-43.1g)	Q3 (43.1-62.6g)	Q4 (62.6-90.6g)	Q5 (90.6-445.6g)	
Men (*n* = 5,432)						
Increased waist circumference	1.00	0.74 (0.57-0.97)	0.78 (0.59-1.02)	0.75 (0.57-0.99)	0.83 (0.61-1.11)	0.7171
Elevated blood pressure	1.00	0.96 (0.76-1.22)	0.77 (0.60-0.98)	0.83 (0.64-1.07)	0.78 (0.60-1.00)	0.0560
Reduced HDL cholesterol	1.00	0.98 (0.78-1.24)	1.08 (0.86-1.37)	1.05 (0.81-1.34)	1.08 (0.83-1.40)	0.5195
Elevated triglyceride	1.00	0.84 (0.68-1.04)	0.76 (0.61-0.95)	0.78 (0.62-0.99)	0.70 (0.55-0.88)	0.0136
Elevated fasting glucose	1.00	0.93 (0.75-1.17)	0.78 (0.62-1.00)	0.72 (0.56-0.93)	0.84 (0.64-1.10)	0.2177
Metabolic syndrome	1.00	0.86 (0.67-1.09)	0.74 (0.57-0.95)	0.74 (0.57-0.97)	0.79 (0.61-1.03)	0.1879

Table 8. (Continued)

	Quintiles of total sugar intake					*P* for trend[a]
	Q1 (1.6-23.2g)	Q2 (23.2-38.7g)	Q3 (38.7-56.2g)	Q4 (56.2-84.3g)	Q5 (84.3-762.3g)	
Women (*n* = 8,540)						
Increased waist circumference	1.00	0.89 (0.74-1.06)	0.91 (0.75-1.10)	0.81 (0.67-0.97)	0.89 (0.72-1.10)	0.3313
Elevated blood pressure	1.00	1.00 (0.80-1.26)	0.88 (0.70-1.12)	0.74 (0.58-0.94)	0.65 (0.50-0.86)	0.0003
Reduced HDL cholesterol	1.00	0.91 (0.78-1.08)	0.91 (0.76-1.08)	0.82 (0.69-0.98)	0.81 (0.67-0.99)	0.0384
Elevated triglyceride	1.00	0.94 (0.76-1.16)	0.86 (0.70-1.07)	0.78 (0.62-0.99)	0.77 (0.60-0.99)	0.0329
Elevated fasting glucose	1.00	0.91 (0.73-1.14)	1.05 (0.84-1.32)	0.91 (0.71-1.17)	0.83 (0.63-1.08)	0.1614
Metabolic syndrome	1.00	0.78 (0.63-0.97)	0.88 (0.71-1.10)	0.74 (0.58-0.93)	0.64 (0.49-0.82)	0.0015

[a] All values and *P* for trend were obtained from a multivariate logistic regression model accounting for the complex sampling design of the national survey. Appropriate sampling weights were used after adjustment for total energy intake, age, family income, education level, alcohol consumption, current smoking status, and physical activity. [b] Metabolic syndrome diagnosis requires the presence of three or more of following components: increased waist circumference (≥90 cm for men and ≥80 cm for women); elevated blood pressure (SBP ≥130 mmHg or DBP ≥85 mmHg); reduced HDL cholesterol (<40 mg/dL for men and <50 mg/dL for women); elevated triglyceride (triglyceride levels ≥150 mg/dL); and elevated fasting glucose (fasting plasma glucose levels ≥100 mg/dL).

Abbreviation: SBP, systolic blood pressure; DBP, diastolic blood pressure; HDL, high density lipoprotein.

3.3.4. Risk of metabolic syndrome according to soft drink consumption

Risk of metabolic syndrome components according to soft drink consumption is shown in Table 9. Metabolic syndrome was associated with soft drink consumption in women but not men. Women in the highest soft drink consumption group had a 74% higher risk of metabolic syndrome than did those in the lowest group (OR: 1.74; 95% CI: 1.00–3.03; *P* for trend <0.0001). Association of increased waist circumference, and blood pressure, triglyceride, and fasting glucose with soft drink consumption showed a positive linear trend in women.

Table 9. Multivariate adjusted odds ratios and 95% CI values[a] for metabolic syndrome components[b] according to soft drink consumption

	Soft drink consumption						*P* for trend[a]
	Rarely	**≤1/month**	**2–3/month**	**1/week**	**2–3/week**	**≥4/week**	
Men (*n* = 5,432)							
Increased waist circumference	1.00	0.93 (0.76–1.15)	1.18 (0.91-1.53)	1.00 (0.78-1.29)	1.21 (0.94-1.57)	1.14 (0.77-1.68)	0.1167
Elevated blood pressure	1.00	0.96 (0.80–1.16)	0.84 (0.67–1.07)	0.82 (0.65–1.05)	0.88 (0.67–1.14)	1.17 (0.81–1.71)	0.4177
Reduced HDL cholesterol	1.00	0.88 (0.73–1.05)	0.96 (0.75–1.21)	0.90 (0.72–1.13)	0.88 (0.69–1.12)	0.76 (0.52–1.12)	0.2152
Elevated triglyceride	1.00	1.01 (0.85–1.20)	0.99 (0.78–1.26)	0.89 (0.72–1.10)	0.94 (0.74–1.19)	1.16 (0.82–1.65)	0.7118
Elevated fasting glucose	1.00	1.13 (0.94–1.38)	1.00 (0.77–1.31)	1.08 (0.85–1.36)	1.21 (0.93–1.57)	1.30 (0.89–1.91)	0.1733
Metabolic syndrome	1.00	0.97 (0.78–1.21)	1.10 (0.84–1.42)	0.94 (0.73–1.21)	0.98 (0.73–1.32)	1.19 (0.80–1.76)	0.7890

Table 9. (Continued)

	Soft drink consumption						*P* for trend[a]
	Rarely	≤1/month	2–3/month	1/week	2–3/week	≥4/week	
Women (*n* = 8,540)							
Increased waist circumference	1.00	1.15 (1.00–1.32)	1.27 (1.06–1.53)	1.58 (1.27–1.96)	1.68 (1.29–2.19)	1.28 (0.84–1.97)	<0.0001
Elevated blood pressure	1.00	0.97 (0.81–1.16)	1.11 (0.85–1.46)	1.33 (0.99–1.77)	1.41 (0.99–2.00)	0.94 (0.46–1.92)	0.0418
Reduced HDL cholesterol	1.00	1.11 (0.98–1.26)	1.10 (0.93–1.30)	1.08 (0.89–1.31)	1.03 (0.80–1.33)	0.97 (0.65–1.46)	0.5255
Elevated triglyceride	1.00	1.10 (0.93–1.30)	0.97 (0.75–1.24)	1.62 (1.25–2.10)	1.35 (0.95–1.91)	1.63 (0.95–2.80)	0.0007
Elevated fasting glucose	1.00	1.19 (1.01–1.41)	1.27 (0.97–1.64)	1.22 (0.92–1.61)	1.30 (0.95–1.79)	1.47 (0.87–2.48)	0.0099
Metabolic syndrome	1.00	1.16 (0.98–1.38)	1.28 (0.99–1.65)	1.74 (1.31–2.31)	1.60 (1.16–2.21)	1.74 (1.00–3.03)	<0.0001

[a] All values and *P* for trend were obtained from a multivariate logistic regression model accounting for the complex sampling design of the national survey. Appropriate sampling weights were used after adjustment for total energy intake, age, family income, education level, alcohol consumption, current smoking status, and physical activity. [b] Metabolic syndrome diagnosis requires the presence of three or more of following components: increased waist circumference (≥90 cm for men and ≥80 cm for women); elevated blood pressure (SBP ≥130 mmHg or DBP ≥85 mmHg); reduced HDL cholesterol (<40 mg/dL for men and <50 mg/dL for women); elevated triglyceride (triglyceride levels ≥150 mg/dL); and elevated fasting glucose (fasting plasma glucose levels ≥100 mg/dL).

Abbreviation: SBP, systolic blood pressure; DBP, diastolic blood pressure; HDL, high density lipoprotein.

The association of soft drink consumption with metabolic syndrome in the highest soft drink consumption group was attenuated after further adjusting for BMI, however, a positive tendency still significantly remained in women (OR: 1.67; 95% CI: 0.86-3.25; *P* for trend = 0.0086). Furthermore, the positive linear trend in blood pressure and fasting glucose disappeared after further adjusting for BMI in women.

Table 10. Multivariate adjusted odds ratios and 95% CI values[a] for metabolic syndrome components[b] according to soft drink consumption, BMI-adjusted analysis

	Soft drink consumption						***P* for trend[a]**
	Rarely	**≤1/month**	**2–3/month**	**1/week**	**2–3/week**	**≥4/week**	
Men (*n* = 5,432)			**+ BMI adjusted**				
Increased waist circumference	1.00	0.76 (0.56-1.02)	1.00 (0.70-1.44)	0.99 (0.71-1.37)	1.09 (0.76-1.56)	0.93 (0.52-1.67)	0.4327
Elevated blood pressure	1.00	0.92 (0.77-1.11)	0.79 (0.62-1.00)	0.83 (0.65-1.05)	0.84 (0.64-1.10)	1.12 (0.76-1.65)	0.3075
Reduced HDL cholesterol	1.00	0.84 (0.70-1.02)	0.90 (0.70-1.16)	0.90 (0.72-1.13)	0.83 (0.65-1.07)	0.71 (0.48-1.05)	0.1084
Elevated triglyceride	1.00	0.97 (0.81-1.15)	0.93 (0.72-1.20)	0.89 (0.72-1.11)	0.88 (0.70-1.12)	1.10 (0.76-1.59)	0.4629
Elevated fasting glucose	1.00	1.10 (0.91-1.34)	0.95 (0.73-1.24)	1.09 (0.85-1.38)	1.17 (0.89-1.53)	1.25 (0.86-1.83)	0.2463
Metabolic syndrome	1.00	0.89 (0.70-1.12)	0.96 (0.70-1.31)	0.92 (0.70-1.21)	0.84 (0.61-1.17)	1.06 (0.70-1.60)	0.6004

Table 10. (Continued)

	Soft drink consumption						*P* for trend[a]
	Rarely	**≤1/month**	**2–3/month**	**1/week**	**2–3/week**	**≥4/week**	
Women (n = 8,540)			**+ BMI adjusted**				
Increased waist circumference	1.00	1.06 (0.86-1.30)	1.18 (0.89-1.57)	1.41 (1.03-1.94)	1.19 (0.80-1.79)	1.27 (0.66-2.42)	0.0430
Elevated blood pressure	1.00	0.93 (0.77-1.12)	1.06 (0.80-1.39)	1.25 (0.93-1.68)	1.25 (0.87-1.79)	0.88 (0.41-1.91)	0.2027
Reduced HDL cholesterol	1.00	1.08 (0.95-1.22)	1.05 (0.88-1.25)	1.01 (0.83-1.24)	0.93 (0.72-1.19)	0.93 (0.62-1.39)	0.7429
Elevated triglyceride	1.00	1.05 (0.88-1.25)	0.90 (0.70-1.17)	1.50(1.14-1.99)	1.17 (0.82-1.68)	1.57 (0.91-2.71)	0.0172
Elevated fasting glucose	1.00	1.15 (0.97-1.36)	1.19 (0.91-1.55)	1.10 (0.83-1.47)	1.11 (0.80-1.55)	1.38 (0.82-2.31)	0.1439
Metabolic syndrome	1.00	1.08 (0.89-1.32)	1.14 (0.86-1.52)	1.55 (1.11-2.17)	1.22 (0.84-1.78)	1.67 (0.86-3.25)	0.0086

[a] All values and *P* for trend were obtained from a multivariate logistic regression model accounting for the complex sampling design of the national survey. Appropriate sampling weights were used after adjustment for total energy intake, age, family income, education level, alcohol consumption, current smoking status, physical activity, and BMI [b] Metabolic syndrome diagnosis requires the presence of three or more of following components: increased waist circumference (≥90 cm for men and ≥80 cm for women); elevated blood pressure (SBP ≥130 mmHg or DBP ≥85 mmHg); reduced HDL cholesterol (<40 mg/dL for men and <50 mg/dL for women); elevated triglyceride (triglyceride levels ≥150 mg/dL); and elevated fasting glucose (fasting plasma glucose levels ≥100 mg/dL).

Abbreviation: BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; HDL, high density lipoprotein.

3.3.5. Comparison of associations of total sugar intake and soft drink consumption with metabolic syndrome

Figure 4 shows associations of total sugar intake and soft drink consumption with metabolic syndrome components as a Forrest plot. The highest soft drink consumption group had significantly higher risk of elevated triglyceride (OR: 1.49; 95% CI: 1.11–2.00; *P* for trend = 0.0002) and fasting glucose (OR: 1.46; 95% CI: 1.08–1.97; *P* for trend = 0.0002), and metabolic syndrome (OR: 1.52; 95% CI: 1.11–2.08; *P* for trend = 0.0001) compared to the lowest consumption group, while the highest quintile of total sugar intake had significantly lower risk of elevated blood pressure (OR: 0.62; 95% CI: 0.52–0.74; *P* for trend <0.0001), triglyceride (OR: 0.60; 95% CI: 0.50–0.72; *P* for trend <0.0001) and fasting glucose (OR: 0.74; 95% CI: 0.61–0.89; *P* for trend = 0.0145), and metabolic syndrome (OR: 0.67; 95% CI: 0.56–0.81; *P* for trend = 0.0012) compared to the lowest quintile.

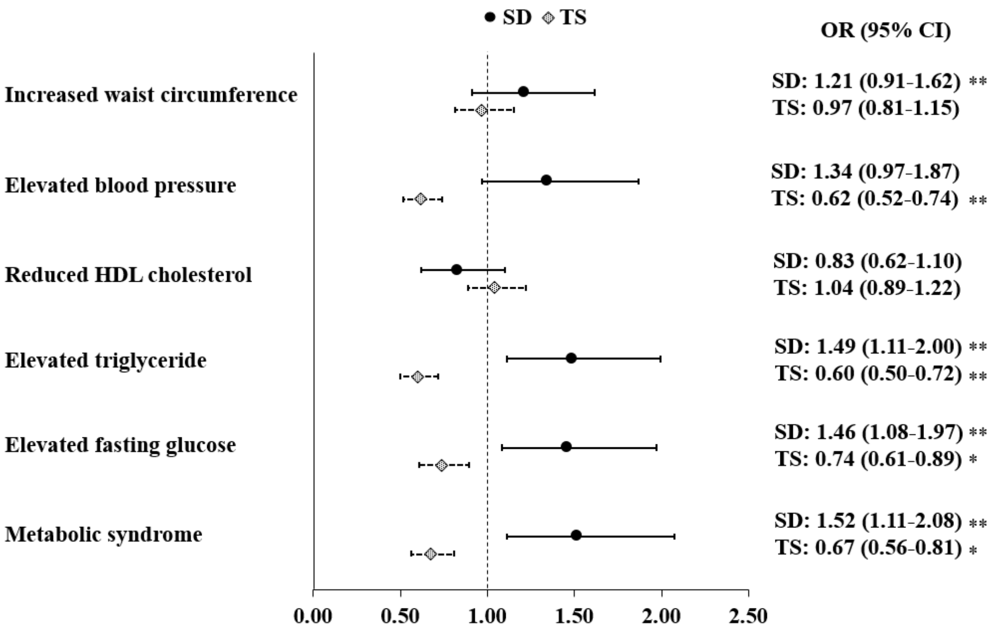

Figure 4. Forrest plot of associations[a] of total sugar intake and soft drink consumption with metabolic syndrome components[b], comparing extreme intake groups.

[a] All values and *P* for trend were obtained from a multivariate logistic regression model accounting for the complex sampling design of the national survey. Appropriate sampling weights were used after adjustment for total energy intake, age, family income, education level, alcohol consumption, current smoking status, and physical activity * *P* for trend <0.005, ** *P* for trend <0.0001

[b] Metabolic syndrome diagnosis requires the presence of three or more of following components: increased waist circumference (≥90 cm for men and ≥80 cm for women); elevated blood pressure (SBP ≥130 mmHg or DBP ≥85 mmHg); reduced HDL cholesterol (<40 mg/dL for men and <50 mg/dL for women); elevated triglyceride (triglyceride levels ≥150 mg/dL); and elevated fasting glucose (fasting plasma glucose levels ≥100 mg/dL).

Abbreviation: SD, soft drink; TS: total sugar; SBP, systolic blood pressure; DBP, diastolic blood pressure; HDL, high density lipoprotein.

Ⅳ. Discussion

This study of 13,972 Korean adult participants in the 2007–2011 KNHANES revealed that soft drink consumption was positively associated with metabolic syndrome only in women. The risk of metabolic syndrome was 74% higher for women in the highest soft drink consumption group than for those in the lowest group. However, total sugar intake was negatively associated with metabolic syndrome in men and women.

Findings of this study were consistent with previous studies conducted in Western populations, that SSB was associated with increased risks for metabolic disease. However, a discrepancy was that the portion size reported by most studies in Western population was one or more SSB servings (one serving = 355 mL or a 12-ounce can) per day (10, 28, 29), while the highest consumption group reported approximately 0.5 servings per day.

One cohort study in Koreans reported that an average of one cup of soft drink per week was associated with a 17% higher risk of metabolic syndrome (30) and another study in Singapore Chinese found that two or more servings of SSBs per week was associated with an 87% increased risk for pancreatic cancer (31). These findings suggest that soft drink consumption at levels lower than those reported for Western populations could be associated with the development of chronic diseases in Asian populations.

Several possible mechanisms have been proposed to link soft drink consumption with metabolic syndrome risk. First, soft drinks contain high amounts of added sugar, which are rapidly absorbed in liquid form (7). SSBs have a moderate glycemic index (GI), but the glycemic load (GL) is high because the drinks are consumed in large quantities, and high GL is associated with impaired glycemic control (32). Another possible mechanism potentially involves fructose, a major component of sugar-sweetened drinks. Fructose is more likely to metabolize to lipids in the liver, providing a link with increased triglyceride levels, which are associated with metabolic dysfunction (33). Moreover, recently, artificial sweeteners have also been reported to be responsible for glucose intolerance. Continued consumption of artificial sweeteners can alter the gut microbiota, which may lead to the induction of metabolic abnormalities, such as glucose intolerance (34).

Contrary to above finding, total sugar intake was negatively associated with metabolic syndrome components. However, total sugar intake level among Koreans was also lower than that in the Western population. The average intake of total sugar in this sample was 62.8 g/day, while that of in Western population was 130 g/day in the United States (35) and 110 g/day in Canada (36). There was a recommendation to limit added sugar intake because added sugar intake leads to insufficient intake of essential micronutrients in the United States (37), however, micronutrient and macronutrient intake in this sample increased across quintiles of total sugar intake. In particular, the highest quintile in women mainly consumed total sugar intake from fruits and they had a 36% lower risk of metabolic syndrome. Thus, this finding implies that examining the association between total sugar intake and metabolic diseases in Korean population is limited due to the low total sugar intake level and balanced nutrition status with high total sugar intake, and major food source of sugar intake plays important role in analyzing the association of sugar intake and metabolic diseases.

Another significant finding was a positive association between soft drink consumption and metabolic syndrome in women, but not in men, even though the proportion of the highest consumption group in women was lower than that in men. It is unclear why only women showed a positive association between soft drink consumption and metabolic disease. However, previous studies in Asian populations reported the same tendency - that high GI and GL were positively associated with components of metabolic syndrome in women, but not men. A study in Japan reported that those in the highest quartile of dietary GL had a 52% higher risk of type 2 diabetes than those in the lowest quartile among women, but not men (38). Another study of Koreans reported that GI and GL were positively associated with metabolic syndrome in women but not men (39). Moreover, a Chinese female cohort study found that those in the highest dietary GI and GL quintiles had a 21 and 34% higher risk of type 2 diabetes, respectively, than women in the lowest quintile (40). Although the factors underlying the much stronger association between dietary sugar and metabolic syndrome in Asian women are not understood, Knopp et al. indicated that estrogens and androgens affect lipoprotein metabolism in opposite ways, and this gender difference leads to different responses to high carbohydrate diets by gender (41). This different response to high sugar consumption in Asian populations warrants further investigation.

High consumption of soft drink is also related to dietary patterns and health behaviors. Americans who tended to consume more snacks, high-fat foods, and fast food had a higher risk of drinking calorically sweetened beverages, such as coffee, fruit and vegetable juice, whole-fat milk, and soft drinks (42). A previous study identified healthy and unhealthy dietary patterns in Korean adults. The unhealthy dietary pattern included soft drinks, high consumption of refined grains and alcoholic beverages, and low consumption of fruits, vegetables, and legumes (30). In this sample, the proportion of participants who skip breakfast was almost three times greater among men and women in the highest (31.6 and 28.7%, respectively) than among those in the lowest soft drink consumption group (10.5 and 10.3%, respectively) (Appendix 1). Moreover, this study found that significantly more men (16.2%) and women (9.9%) in the highest soft drink consumption groups ate out frequently (≥2 times a day) compared with those in the lowest soft drink consumption group (men 11.7 and women 2.2%) (Appendix 1).

Health behaviors varied according to soft drink consumption (Appendix 2). Women in the highest soft drink consumption group were more likely to consume alcohol frequently than were those in the lowest group. The proportion of women who consumed alcohol ≥2 times per week in the highest soft drink consumption group was more than two times higher than that in the group with the lowest soft drink consumption (22.2 and 9.6%, respectively). Moreover, it was found that men and women in the highest soft drink consumption group were more likely to smoke and reported more stress compared with participants in the lowest group. Hu (4) argued that the scientific evidence was sufficient to recommend a reduction in SSB consumption to prevent chronic disease, although the current evidence provides no absolute proof.

This study has limitations and strengths. First, the cross-sectional design of this study did not allow this study to establish a causal relationship between soft drink consumption and total sugar intake and the development of metabolic syndrome. Second, soft drink consumption was defined as a frequency based because the amount of intake and energy intake from soft drinks were too low to be divided into several groups for analyses. Thus, this study grouped participants based on soft drink consumption frequency and further assessed amount of intake and energy intake from soft drinks, and compared sugar intake or its food sources based on 24-hour dietary recall data by soft drink consumption frequency groups. Additionally, the food frequency questionnaire provided usual consumption patterns. Finally, this study examined only the soft drink consumption among SSBs because the food frequency questionnaire in KNHANES had no information about other types of SSBs. Therefore, soft drink consumption in this study may not reflect the overall consumption of SSB, however, this study examined that amount of intake and energy intake from several types of SSBs increased across soft drink consumption groups. As soft drinks and SSBs receive paid more attention, the type and amount of SSBs should be considered in the food-frequency questionnaire in the KNHANES.

Despite these limitations, the strengths of this study include the large sample, selected from a nationally representative survey conducted in Korea. This is the first study to investigate the associations of SSB consumption with metabolic syndrome components and compare the associations of SSB and total sugar intake with metabolic syndrome risk according to sex in a large sample of Korean adults. Further studies are needed to confirm this finding in a prospective study and to explore the mechanism underlying the association between soft drink consumption and metabolic disease in Asian women.

Ⅴ. Summary and conclusion

This study of 13,972 Korean adult participants in the 2007–2011 KNHANES revealed that soft drink consumption was positively associated with metabolic syndrome in women. However, total sugar intake was negatively associated with metabolic syndrome components in men and women.

Although soft drink consumption and total sugar intake in Korean population were low compared to the Western population, major sugar sources of soft drink consumption and total sugar intake were different. Soft drink consumption was positively associated with sugar intake from processed foods and negatively associated with sugar intake from milk and fruits. Greater total sugar intake was related to sufficient nutrient intake and high sugar intake from milk and fruits. The difference of sugar intake by its food sources and the tendency of metabolic syndrome risk were more distinct in women than in men among both soft drink consumption groups and quintiles of total sugar intake.

In conclusion, high levels of soft drink consumption might constitute an important determinant of metabolic syndrome and its components in Korean adult women.

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Appendices

Appendix 1. Eating behaviors[a] of participants according to soft drink consumption

	Soft drink consumption						*P*-value[b]
	Rarely	**≤1/month**	**2-3/month**	**1/week**	**2-3/week**	**≥4/week**	
Men (n=5,432)							
Total (*n*, %)	1,780 (27.9)	1,423 (26.0)	634 (12.3)	784 (15.8)	611 (13.4)	200 (4.6)	<.0001
Skipping breakfast[c] (%)							<.0001
Often	10.5	12.5	14.9	18.5	24.9	31.6	
Occasionally	7.6	8.6	10.4	11.0	13.1	11.5	
Rarely	81.8	78.9	74.7	70.5	62.0	56.9	
Eating-out (%)							<.0001
≥ 2 times/day	11.7	12.3	13.9	17.4	16.2	16.2	
Once a day	19.1	21.9	28.9	26.6	29.7	32.9	
1-6 times/week	38.3	45.8	42.5	43.5	41.3	37.4	
1-3 times/month	17.3	13.5	9.0	9.0	9.3	10.2	
Rarely	13.6	6.5	5.8	3.5	3.5	3.2	

Appendix 1. (Continued)

	Soft drink consumption						*P*-value[b]
	Rarely	≤1/month	2-3/month	1/week	2-3/week	≥4/week	
Women (n=8,540)							
Total (*n*, %)	3,944 (44.5)	2,456 (29.1)	879 (10.5)	742 (9.3)	384 (4.9)	135 (1.7)	<.0001
Skipping breakfast[c] (%)							<.0001
Often	10.3	11.5	14.3	16.8	24.6	28.7	
Occasionally	7.5	9.5	9.1	9.2	11.7	12.7	
Rarely	82.2	78.9	76.6	74.0	63.7	58.6	
Eating-out (%)							<.0001
≥ 2 times/day	2.2	3.0	4.1	4.5	4.2	9.9	
Once a day	6.3	7.0	6.8	8.6	8.3	17.6	
1-6 times/week	39.9	46.2	47.2	55.1	50.1	48.4	
1-3 times/month	32.9	33.0	34.0	26.1	30.1	15.8	
Rarely	18.7	10.8	7.9	5.7	7.4	8.3	

[a] All values reflected the complex sampling design of the national survey, and appropriate sampling weights were used.

[b] *P*-values were derived from the χ^2 test for categorical variables.

[c] Skipping breakfast was based on the question "Did you skip breakfast the day before yesterday/yesterday?": Often, skipped for 2 days; Occasionally, skipped for a day; Rarely, did not skip for 2 days

Appendix 2. Health behaviors[a] of participants according to soft drink consumption

	Soft drink consumption						P-value[b]
	Rarely	≤1/month	2-3/month	1/week	2-3/week	≥4/week	
Men (*n*=5,432)							
Total (*n*, %)	1,780 (27.9)	1,423 (26.0)	634 (12.3)	784 (15.8)	611 (13.4)	200 (4.6)	<.0001
Alcohol consumption[c] (%)							0.0310
Never or rarely	24.0	23.8	26.8	22.8	23.7	23.9	
1-4/month	32.3	37.9	37.5	38.5	40.6	34.2	
≥2/week	43.7	38.3	35.6	38.7	35.7	41.9	
Smoking status (%)							<.0001
Yes	44.1	42.9	43.7	56.0	54.9	64.9	
No	55.9	57.1	56.3	44.0	45.1	35.1	
Physical activity[d] (%)							0.0429
<5 times/week	56.2	58.6	61.1	63.3	56.2	55.0	
≥5 times/week	43.8	41.4	38.9	36.7	43.8	45.0	
Stress recognition (%)							0.0212
Always, Usually	23.0	24.1	27.3	28.5	29.2	30.2	
Occasionally, Rarely	77.0	75.9	72.7	71.5	70.8	69.8	

Appendix 2. (Continued)

	Soft drink consumption						*P*-value[b]
	Rarely	**≤1/month**	**2-3/month**	**1/week**	**2-3/week**	**≥4/week**	
Women (*n*=8,540)							
Total (*n*, %)	3,944 (44.5)	2,456 (29.1)	879 (10.5)	742 (9.3)	384 (4.9)	135 (1.7)	<.0001
Alcohol consumption[c] (%)							<.0001
Never or rarely	62.2	56.0	52.0	50.7	45.3	44.7	
1-4/month	28.2	34.7	37.8	37.4	37.1	33.1	
≥2/week	9.6	9.3	10.1	11.9	17.6	22.2	
Smoking status (%)							0.0067
Yes	5.1	5.3	5.7	6.7	9.9	9.9	
No	94.9	94.7	94.3	93.3	90.1	90.1	
Physical activity[d] (%)							0.0613
<5 times/week	58.4	61.8	63.1	63.1	58.0	56.5	
≥5 times/week	41.6	38.2	36.9	36.9	42.0	43.5	
Stress recognition (%)							<.0001
Always, Usually	27.1	25.6	29.6	31.5	36.0	49.0	
Occasionally, Rarely	72.9	74.4	70.4	68.5	64.0	51.0	

[a] All values reflected the complex sampling design of the national survey, and appropriate sampling weights were used.

[b] *P*-values were derived from the χ^2 test for categorical variables.

[c] Alcohol consumption was based on the question "How often during the last year have you had an alcoholic drink?"

[d] Physical activity was defined as walking ≥30 min each time.

Korean Abstract

한국 성인의 탄산음료 섭취와 대사증후군의 관련성: 2007-2011 국민건강영양조사자료를 이용하여

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가공식품 섭취가 증가하면서 가당음료(SSB)의 섭취가 전세계적으로 증가하고 있다. 이에 따라, 서양인을 대상으로 가당음료의 섭취와 대사질환의 연관성을 분석한 여러 연구들에서 양의 연관성이 보고되고 있다.
한국인은 가공식품 중 가당음료를 통해 가장 많은 당을 섭취하고 있는 것으로 보고되었고 그 중 탄산음료가 여러 음료들 가운데 가장 높은 당류 급원식품으로 밝혀진 바 있다. 하지만 현재 한국인을 대상으로

가당음료 섭취와 대사 질환과의 연관성을 분석한 연구는 부족한 실정이다. 따라서 본 연구에서는 한국 성인의 탄산음료 섭취와 대사증후군의 연관성을 알아보고자 하였다.

2007-2011 년 국민건강영양조사에 참여한 13,972 명 (남자 5,432 명, 여자 8,540 명)의 30 세 이상 성인을 대상자로 선정하였고, 대상자는 식품섭취빈도조사에서 응답한 '탄산음료' 섭취 수준에 근거하여 여섯 그룹으로 분류하였다. 또한 대사증후군과 탄산음료 섭취, 그리고 대사증후군과 총 당류 섭취와의 연관성을 비교하기 위해 총 당류 섭취량을 24 시간 식사 회상법 자료를 이용하여 5 분위로 나누어 탄산음료 섭취 그룹과 비교 분석하였다. 영양소 섭취량은 24 시간 식사 회상법 자료를 이용하여 산출해 그룹간 비교하였다.

가장 높은 탄산음료 섭취 빈도는 '≥4 회/주' 이었으며, 남자는 4.6%, 여자는 1.7%를 차지하고 있었다. 가공식품을 통한 에너지 대비 당 섭취비율은 탄산음료 섭취에 따라 증가하였지만, 가장 높은 탄산음료 섭취 그룹에서 가공식품을 통한 에너지 대비 당 섭취비율은 여자가 11.0%, 남자가 8.9%로 여자에게서 더 높았다. 우유와 과일을 통한 에너지 대비 당 섭취비율은 여자에서 유의하게 감소하였다. 반면, 총 당류 섭취가 증가할수록 우유, 과일, 가공식품을 통한 에너지 대비 당 섭취 비율이 남자와 여자에서 증가하였다.

여러 잠재적 혼란변수들을 보정한 후 대사증후군의 위험도를 분석한 결과, 여자에게서만 HDL 콜레스테롤을 제외한 모든 대사증후군 위험요인과 탄산음료 섭취 간에 양의 연관성을 보였다. 탄산음료를 '≥4 회/주'로 섭취하는 여자 그룹이 탄산음료를 거의 섭취하지 않는 그룹에 비해 대사증후군의 위험이 74% 높았다 (OR: 1.74; 95%CI:

1.00–3.03; P for trend <0.0001). 반면, 총 당류 섭취량은 남자와 여자에게서 대사증후군 위험요인과 음의 연관성을 보였다.

결론적으로, 한국 여자 성인에게서 탄산음료의 높은 섭취는 대사증후군과 대사증후군 위험 요인의 중요한 결정요인으로 작용할 수 있다.

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주제어: 탄산음료, 당 섭취, 대사증후군, 한국 성인

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