보건학석사 학위논문

Association of Dietary Sugar and Sugar-Sweetened Beverage Intake with Obesity in Korean Children and Adolescents

한국 아동 및 청소년의 당류 및 가당음료 섭취와 비만과의 관련성

2015년 8월

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ABSTRACT

Association of Dietary Sugar and Sugar-Sweetened Beverage Intake with Obesity in Korean Children and Adolescents

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In recent years, there has been growing concern that dietary sugar intake—including sugar-sweetened beverages (SSBs)—is associated with obesity in children and adolescents. However, in the Asian population, relatively low sugar intake is typically reported and few studies have examined the association between dietary sugar intake and obesity in Asian children and adolescents. Thus, this study aimed to evaluate dietary sugar and its food source and examine the association of sugar intake with obesity in Korean children and adolescents.

Data were obtained from five studies conducted between 2002 and 2011. The study included 2,599 children who had completed three or more days of dietary records and had anthropometric data as well as confounding variables evaluated. Pediatric overweight and obesity were defined using national reference, age- and gender-specific percentile of body mass index (BMI); overweight if 85th $\leq$ BMI $<$ 95th percentile and obesity if $\geq$ 95th percentile or BMI $\geq$ 25 kg/m^2.

The mean intake of total sugar was 51.4 g (11.8% of total energy) and girls had higher sugar intakes than boys (54.3 g for girls and 46.6 g for boys). Total sugar intake was inversely associated with obesity in girls (OR for obesity, 0.53; 95% CI, 0.29-0.96; *p* for trend=0.0301). Among sugar intake from various food sources, sugar intake from milk and fruits was inversely associated with overweight or obesity only in girls (OR for overweight, 0.54; 95% CI, 0.34-0.86; *p* for trend=0.0275 and OR for obesity, 0.47; 95% CI, 0.25-0.87; *p* for trend=0.0225) and sugar from processed foods was not significantly associated with overweight or obesity in both genders. Regarding SSB intake, 10.7% of boys and 7.7% of girls consumed 200 mL or more per day, but energy contribution was 5.8% in boys and 6.0% in girls. SSB consumption was not associated with obesity in girls, while boys had lower odds ratios for obesity (OR for obesity, 0.53; 95% CI, 0.27-1.07; *p* for trend=0.0355).

In conclusion, total sugar and SSB intake in Korean children and adolescents remains relatively low and sugar intake from milk and fruits appears to have favorable effects on overweight or obesity in girls.

Keywords : dietary sugar, sugar-sweetened beverages, sugar from milk and fruits, obesity, children, adolescents
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Ⅰ. INTRODUCTION

1. Background

1) Childhood obesity

Obesity in childhood and adolescence is a major public health concern worldwide. The prevalence of obesity in children and adolescents has remained high and was 16.9% for 2-19 year olds in the United States, 14% for 2-15 year olds in the UK and 12.6% for 8-17 year olds in Spain[1-3].

In Korea, the pediatric obesity rate has increased almost twofold in the previous decade. The prevalence of obesity in young Korean boys was 12.2% and 7.2% in girls among 2-18-year-old subjects[4,5]. Childhood obesity is associated with increased risks of chronic diseases such as diabetes and cardiovascular diseases[6,7]. Moreover, approximately 70% of obese adolescents remain obese in adulthood[8], thus preventing and managing obesity in childhood and adolescence is important.

2) Sugar intake and obesity

Although complex interactions of genetic, metabolic, cultural, environmental, socioeconomic and behavioral factors contribute to obesity, dietary factors are major determinants of childhood obesity[9]. A review paper reported that excessive energy intake, the frequency of daily meals, eating alone and snack and beverage consumption were associated with childhood obesity[10]. In Korea, with the rapid economic growth and adaptation to a Western lifestyle, dietary patterns gradually changed from the traditional diet to Western diet which is reportedly associated with an increased risk of being overweight[11]. Additionally, intake of processed foods or dietary sugar has increased and sugar intake from processed foods—such as beverages, breads and ice cream—has attracted attention. Recently, a number of studies investigated the association of sugar intake with weight gain or obesity. Based on a meta-analysis of 15 cohort studies that included children, high consumption of sugar-sweetened beverages (SSBs) at baseline was associated with an increased risk of overweight or obesity at follow-up[12].

According to the 2008-2011 Korea National Health and Nutrition Examination Survey (KNHANES), the sugar intake of Koreans gradually increased[13]. Mean total sugar intake of Korean aged more than 1 year was 61.9g and it was highest in adolescents aged 12-18 years among various age groups. Dietary Reference Intakes for Koreans (2010)[14] has recommended that total sugar intake should make up 10-20% of total energy intake per day and mean percent energy from total sugar of Korean children and adolescents were within the range of guideline which were 13.9% in 6-11-year-old subjects and 13.0% in 12-18-year-old subjects[13]. However, it is still necessary to pay attention to the status of Korean sugar intake because World Health Organization (WHO) recently suggested that free sugars[i)] have to be consumed less than 10% of total energy intake[15].

3) Necessity of the study

Although total sugar intake of Korean has been lower than that of Western countries[16-18], contribution rate of processed foods for sugar intake in Korean has been continuously increasing from 58.2% in 2010 to 61.3% in 2012[19]. Moreover, few studies were investigated the associations of sugar intake with obesity in Asian children, but they focused on sugar intake from SSBs[20-22]. Considering the increasing trend in sugar intake and prevalence of childhood obesity, examining the associations of pediatric obesity with dietary sugar intake in the Asian population is necessary.

[i)] Free sugars: Monosaccharides and disaccharides added to foods by the manufacturer, cook or consumer, and sugars naturally present in honey, syrups, fruit juices and fruit concentrates[15]

2. Objective

Thus, this study aimed to investigate the relationship between dietary sugar intake and obesity in Korean children and adolescents.

The specific objectives of this study were to:

1. Evaluate dietary sugar intake including sugar intake from major food sources according to gender and age groups in Korean children and adolescents
2. Examine the associations of total sugar intake and sugar intake from major food sources with overweight and obesity in Korean children and adolescents

Ⅱ. SUBJECTS AND METHODS

1. Study Population and Data Collection

Data were obtained from five studies conducted on Korean children and adolescents between 2002 and 2011. All five studies used the same protocols to assess dietary intake and included anthropometric data, although outcome variables such as bone mineral density or food allergy varied among the studies. The initial sample included 4,953 children and adolescents 9-14 years of age recruited from seven elementary schools, two middle schools and a pediatric center through the university hospital in or near Seoul metropolitan area. Inclusion criteria were if a subject completed at least 3 or more days of dietary records and general demographics such as age and gender without any specific disease (n=4,088). Among the 4,088 eligible subjects, those with missing information regarding anthropometric measurements such as height and weight (n=95) and missing data for maternal education (n=1,255) and physical activity (n=139) were excluded. The final sample consisted of 2,599 children and adolescents (1,048 boys and 1,551 girls) 9-14 years of age. This study was approved by the Institutional Review Board of Seoul National University, Republic of Korea and written informed consent was obtained from all participants.

2. Dietary Measurement

Dietary data were collected by dietary records for 3-7 days. Each subjects was instructed how to record dietary information in person by a trained staff member and asked to complete 3 days or more including one weekend day. The completed dietary records were reviewed by the trained staff and incomplete or unclear records were clarified with the subjects at the interview.

All nutrient intakes were calculated using the CAN-Pro 3.0 (Computer Aided Nutritional Analysis Program, the Korean Nutrition Society) or DS24 (Seoul National University) software. To evaluate the adequacy of nutrient intake, the Dietary Reference Intakes for Koreans (2010)[14] was used and energy intake was compared with age- and gender-specific Estimated Energy Requirement (EER); other nutrients were compared with Recommended Nutrient Intake (RNI).

3. Sugar Intake and Its Food Sources

Daily sugar intakes were calculated using a sugar database recently established for Korean food items by Lee *et al*[13]. and expanded in this study. Because a database of added sugar for Korean food items did not exist, sugar intake according to food source was evaluated by grouping four major food sources: fruits, milk, processed foods and commodity type foods. Fruits included fresh fruits, dried fruits and 100% fruit juices and milk included only white milk (whole, low-fat and nonfat). Processed foods included all types of beverages, breads and snacks, flavored milk and yogurt, ice cream and frozen confections, sweets, jams and other similar items.

Because SSBs are major contributors to added sugar intake, SSB intake was evaluated. SSB was defined as all types of beverage including carbonated beverages, fruit and vegetable drinks, sports drinks, flavored soy milk, sweetened tea and coffee drinks, but excluding brewed coffee/tea and 100% fruit juices.

To investigate the dietary pattern of study subjects according to dietary sugar based on food sources, mean percent energy from various food groups were estimated. For these additional analyses, food groups were newly divided into twenty-seven groups to identify the accurate dietary pattern: white rice, other grain, noddle and dumpling, flour and bread, pizza and hamburger, cereals and snack, potatoes and starch, sugars and sweets, legumes, nuts and seeds, vegetables, kimchi, mushrooms, fruits, meats, eggs, fishes and shellfishes, seaweeds, milk, flavored milk, dairy products, ice cream and frozen confections, sugar-sweetened beverage, brewed coffee/tea, seasonings, oils and others.

Regarding SSB intake, subjects were classified into three groups; non-drinkers who did not consume any beverage during the study period, light drinkers who consumed < 200 mL/day and moderate drinkers who consumed ≥ 200 mL/day. The common serving size of a beverage, 200 mL, was used as the cut-off value.

4. Anthropometric Measurements and Pediatric Obesity

Anthropometric data consisted of height and weight and were measured by trained surveyors in most of the studies (92% of subjects). Only in one study (8% of subjects) data were self-reported by subjects or their parents. The body mass index (BMI) was calculated as body weight in kilograms divided by the square of body height in meters (kg/m^2).

Pediatric overweight or obesity were defined using national reference age- and gender-specific percentile of BMI from the Korean Growth Chart (2007); overweight if 85th $\leq$ BMI < 95th percentile, obesity if $\geq$ 95th percentile or BMI $\geq$ 25 kg/m^2.

5. Confounding Variables

Confounding variables included basic characteristics such as age and gender and socioeconomic characteristics such as maternal educational level. Among lifestyle factors, physical activity levels were obtained.

Due to distinct differences in physical growth, all analyses were stratified according to gender (boys and girls). Because data used in this study were pooled from five studies, the study number was used as a covariate. In addition, each study had different variables and categories. Maternal education was divided into three categories: middle school or less, high school, and college or higher. Physical activity was defined as moderate or vigorous activities of at least 20 minutes per day or at least three times in the past 7 days.

6. Statistical Analyses

All statistical analyses were conducted using Statistical Analysis System (SAS version 9.3, SAS Institute, Cary, NC, USA). All p-values were two-sided and $p < 0.05$ was considered to indicate statistical significance.

Demographic and anthropometric variables were expressed as means ± standard deviation for continuous variables and percentage (%) for categorical variables. Continuous variables were tested across genders using the generalized linear model (GLM) and categorical variables were tested using the chi-squared test.

Mean daily nutrient intake and sugar intake from food sources as well as mean percent energy from food groups were estimated using GLM and expressed as adjusted mean ± standard error. Total sugar intake and sugar intake from milk and fruits and processed foods by each gender were energy-adjusted using the residual method. A multivariate adjusted logistic regression analysis was performed to estimate odds ratios (ORs) and 95% confidence interval (CI) for pediatric overweight and obesity across quartile groups and p for trend was also calculated with the lowest quartile set as the reference. Association of SSB with pediatric overweight and obesity was also analyzed using a multivariate adjusted logistic regression.

Ⅲ. RESULTS

1. General Characteristics of Study Subjects

A total of 2,599 Korean children and adolescents were included in this study. Mean age was 11.4±1.8 years, and 40% were boys and 60% girls. Table 1 presents the general characteristics of subjects according to gender. Height, weight and BMI in boys were significantly higher than in girls (p<0.0001 for all variables). In particular, boys were more frequently overweight (15.0%) than girls (13.0%). Furthermore, boys (13.9%) were significantly more obese than girls (7.7%; p<0.0001). Maternal educational level in girls was generally higher than boys, but the difference was not significant. Boys tended to have significantly higher physical activity level than girls (p<0.0001).

Table 1. General characteristics of study subjects according to gender

	Boys (n=1,048)	Girls (n=1,551)	*P*-value
Age (y) [Mean±SD]	11.8±1.7	11.1±1.7	<0.0001
Height (cm) [Mean±SD]	154.3±12.8	147.6±10.7	<0.0001
Weight (kg) [Mean±SD]	49.6±13.6	42.3±11.1	<0.0001
BMI (kg/m^2)[1)] [Mean±SD]	20.5±3.6	19.1±3.2	<0.0001
Overweight [n, (%)]			0.1424
85-95th percentile	157 (15.0)	201 (13.0)	
Obesity [n, (%)]			<0.0001
≥ 95th percentile or BMI ≥ 25	146 (13.9)	120 (7.7)	
Maternal education (%)			0.4759
Middle school or less	6.8	5.7	
High school	45.3	45.1	
College or more	47.9	49.3	
Physical activity[2)] (%)			<0.0001
No	42.8	56.2	
Yes	57.2	43.8	

1) BMI (Body Mass Index)

2) Physical activity was defined as having moderate or vigorous activities for ≥ 20 minutes per day or at least 3 days during the past 7 days.

3) All values for continuous variables were tested using a generalized linear model (GLM) and all values for categorical variables were evaluated using the chi-squared test.

2. Daily Nutrient Intake and Sugar Intake

1) Daily nutrient intake including sugar intake according to gender

Mean daily nutrient intake including sugar intake according to gender are shown in Table 2. The energy intake was 1806.0±19.1 kcal in boys and 1631.9±16.9 kcal in girls ($p<0.0001$). When comparing energy intake to EER, the mean percent of EER in all groups was less than 100% and significantly lower for boys (77.3%) than girls (85.6%; $p<0.0001$). When comparing vitamin and mineral intake to RNI, boys showed generally higher percent RNI than girls for most nutrients, such as thiamin, niacin and iron. The percent of RNI ranged from 80-120%; however, the most inadequate nutrient was calcium, the percent of RNI for which was 57.3% in boys and 55.5% in girls. Conversely, the most adequate nutrients were thiamin and iron and the percent of RNI for thiamin was 141.8% and that for iron was 134.3% in boys.

Total sugar intake in all subjects was 51.4±25.0 g and the average intake in girls was 54.3±0.8 g, which was significantly higher than that in boys (46.6±0.9 g) after adjusting for confounding variables including energy intake. The percent of energy from total sugar was 12.5% in girls and 10.8% in boys and differed significantly according to gender.

Table 2. Mean daily nutrient intake including sugar intake from food sources according to gender

	Boys (n=1,048)	Girls (n=1,551)	P-value
Energy (kcal/day) [Mean±SE]	1806.0±19.1	1631.9±16.9	<0.0001
Carbohydrate (g) [Mean±SE]	244.3±1.3	247.0±1.1	0.0356
Protein (g) [Mean±SE]	66.8±0.5	66.2±0.5	0.3124
Fat (g) [Mean±SE]	53.1±0.5	53.1±0.4	0.9476
Percent of EER[1)] [%]	77.3	85.6	<0.0001
Percent of RNI[2)] [%]			
Thiamin	141.8	119.2	<0.0001
Riboflavin	90.8	100.0	<0.0001
Niacin	119.3	108.6	<0.0001
Vitamin C	79.7	75.3	0.0673
Calcium	57.3	55.5	0.1339
Phosphorus	97.0	97.1	0.9329
Iron	134.3	104.5	0.0013
Total Sugar (g) [Mean±SE]	46.6±0.9	54.3±0.8	<0.0001
Total Sugar (% of Energy)	10.8	12.5	<0.0001

1) EER (Estimated Energy Requirements)

2) RNI (Recommended Nutrient Intake)

3) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, maternal education and physical activity and energy intake, with the exception of energy intake models.

2) Food sources of total sugar intake according to gender

Distribution of total sugar intake among different food groups by gender is shown in Figure 1. The major food source of sugar intake in all subjects was processed foods (including breads, beverages, ice cream and others). The percent of sugar from processed foods in girls was 63.2% and was significantly greater than that in boys (60.3%; $p<0.0001$). With the exception of processed foods, fruits were the major food source that contributed to total sugar intake in all groups. The percent of sugar from fruits was significantly higher in girls (14.9%) than boys (13.5%; $p=0.0304$), whereas the percent of sugar from milk was significantly higher in boys (13.3%) than girls (11.0%; $p<0.0001$).

Among processed foods, breads, snacks and rice cakes was the major food source of sugar intake in all groups and girls (18.2% for all groups and 18.7% for girls) followed by sugar (18.1% for all groups and 17.2% for girls) (Figure 2). For boys, sugar was the major food source that contributed to total sugar intake (19.0%) followed by breads, snacks and rice cakes (17.8%).

Figure 3 presents distribution of total sugar intake by gender and age groups. In general, 12-14-year-old subjects showed lower percent of sugar from milk and fruit and higher percent of sugar from processed foods than 9-11-year-old subjects. This trend was observed similarly in both genders, but the difference was not statistically significant.

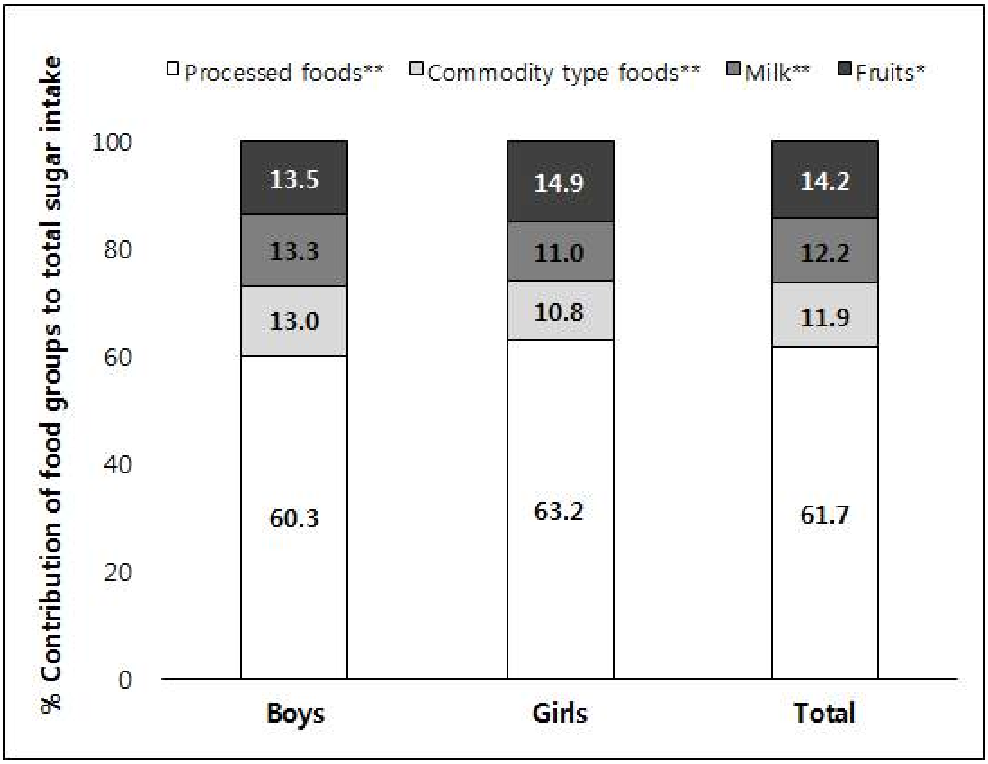

Figure 1. Distribution of total sugar intake among different food groups by gender in Korean children and adolescents

1) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, energy intake, maternal education and physical activity.

2) $*p<0.05$, $**p<0.0001$

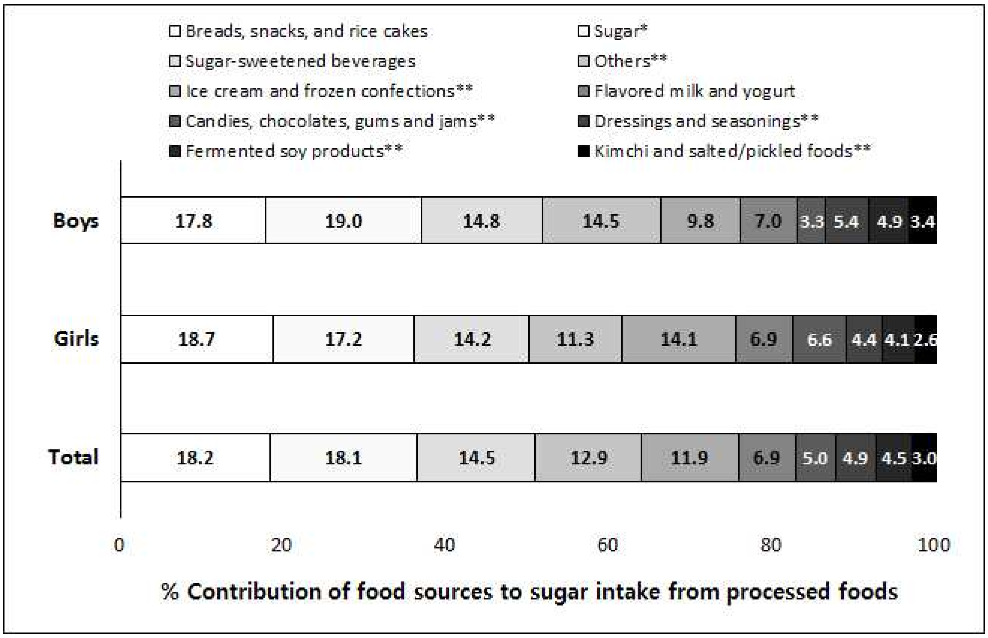

Figure 2. Distribution of sugar intake from processed foods among different food sources by gender in Korean children and adolescents

1) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, energy intake, maternal education and physical activity.

2) $*p<0.05$, $**p<0.0001$

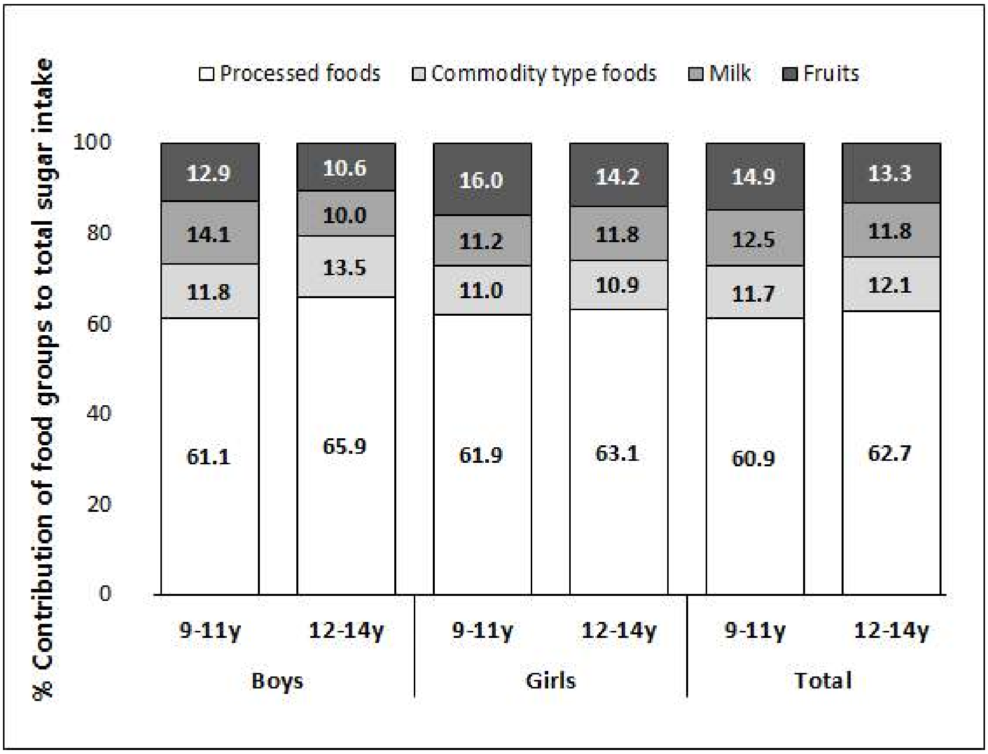

Figure 3. Distribution of total sugar intake among different food groups by gender and age groups in Korean children and adolescents

1) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, energy intake, maternal education and physical activity.

3. Association of Dietary Sugar and Sugar-Sweetened Beverage Intake with Obesity

1) Association of total sugar intake with pediatric obesity

Table 3 shows the multivariate adjusted ORs and 95% CIs for pediatric overweight and obesity across quartiles of total sugar intake. After adjusting for confounding variables, total sugar was significantly associated in girls with a lower prevalence of obesity (OR for highest quartile, 0.53; 95% CI, 0.29-0.96; p for trend=0.0301). However, no significant association was observed in boys.

Mean daily nutrient including sugar intake and mean daily percent energy from food groups of each gender according to quartiles of total sugar intake are presented in Table 4-1 to Table 5-4. Compared the highest quartile to the lowest quartile of total sugar intake, carbohydrate intake increased, while protein and fat intake significantly decreased in both genders after adjusting for confounding variables. As total sugar intake increased, the percent energy from white rice and noddle and dumpling significantly decreased; however, that from flour and bread and cereal and snack significantly increased in both genders. In addition, subjects of the highest quartile in both genders had higher consumption of milk, flavored milk, dairy products, ice cream and frozen confection, and sugar-sweetened beverages (p for trend<0.0001 for all variables).

Table 3. Multivariate adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for pediatric overweight and obesity across quartiles of total sugar intake

	Quartiles of total sugar intake (g/day)[1]				
	Q1	Q2	Q3	Q4	*P* for trend[3]
Boys (n=1,048)					
Sugar intake [Mean±SE]	27.1±0.6	41.8±0.6	54.1±0.6	76.0±0.6	
Overweight[2]	1.00	0.90 (0.54-1.51)	1.23 (0.75-2.02)	1.03 (0.61-1.73)	0.7048
Obesity[2]	1.00	0.68 (0.42-1.11)	0.66 (0.40-1.10)	0.66 (0.39-1.11)	0.1286
Girls (n=1,551)					
Sugar intake	30.8±0.5	44.6±0.5	56.3±0.5	76.9±0.5	
Overweight	1.00	1.05 (0.70-1.59)	0.81 (0.53-1.24)	0.83 (0.53-1.27)	0.2379
Obesity	1.00	1.11 (0.67-1.82)	0.95 (0.57-1.59)	0.53 (0.29-0.96)	0.0301

1) Total sugar intake was energy-adjusted using the residual method and categorized into quartiles.

2) Overweight was defined as 85-95th percentile for age, gender-specific BMI; obesity was defined as ≥ 95th percentile or BMI ≥25.

3) Logistic regression analysis was used to test associations between dietary sugars and obesity after adjusting for age, study number, maternal education and physical activity.

Table 4-1. Mean daily nutrient intake including sugar intake of each gender according to quartiles of total sugar intake

	Quartiles of total sugar intake[3]				
	Q1	Q2	Q3	Q4	*P* for trend
Boys (n=1,048)					
Energy (kcal/day) [Mean±SE]	1855.9±37.9	1890.1±37.4	1820.3±38.2	1803.1±36.5	0.0975
Carbohydrate (g) [Mean±SE]	247.5±2.3	257.5±2.3	262.2±2.4	267.7±2.2	<.0001
Protein (g) [Mean±SE]	75.1±1.0	73.1±0.9	71.0±1.0	68.9±0.9	<.0001
Fat (g) [Mean±SE]	60.9±0.9	58.1±0.9	56.8±0.9	56.2±0.9	<.0001
Percent of EER[1] [%]	79.0	80.2	77.3	77.3	0.2236
Percent of RNI[2] [%]					
Thiamin	151.2	145.6	152.4	130.3	0.1686
Riboflavin	87.7	88.4	89.0	91.1	0.2892
Niacin	129.4	124.9	115.6	111.6	<.0001
Vitamin C	60.0	69.5	75.5	89.3	<.0001
Calcium	49.0	54.3	56.5	62.0	<.0001
Phosphorus	99.1	100.9	97.2	98.2	0.5116
Iron	133.3	137.4	141.7	134.3	0.9634
Total Sugar (g) [Mean±SE]	27.0±0.8	41.4±0.8	54.2±0.8	75.8±0.8	<.0001
Total Sugar (% of Energy)	5.8	9.0	11.4	16.0	<.0001

1) EER (Estimated Energy Requirements) 2) RNI (Recommended Nutrient Intake)

3) Total sugar intake was energy-adjusted using the residual method and categorized into quartiles.

4) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, maternal education and physical activity and energy intake, with the exception of energy intake models.

Table 4-2. Mean daily nutrient intake including sugar intake of each gender according to quartiles of total sugar intake

	Quartiles of total sugar intake[3]				
	Q1	Q2	Q3	Q4	*P* for trend
Girls (n=1,551)					
Energy (kcal/day) [Mean±SE]	1607.8±25.5	1649.2±26.4	1652.2±26.3	1584.2±26.0	0.3403
Carbohydrate (g) [Mean±SE]	231.3±1.7	234.6±1.8	235.8±1.8	248.2±1.7	<.0001
Protein (g) [Mean±SE]	64.7±0.7	63.7±0.7	62.6±0.7	58.2±0.7	<.0001
Fat (g) [Mean±SE]	50.4±0.7	49.8±0.7	50.6±0.7	47.6±0.7	0.0007
Percent of EER[1] [%]	83.9	86.5	86.8	83.8	0.8023
Percent of RNI[2] [%]					
Thiamin	118.8	121.3	123.6	119.1	0.8746
Riboflavin	94.3	100.9	105.5	102.3	0.0075
Niacin	113.1	111.8	110.8	96.7	<.0001
Vitamin C	52.7	68.7	81.9	104.2	<.0001
Calcium	48.6	55.2	60.9	60.7	<.0001
Phosphorus	94.8	98.3	99.6	93.2	0.4180
Iron	100.8	105.7	112.5	99.7	0.9791
Total Sugar (g) [Mean±SE]	31.3±0.6	44.8±0.6	56.9±0.6	76.3±0.6	<.0001
Total Sugar (% of Energy)	7.5	10.9	13.8	18.5	<.0001

1) EER (Estimated Energy Requirements) 2) RNI (Recommended Nutrient Intake)

3) Total sugar intake was energy-adjusted using the residual method and categorized into quartiles.

4) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, maternal education and physical activity and energy intake, with the exception of energy intake models.

Table 5-1. Mean daily percent energy from food groups of each gender according to quartiles of total sugar intake

Food group (% of energy from food group)	Quartiles of total sugar intake[1)] Q1	Q2	Q3	Q4	*P* for trend
Boys (n=1,048)	←	Mean±SE	→		
White rice	36.3±0.8	31.1±0.8	31.1±0.8	28.0±0.8	<.0001
Other grain	5.1±0.4	5.7±0.4	4.6±0.4	4.6±0.4	0.0607
Noddle and dumpling	9.0±0.6	8.3±0.6	7.9±0.6	6.4±0.6	0.0002
Flour and bread	3.7±0.4	5.3±0.4	5.1±0.4	6.2±0.4	<.0001
Pizza and hamburger	1.6±0.4	2.5±0.4	2.1±0.4	2.2±0.4	0.4383
Cereals and snack	1.7±0.4	3.7±0.4	3.5±0.4	3.6±0.4	0.0003
Potatoes and starch	1.2±0.2	1.7±0.2	1.6±0.2	1.3±0.2	0.9027
Sugars and sweets	1.3±0.1	1.7±0.1	2.0±0.1	2.3±0.1	<.0001
Legumes	1.8±0.2	1.8±0.2	1.8±0.2	1.4±0.2	0.0229
Nuts and seeds	0.4±0.1	0.3±0.1	0.4±0.1	0.5±0.1	0.1466
Vegetables	1.9±0.1	1.8±0.1	1.9±0.1	1.9±0.1	0.9505
Kimchi	0.7±0.0	0.6±0.0	0.6±0.0	0.6±0.0	0.0574
Mushrooms	0.1±0.0	0.1±0.0	0.1±0.0	0.1±0.0	0.9643

1) Total sugar intake was energy-adjusted using the residual method and categorized into quartiles.

2) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, maternal education and physical activity.

Table 5-2. Mean daily percent energy from food groups of each gender according to quartiles of total sugar intake

Food group (% of energy from food group)	Quartiles of total sugar intake[1)] Q1	Q2	Q3	Q4	*P* for trend
Boys (n=1,048)	←	Mean±SE	→		
Fruits	0.5±0.2	1.4±0.2	2.0±0.2	3.7±0.2	<.0001
Meats	15.3±0.6	12.9±0.6	12.0±0.6	11.4±0.6	<.0001
Eggs	2.6±0.2	2.2±0.2	2.2±0.2	1.7±0.2	<.0001
Fishes and shellfishes	4.2±0.2	4.2±0.2	4.1±0.2	3.9±0.2	0.2767
Seaweeds	0.3±0.0	0.4±0.0	0.2±0.0	0.2±0.0	0.0050
Milk	2.7±0.3	3.8±0.3	4.7±0.3	5.7±0.3	<.0001
Flavored milk	0.1±0.1	0.2±0.1	0.4±0.1	0.9±0.1	<.0001
Dairy products	0.4±0.1	0.5±0.1	0.8±0.1	1.0±0.1	<.0001
Ice cream and frozen confections	0.6±0.3	1.4±0.3	2.1±0.3	3.5±0.3	<.0001
Sugar-sweetened beverages	0.3±0.2	1.2±0.2	1.7±0.2	2.8±0.2	<.0001
Brewed coffee and tea	0.1±0.1	0.2±0.1	0.2±0.1	0.3±0.1	0.0193
Seasonings	2.8±0.1	2.8±0.1	2.6±0.1	2.3±0.1	0.0004
Oils	5.2±0.2	4.3±0.2	4.4±0.2	3.5±0.2	<.0001
Others	0.1±0.1	0.1±0.1	0.0±0.1	0.2±0.1	0.1151

1) Total sugar intake was energy-adjusted using the residual method and categorized into quartiles.

2) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, maternal education and physical activity.

Table 5-3. Mean daily percent energy from food groups of each gender according to quartiles of total sugar intake

Food group (% of energy from food group)	Quartiles of total sugar intake[1)] Q1	Q2	Q3	Q4	*P* for trend
Girls (n=1,551)	←	Mean±SE		→	
White rice	34.3±0.6	29.8±0.6	26.4±0.6	25.3±0.6	<.0001
Other grain	5.9±0.3	5.8±0.3	5.1±0.3	4.9±0.3	0.0031
Noddle and dumpling	8.4±0.4	7.9±0.5	6.8±0.5	6.6±0.5	<.0001
Flour and bread	4.5±0.4	5.7±0.4	6.5±0.4	7.1±0.4	<.0001
Pizza and hamburger	1.4±0.3	1.5±0.3	2.6±0.3	1.7±0.3	0.1172
Cereals and snack	3.4±0.3	3.8±0.3	4.7±0.3	4.6±0.3	0.0002
Potatoes and starch	1.3±0.2	1.8±0.2	1.8±0.2	1.5±0.2	0.3585
Sugars and sweets	1.8±0.2	2.4±0.2	2.6±0.2	3.3±0.2	<.0001
Legumes	1.7±0.1	1.6±0.1	1.6±0.1	1.5±0.1	0.1390
Nuts and seeds	0.4±0.1	0.4±0.1	0.4±0.1	0.5±0.1	0.5277
Vegetables	2.0±0.1	2.0±0.1	1.9±0.1	1.9±0.1	0.0534
Kimchi	0.7±0.0	0.7±0.0	0.6±0.0	0.7±0.0	0.0197
Mushrooms	0.1±0.0	0.1±0.0	0.1±0.0	0.1±0.0	0.8663

1) Total sugar intake was energy-adjusted using the residual method and categorized into quartiles.
2) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, maternal education and physical activity.

Table 5-4. Mean daily percent energy from food groups of each gender according to quartiles of total sugar intake

Food group (% of energy from food group)	Quartiles of total sugar intake[1)] Q1	Q2	Q3	Q4	*P* for trend
Girls (n=1,551)	←	Mean±SE	→		
Fruits	0.9±0.2	1.9±0.2	2.7±0.2	5.1±0.2	<.0001
Meats	12.6±0.4	11.3±0.4	10.8±0.4	8.8±0.4	<.0001
Eggs	2.7±0.1	2.5±0.1	2.2±0.1	2.0±0.1	<.0001
Fishes and shellfishes	4.5±0.2	4.3±0.2	4.2±0.2	3.6±0.2	<.0001
Seaweeds	0.3±0.0	0.3±0.0	0.3±0.0	0.2±0.0	0.0015
Milk	3.1±0.3	4.6±0.3	5.1±0.3	5.6±0.3	<.0001
Flavored milk	0.3±0.1	0.3±0.1	0.6±0.1	0.7±0.1	<.0001
Dairy products	0.6±0.1	0.9±0.1	0.9±0.1	1.3±0.1	<.0001
Ice cream and frozen confections	1.0±0.2	1.7±0.2	3.3±0.2	4.3±0.2	<.0001
Sugar-sweetened beverages	0.6±0.1	1.2±0.1	1.7±0.1	2.3±0.1	<.0001
Brewed coffee and tea	0.2±0.0	0.1±0.0	0.1±0.0	0.1±0.0	0.1130
Seasonings	2.8±0.1	2.7±0.1	2.6±0.1	2.6±0.1	0.0224
Oils	4.5±0.1	4.5±0.1	4.1±0.1	3.6±0.1	<.0001
Others	0.0±0.1	0.0±0.1	0.0±0.1	0.2±0.1	0.0035

1) Total sugar intake was energy-adjusted using the residual method and categorized into quartiles.
2) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, maternal education and physical activity.

2) Association of sugar intake from milk and fruits with pediatric obesity

Table 6 shows the multivariate adjusted ORs and 95% CIs for pediatric overweight and obesity across quartiles of sugar intake from milk and fruits. After adjusting for confounding variables, sugar intake from milk and fruits was significantly associated in girls with a lower prevalence of overweight (OR for highest quartile, 0.54; 95% CI, 0.34-0.86; *p* for trend=0.0275) and obesity (OR for highest quartile, 0.47; 95% CI, 0.25-0.87; *p* for trend=0.0225). However, no significant association was observed in boys.

Mean daily nutrient including sugar intake and mean daily percent energy from food groups of each gender according to quartiles of total sugar intake are presented in Table 7-1 to Table 8-4. At the highest quartile of sugar intake from milk and fruits, most nutrients showed generally higher percent RNI which were ranged from 95-140%.

Table 6. Multivariate adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for pediatric overweight and obesity across quartiles of sugar intake from milk and fruits

	Quartiles of sugar intake from milk and fruits (g/day)[1]				
	Q1	Q2	Q3	Q4	*P* for trend[3]
Boys (n=1,048)					
Sugar intake [Mean±SE]	3.2±0.4	8.6±0.4	16.0±0.4	31.6±0.4	
Overweight[2]	1.00	1.01 (0.61-1.69)	0.94 (0.55-1.61)	1.13 (0.66-1.95)	0.6209
Obesity[2]	1.00	0.98 (0.60-1.59)	0.81 (0.48-1.37)	0.70 (0.39-1.23)	0.1688
Girls (n=1,551)					
Sugar intake	4.2±0.4	10.7±0.4	17.8±0.4	34.6±0.4	
Overweight	1.00	0.60 (0.39-0.93)	0.65 (0.42-1.00)	0.54 (0.34-0.86)	0.0275
Obesity	1.00	0.74 (0.44-1.25)	0.78 (0.45-1.33)	0.47 (0.25-0.87)	0.0225

1) Sugar intake from milk and fruits was energy-adjusted using the residual method and categorized into quartiles.
2) Overweight was defined as 85-95th percentile for age, gender-specific BMI; obesity was defined as ≥ 95th percentile or BMI ≥25.
3) Logistic regression analysis was used to test associations between dietary sugars and obesity after adjusting for age, study number, maternal education and physical activity.

Table 7-1. Mean daily nutrient intake including sugar intake of each gender according to quartiles of sugar intake from milk and fruits

	Quartiles of sugar intake from milk and fruits[3)]				
	Q1	Q2	Q3	Q4	*P* for trend
Boys (n=1,048)					
Energy (kcal/day) [Mean±SE]	1863.0±37.5	1849.3±38.0	1870.8±38.3	1784.5±38.1	0.0818
Carbohydrate (g) [Mean±SE]	254.7±2.4	258.1±2.4	258.7±2.4	265.0±2.4	0.0004
Protein (g) [Mean±SE]	71.1±1.0	72.0±1.0	73.2±1.0	71.7±1.0	0.6895
Fat (g) [Mean±SE]	59.5±0.9	58.4±0.9	57.8±0.9	56.1±0.9	0.0020
Percent of EER[1)] [%]	78.1	79.5	79.8	76.7	0.3455
Percent of RNI[2)] [%]					
Thiamin	140.1	138.8	161.5	138.3	0.9958
Riboflavin	83.3	85.9	93.0	95.4	0.0002
Niacin	120.5	122.2	123.8	115.0	0.1483
Vitamin C	54.9	63.1	79.7	101.5	<.0001
Calcium	47.4	53.0	59.9	64.2	<.0001
Phosphorus	93.9	98.4	102.2	102.2	0.0072
Iron	120.8	144.5	162.7	125.8	0.9634
Total Sugar (g) [Mean±SE]	39.6±1.4	46.0±1.4	52.7±1.4	65.6±1.4	<.0001
Total Sugar (% of Energy)	8.3	9.9	11.1	14.0	<.0001

1) EER (Estimated Energy Requirements) 2) RNI (Recommended Nutrient Intake)

3) Sugar intake from milk and fruits was energy-adjusted using the residual method and categorized into quartiles.

4) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, maternal education and physical activity and energy intake, with the exception of energy intake models.

Table 7-2. Mean daily nutrient intake including sugar intake of each gender according to quartiles of sugar intake from milk and fruits

	Quartiles of sugar intake from milk and fruits[3]				
	Q1	Q2	Q3	Q4	*P* for trend
Girls (n=1,551)					
Energy (kcal/day) [Mean±SE]	1603.0±26.2	1633.7±25.8	1655.6±26.5	1592.1±27.8	0.5360
Carbohydrate (g) [Mean±SE]	236.9±1.8	234.4±1.8	236.8±1.8	243.0±1.9	0.0004
Protein (g) [Mean±SE]	61.0±0.8	62.8±0.7	63.0±0.8	62.7±0.8	0.1481
Fat (g) [Mean±SE]	49.7±0.7	50.5±0.7	49.9±0.7	48.1±0.7	0.0137
Percent of EER[1] [%]	83.6	85.5	86.8	85.1	0.5232
Percent of RNI[2] [%]					
Thiamin	114.5	119.8	124.6	125.7	0.0019
Riboflavin	88.1	99.2	107.6	111.8	<.0001
Niacin	106.0	111.1	108.7	106.4	0.6613
Vitamin C	50.3	63.5	81.5	125.0	<.0001
Calcium	46.3	54.9	61.0	66.0	<.0001
Phosphorus	89.3	96.0	101.2	101.2	<.0001
Iron	100.8	101.8	115.4	99.9	0.9977
Total Sugar (g) [Mean±SE]	41.3±1.1	48.6±1.1	54.7±1.1	68.2±1.2	<.0001
Total Sugar (% of Energy)	10.0	11.7±	13.3	16.7	<.0001

1) EER (Estimated Energy Requirements) 2) RNI (Recommended Nutrient Intake)

3) Sugar intake from milk and fruits was energy-adjusted using the residual method and categorized into quartiles.

4) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, maternal education and physical activity and energy intake, with the exception of energy intake models.

Table 8-1. Mean daily percent energy from food groups of each gender according to quartiles of sugar intake from milk and fruits

Food group (% of energy from food group)	Quartiles of sugar intake from milk and fruits[1)]				
	Q1	Q2	Q3	Q4	*P* for trend
Boys (n=1,048)	←	Mean±SE		→	
White rice	34.3±0.8	30.6±0.8	30.1±0.8	30.0±0.8	0.0003
Other grain	4.7±0.4	5.9±0.4	5.3±0.4	4.4±0.4	0.1300
Noddle and dumpling	8.9±0.6	7.8±0.6	8.0±0.6	6.6±0.6	0.0034
Flour and bread	4.9±0.4	5.4±0.4	5.3±0.4	4.9±0.4	0.6524
Pizza and hamburger	2.4±0.4	2.7±0.4	1.7±0.4	1.6±0.4	0.0338
Cereals and snack	2.4±0.4	3.1±0.4	3.5±0.4	3.7±0.4	0.0058
Potatoes and starch	1.3±0.2	1.8±0.2	1.3±0.2	1.3±0.2	0.3310
Sugars and sweets	1.9±0.1	1.9±0.1	2.0±0.1	1.6±0.1	0.0395
Legumes	1.7±0.2	1.7±0.2	1.8±0.2	1.6±0.2	0.5391
Nuts and seeds	0.4±0.1	0.4±0.1	0.3±0.1	0.5±0.1	0.3304
Vegetables	1.9±0.1	1.9±0.1	1.9±0.1	1.8±0.1	0.4336
Kimchi	0.6±0.0	0.6±0.0	0.6±0.0	0.6±0.0	0.4627
Mushrooms	0.1±0.0	0.1±0.0	0.1±0.0	0.1±0.0	0.7682

1) Sugar intake from milk and fruits was energy-adjusted using the residual method and categorized into quartiles.

2) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, maternal education and physical activity.

Table 8-2. Mean daily percent energy from food groups of each gender according to quartiles of sugar intake from milk and fruits

Food group (% of energy from food group)	Quartiles of sugar intake from milk and fruits[1)] Q1	Q2	Q3	Q4	*P* for trend
Boys (n=1,048)	←	Mean±SE		→	
Fruits	0.0±0.2	0.6±0.2	2.1±0.2	5.2±0.2	<.0001
Meats	14.2±0.6	12.8±0.6	12.6±0.6	11.7±0.6	0.0011
Eggs	2.3±0.2	2.3±.2	2.2±0.2	1.8±0.2	0.0039
Fishes and shellfishes	3.7±0.2	4.3±0.2	4.3±0.2	4.2±0.2	0.2673
Seaweeds	0.3±0.0	0.3±0.0	0.3±0.0	0.2±0.0	0.1687
Milk	1.2±0.3	3.5±0.3	5.0±0.3	7.9±0.3	<.0001
Flavored milk	0.5±0.1	0.4±0.1	0.4±0.1	0.3±0.1	0.2669
Dairy products	0.5±0.1	0.7±0.1	0.9±0.1	0.7±0.1	0.2817
Ice cream and frozen confections	2.5±0.3	1.7±0.3	1.9±0.3	1.7±0.3	0.0529
Sugar-sweetened beverages	1.5±0.2	2.0±0.2	1.5±0.2	1.4±0.2	0.1036
Brewed coffee and tea	0.1±0.1	0.2±0.1	0.3±0.1	0.2±0.1	0.4746
Seasonings	2.7±0.1	2.7±0.1	2.6±0.1	2.5±0.1	0.0432
Oils	4.8±0.2	4.5±0.2	4.2±0.2	3.6±0.2	<.0001
Others	0.1±0.1	0.1±0.1	0.1±0.1	0.1±0.1	0.8264

1) Sugar intake from milk and fruits was energy-adjusted using the residual method and categorized into quartiles.

2) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, maternal education and physical activity.

Table 8-3. Mean daily percent energy from food groups of each gender according to quartiles of sugar intake from milk and fruits

Food group (% of energy from food group)	Quartiles of sugar intake from milk and fruits[1)] Q1	Q2	Q3	Q4	*P* for trend
Girls (n=1,551)	←	Mean±SE	→		
White rice	31.5±0.6	29.6±0.6	27.9±0.6	26.6±0.7	<.0001
Other grain	5.8±0.3	5.0±0.3	5.6±0.3	5.2±0.3	0.3883
Noddle and dumpling	8.3±0.5	7.7±0.4	7.1±0.5	6.3±0.5	0.0003
Flour and bread	5.6±0.4	6.1±0.4	6.2±0.4	5.9±0.4	0.7659
Pizza and hamburger	2.3±0.3	2.0±0.3	1.5±0.3	1.0±0.3	0.0001
Cereals and snack	4.3±0.3	3.9±0.3	4.4±0.3	3.5±0.4	0.0851
Potatoes and starch	1.6±0.2	1.7±0.2	1.5±0.2	1.5±0.2	0.3753
Sugars and sweets	2.6±0.2	2.6±0.2	2.6±0.2	2.3±0.2	0.0575
Legumes	1.6±0.1	1.6±0.1	1.5±0.1	1.6±0.1	0.9596
Nuts and seeds	0.5±0.1	0.3±0.1	0.4±0.1	0.5±0.1	0.2069
Vegetables	2.1±0.1	2.0±0.1	2.0±0.1	1.9±0.1	0.0820
Kimchi	0.7±0.0	0.7±0.0	0.7±0.0	0.7±0.0	0.6741
Mushrooms	0.1±0.0	0.1±0.0	0.1±0.0	0.1±0.0	0.5633

1) Sugar intake from milk and fruits was energy-adjusted using the residual method and categorized into quartiles.
2) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, maternal education and physical activity.

Table 8-4. Mean daily percent energy from food groups of each gender according to quartiles of sugar intake from milk and fruits

Food group (% of energy from food group)	Quartiles of sugar intake from milk and fruits[1)] Q1	Q2	Q3	Q4	P for trend
Girls (n=1,551)	←		Mean±SE	→	
Fruits	0.4±0.1	1.5±0.1	2.9±0.1	7.2±0.1	<.0001
Meats	11.4±0.4	11.5±0.4	10.6±0.4	9.9±0.4	0.0004
Eggs	2.4±0.1	2.3±0.1	2.5±0.1	2.3±0.1	0.4278
Fishes and shellfishes	4.3±0.2	4.0±0.2	4.2±0.2	4.1±0.2	0.7762
Seaweeds	0.3±0.0	0.3±0.0	0.3±0.0	0.3±0.0	0.9584
Milk	1.7±0.2	4.2±0.2	6.0±0.2	7.6±0.3	<.0001
Flavored milk	0.5±0.1	0.5±0.1	0.6±0.1	0.4±0.1	0.2646
Dairy products	0.8±0.1	1.0±0.1	0.9±0.1	0.9±0.1	0.7216
Ice cream and frozen confections	2.4±0.2	2.8±0.2	2.5±0.2	2.4±0.3	0.5706
Sugar-sweetened beverages	1.6±0.1	1.5±0.1	1.3±0.1	1.2±0.2	0.0377
Brewed coffee and tea	0.1±0.0	0.1±0.0	0.1±0.0	0.1±0.0	0.3173
Seasonings	2.9±0.1	2.7±0.1	2.6±0.1	2.5±0.1	0.0070
Oils	4.4±0.1	4.0±0.1	4.0±0.1	4.1±0.1	0.0763
Others	0.1±0.0	0.1±0.0	0.1±0.0	0.1±0.0	0.9465

1) Sugar intake from milk and fruits was energy-adjusted using the residual method and categorized into quartiles.
2) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, maternal education and physical activity.

3) Association of sugar intake from processed foods with pediatric obesity

Table 9 shows the multivariate adjusted ORs and 95% CIs for pediatric overweight and obesity across quartiles of sugar intake from processed foods. After adjusting for confounding variables, sugar intake from processed foods was not significantly associated with overweight or obesity in both genders.

Mean daily nutrient including sugar intake and mean daily percent energy from food groups of each gender according to quartiles of total sugar intake are presented in Table 10-1 to Table 11-4. The more sugar intake from processed foods was consumed, the higher consumption of flour and bread, pizza and hamburger, cereals and snacks, ice cream and frozen confection and sugar-sweetened beverage occurred in all subjects (p for trend<0.0001 for all variables except for pizza and hamburger; p for trend$=0.0012$ for pizza and hamburger in boys).

Table 9. Multivariate adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for pediatric overweight and obesity across quartiles of sugar intake from processed foods

	Quartiles of sugar intake from processed foods (g/day)[1)]				
	Q1	Q2	Q3	Q4	*P* for trend[3)]
Boys (n=1,048)					
Sugar intake [Mean±SE]	15.1±0.5	24.9±0.5	34.6±0.6	54.0±0.5	
Overweight[2)]	1.00	0.76 (0.47-1.25)	0.93 (0.58-1.50)	0.89 (0.55-1.44)	0.8584
Obesity[2)]	1.00	0.84 (0.52-1.34)	0.52 (0.31-0.88)	0.69 (0.42-1.13)	0.0710
Girls (n=1,551)					
Sugar intake	15.4±0.5	25.0±0.5	34.6±0.5	53.1±0.5	
Overweight	1.00	0.98 (0.64-1.50)	0.90 (0.58-1.39)	1.12 (0.73-1.72)	0.6265
Obesity	1.00	0.87 (0.51-1.46)	0.82 (0.48-1.39)	0.91 (0.53-1.55)	0.7436

1) Sugar intake from processed foods was energy-adjusted using the residual method and categorized into quartiles.

2) Overweight was defined as 85-95th percentile for age, gender-specific BMI; obesity was defined as ≥ 95th percentile or BMI ≥25.

3) Logistic regression analysis was used to test associations between dietary sugars and obesity after adjusting for age, study number, maternal education and physical activity.

Table 10-1. Mean daily nutrient intake including sugar intake of each gender according to quartiles of sugar intake from processed foods

	Quartiles of sugar intake from processed foods[3]				
	Q1	Q2	Q3	Q4	*P* for trend
Boys (n=1,048)					
Energy (kcal/day) [Mean±SE]	1851.2±37.0	1847.2±37.2	1867.3±37.5	1801.6±37.0	0.2657
Carbohydrate (g) [Mean±SE]	252.0±2.3	257.1±2.3	260.8±2.3	266.1±2.3	<.0001
Protein (g) [Mean±SE]	76.1±0.9	72.3±0.9	70.3±0.9	68.9±0.9	<.0001
Fat (g) [Mean±SE]	58.9±0.9	58.6±0.9	58.0±0.9	56.5±0.9	0.0151
Percent of EER[1] [%]	78.2	79.5	79.2	76.9	0.4242
Percent of RNI[2] [%]					
Thiamin	153.0	141.8	156.6	125.6	0.0800
Riboflavin	89.9	90.6	89.7	86.4	0.2159
Niacin	129.3	121.5	119.4	110.2	<.0001
Vitamin C	76.1	76.7	73.6	70.4	0.1240
Calcium	53.8	55.1	57.5	56.6	0.2394
Phosphorus	102.7	99.3	99.0	94.5	0.0032
Iron	117.1	148.9	135.0	144.6	0.4026
Total Sugar (g) [Mean±SE]	34.0±1.1	43.8±1.1	54.4±1.2	70.5±1.1	<.0001
Total Sugar (% of Energy)	7.4	9.4	11.7	14.7	<.0001

1) EER (Estimated Energy Requirements) 2) RNI (Recommended Nutrient Intake)

3) Sugar intake from processed foods was energy-adjusted using the residual method and categorized into quartiles.

4) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, maternal education and physical activity and energy intake, with the exception of energy intake models.

Table 10-2. Mean daily nutrient intake including sugar intake of each gender according to quartiles of sugar intake from processed foods

	Quartiles of sugar intake from processed foods[3]				
	Q1	Q2	Q3	Q4	*P* for trend
Girls (n=1,551)					
Energy (kcal/day) [Mean±SE]	1631.6±26.2	1646.0±26.3	1616.9±26.0	1594.1±26.0	0.1206
Carbohydrate (g) [Mean±SE]	234.2±1.8	235.1±1.8	237.1±1.8	242.9±1.8	<.0001
Protein (g) [Mean±SE]	65.5±0.7	63.7±0.7	62.2±0.7	58.2±0.7	<.0001
Fat (g) [Mean±SE]	49.2±0.7	50.0±0.7	49.8±0.7	49.5±0.7	0.8184
Percent of EER[1] [%]	85.8	86.5	85.3	83.2	0.0725
Percent of RNI[2] [%]					
Thiamin	125.6	123.7	119.6	114.0	0.0002
Riboflavin	101.4	102.3	100.5	97.8	0.1809
Niacin	117.4	111.8	108.8	95.5	<.0001
Vitamin C	80.3	78.9	74.2	72.4	0.0395
Calcium	55.9	55.0	56.3	56.9	0.4573
Phosphorus	101.3	97.7	96.9	89.8	<.0001
Iron	105.6	98.3	119.5	94.2	0.4894
Total Sugar (g) [Mean±SE]	37.3±1.0	44.6±1.0	53.5±1.0	70.1±1.0	<.0001
Total Sugar (% of Energy)	9.2	10.8	12.9	16.9	<.0001

1) EER (Estimated Energy Requirements) 2) RNI (Recommended Nutrient Intake)

3) Sugar intake from processed foods was energy-adjusted using the residual method and categorized into quartiles.

4) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, maternal education and physical activity and energy intake, with the exception of energy intake models.

Table 11-1. Mean daily percent energy from food groups of each gender according to quartiles of sugar intake from processed foods

Food group	Quartiles of sugar intake from processed foods[1)]				
(% of energy from food group)	Q1	Q2	Q3	Q4	*P* for trend
Boys (n=1,048)	←	Mean±SE		→	
White rice	36.3±0.8	31.1±0.8	29.9±0.8	28.4±0.8	<.0001
Other grain	5.0±0.4	5.3±0.4	5.0±0.4	4.7±0.4	0.3508
Noddle and dumpling	7.4±0.6	9.3±0.6	7.5±0.6	7.2±0.6	0.2075
Flour and bread	3.4±0.4	5.1±0.4	5.5±0.4	6.4±0.4	<.0001
Pizza and hamburger	1.2±0.4	2.0±0.4	2.8±0.4	2.5±0.4	0.0012
Cereals and snack	1.9±0.4	3.1±0.4	4.1±0.4	3.5±0.4	<.0001
Potatoes and starch	1.3±0.2	1.6±0.2	1.4±0.2	1.3±0.2	0.8832
Sugars and sweets	1.3±0.1	1.5±0.1	2.0±0.1	2.5±0.1	<.0001
Legumes	1.9±0.2	1.8±0.2	1.6±0.2	1.5±0.2	0.0050
Nuts and seeds	0.4±0.1	0.5±0.1	0.4±0.1	0.4±0.1	0.8808
Vegetables	1.9±0.1	1.9±0.1	1.8±0.1	1.8±0.1	0.3515
Kimchi	0.6±0.0	0.6±0.0	0.6±0.0	0.6±0.0	0.1607
Mushrooms	0.1±0.0	0.1±0.0	0.1±0.0	0.1±0.0	0.6235

1) Sugar intake from processed foods was energy-adjusted using the residual method and categorized into quartiles.
2) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, maternal education and physical activity.

Table 11-2. Mean daily percent energy from food groups of each gender according to quartiles of sugar intake from processed foods

Food group (% of energy from food group)	Quartiles of sugar intake from processed foods[1)] Q1	Q2	Q3	Q4	P for trend
Boys (n=1,048)	←	Mean±SE	→		
Fruits	1.9±0.2	1.9±0.2	2.2±0.2	1.8±0.2	0.5658
Meats	15.0±0.6	12.4±0.6	12.6±0.6	11.4±0.6	<.0001
Eggs	2.5±0.2	2.2±0.2	1.9±0.2	1.9±0.2	0.0005
Fishes and shellfishes	4.3±0.2	4.1±0.2	3.9±0.2	4.0±0.2	0.2195
Seaweeds	0.3±0.0	0.4±0.0	0.3±0.0	0.2±0.0	0.0012
Milk	4.3±0.3	4.4±0.3	4.6±0.3	3.8±0.3	0.1483
Flavored milk	0.0±0.1	0.2±0.1	0.3±0.1	1.1±0.1	<.0001
Dairy products	0.3±0.1	0.6±0.1	0.7±0.1	1.1±0.1	<.0001
Ice cream and frozen confections	0.4±0.2	1.4±0.2	2.2±0.3	3.8±0.2	<.0001
Sugar-sweetened beverages	0.3±0.2	0.8±0.2	1.9±0.2	3.2±0.2	<.0001
Brewed coffee and tea	0.2±0.1	0.2±0.1	0.2±0.1	0.3±0.1	0.0166
Seasonings	2.9±0.1	2.7±0.1	2.5±0.1	2.4±0.1	0.0009
Oils	4.8±0.2	4.5±0.2	4.1±0.2	3.7±0.2	<.0001
Others	0.1±0.1	0.1±0.1	0.0±0.1	0.2±0.1	0.0386

1) Sugar intake from processed foods was energy-adjusted using the residual method and categorized into quartiles.

2) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, maternal education and physical activity.

Table 11-3. Mean daily percent energy from food groups of each gender according to quartiles of sugar intake from processed foods

Food group (% of energy from food group)	Quartiles of sugar intake from processed foods[1)] Q1	Q2	Q3	Q4	*P* for trend
Girls (n=1,551)	←	Mean±SE		→	
White rice	33.7±0.6	30.4±0.6	28.5±0.6	24.5±0.6	<.0001
Other grain	5.9±0.3	5.4±0.3	5.4±0.3	5.1±0.3	0.0533
Noddle and dumpling	7.5±0.5	7.8±0.5	6.9±0.5	7.6±0.5	0.7465
Flour and bread	3.6±0.4	5.9±0.4	6.0±0.4	7.9±0.4	<.0001
Pizza and hamburger	0.8±0.3	1.6±0.3	2.0±0.3	2.5±0.3	<.0001
Cereals and snack	2.6±0.3	3.9±0.3	4.7±0.3	5.1±0.3	<.0001
Potatoes and starch	1.5±0.2	1.6±0.2	1.7±0.2	1.4±0.2	0.5740
Sugars and sweets	1.7±0.2	2.0±0.2	2.8±0.2	3.5±0.2	<.0001
Legumes	1.8±0.1	1.6±0.1	1.7±0.1	1.4±0.1	0.0120
Nuts and seeds	0.5±0.1	0.3±0.1	0.5±0.1	0.3±0.1	0.0760
Vegetables	2.1±0.1	2.1±0.1	2.0±0.1	1.8±0.1	<.0001
Kimchi	0.8±0.0	0.7±0.0	0.7±0.0	0.6±0.0	<.0001
Mushrooms	0.1±0.0	0.1±0.0	0.1±0.0	0.1±0.0	0.1765

1) Sugar intake from processed foods was energy-adjusted using the residual method and categorized into quartiles.
2) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, maternal education and physical activity.

Table 11-4. Mean daily percent energy from food groups of each gender according to quartiles of sugar intake from processed foods

Food group (% of energy from food group)	Quartiles of sugar intake from processed foods[1) Q1	Q2	Q3	Q4	*P* for trend
Girls (n=1,551)	←	Mean±SE		→	
Fruits	3.1±0.2	2.6±0.2	2.6±0.2	2.4±0.2	0.0040
Meats	12.3±0.4	11.3±0.4	10.9±0.4	9.3±0.4	<.0001
Eggs	2.6±0.1	2.7±0.1	2.3±0.1	1.9±0.1	<.0001
Fishes and shellfishes	4.7±0.2	4.2±0.2	4.3±0.2	3.6±0.2	<.0001
Seaweeds	0.4±0.0	0.3±0.0	0.3±0.0	0.2±0.0	<.0001
Milk	4.9±0.3	4.6±0.3	4.6±0.3	4.3±0.3	0.0608
Flavored milk	0.2±0.1	0.3±0.1	0.5±0.1	0.9±0.1	<.0001
Dairy products	0.6±0.1	0.8±0.1	0.9±0.1	1.4±0.1	<.0001
Ice cream and frozen confections	0.8±0.2	1.6±0.2	2.5±0.2	5.0±0.2	<.0001
Sugar-sweetened beverages	0.3±0.1	1.0±0.1	1.5±0.1	2.7±0.1	<.0001
Brewed coffee and tea	0.2±0.0	0.1±0.0	0.1±0.0	0.1±0.0	0.2038
Seasonings	2.8±0.1	2.8±0.1	2.6±0.1	2.5±0.1	0.0151
Oils	4.6±0.1	4.3±0.1	4.1±0.1	3.6±0.1	<.0001
Others	0.0±0.1	0.0±0.1	0.1±0.1	0.2±0.1	0.0029

1) Sugar intake from processed foods was energy-adjusted using the residual method and categorized into quartiles.
2) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, maternal education and physical activity.

4) Association of sugar-sweetened beverage intake with pediatric obesity

Table 12 shows the multivariate adjusted ORs and 95% CIs for pediatric overweight and obesity across SSB intake. Among subjects, 43% were non-drinkers whereas 10.7% of boys and 7.7% of girls consumed 200 mL or more per day. In terms of the percent of energy from SSB, girls consumed 6.0% of energy from SSB, which was higher than that by boys (5.8%).

After adjusting for confounding variables, boys who consumed more than 200 mL per day had a significantly lower prevalence of obesity (OR 0.53; CI 0.27-1.07; p for trend=0.0355) compared to non-drinkers. However, no significant association was observed in girls.

Mean daily nutrient including sugar intake and mean daily percent energy from food groups of each gender according to sugar-sweetened beverage intake are presented in Table 13-1 to Table 14-4. In all subjects, the mean percent of EER significantly increased by SSB intake (p for trend<0.0001 for both genders). As SSB intake increased, boys had significantly lower percent energy from white rice, vegetable, kimchi and milk and higher percent energy from pizza and hamburger.

Table 12. Multivariate adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for pediatric overweight and obesity across sugar-sweetened beverage intake

	Sugar-sweetened beverage (SSB) intake (mL/day)[1]			
	Non-drinker	< 200 mL/day	≥ 200 mL/day	*P* for trend[3]
Boys (n=1 048)				
N (%)	461 (44.0)	475 (45.3)	112 (10.7)	
SSB intake [Mean±SE]	0	87.8±3.2	301.7±5.2	
SSB (% of energy)	0	2.1	5.8	
Overweight[2]	1.00	0.96 (0.67-1.39)	0.66 (0.33-1.29)	0.2348
Obesity[2]	1.00	0.60 (0.41-0.87)	0.53 (0.27-1.07)	0.0355
Girls (n=1 551)				
N (%)	647 (41.7)	785 (50.6)	119 (7.7)	
SSB intake	0	74.4±2.1	260.9±4.0	
SSB (% of energy)	0	2.0	6.0	
Overweight	1.00	0.99 (0.72-1.36)	0.98 (0.53-1.84)	0.9458
Obesity	1.00	1.27 (0.85-1.90)	1.36 (0.62-2.95)	0.3235

1) SSB intakes were categorized into two groups: those who drank SSB < 200 mL and SSB ≥ 200 mL per day among SSB drinkers.

2) Overweight was defined as 85-95th percentile for age, gender-specific BMI; obesity was defined as ≥ 95th percentile or BMI ≥ 25.

3) Logistic regression analysis was used to test associations between SSB and obesity after adjusting for age, study number, energy intake, maternal education and physical activity.

Table 13-1. Mean daily nutrient intake including sugar intake of each gender according to sugar-sweetened beverage intake

	Sugar-sweetened beverage (SSB) intake[3]			
	Non-drinker	< 200 mL/day	≥ 200 mL/day	*P* for trend
Boys (n=1,048)				
Energy (kcal/day) [Mean±SE]	1735.1±30.5	1882.8±30.8	2112.5±49.5	<.0001
Carbohydrate (g) [Mean±SE]	258.2±2.0	257.4±2.0	268.5±3.2	0.0030
Protein (g) [Mean±SE]	72.6±0.8	72.1±0.8	68.3±1.3	0.0015
Fat (g) [Mean±SE]	57.7±0.8	58.9±0.8	55.3±1.3	0.0993
Percent of EER[1] [%]	73.9	80.1	90.3	<.0001
Percent of RNI[2] [%]				
Thiamin	134.3	153.4	146.2	0.3660
Riboflavin	87.4	90.0	92.6	0.1584
Niacin	115.8	121.4	133.0	0.0004
Vitamin C	70.0	75.5	87.1	0.0022
Calcium	55.1	55.0	60.9	0.1627
Phosphorus	95.6	99.9	108.4	0.0003
Iron	108.7	154.5	178.9	0.0120
Total Sugar (g) [Mean±SE]	42.6±1.2	53.9±1.2	70.8±2.0	<.0001
Total Sugar (% of Energy)	9.0	11.6	14.6	<.0001

1) EER (Estimated Energy Requirements) 2) RNI (Recommended Nutrient Intake)

3) SSB intakes were categorized into two groups: those who drank SSB < 200 mL and SSB ≥ 200 mL per day among SSB drinkers.

4) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, maternal education and physical activity and energy intake, with the exception of energy intake models.

Table 13-2. Mean daily nutrient intake including sugar intake of each gender according to sugar-sweetened beverage intake

	Sugar-sweetened beverage (SSB) intake[3]			
	Non-drinker	< 200 mL/day	≥ 200 mL/day	*P* for trend
Girls (n=1,551)				
Energy (kcal/day) [Mean±SE]	1538.2±21.5	1658.7±21.3	1872.3±39.8	<.0001
Carbohydrate (g) [Mean±SE]	238.3±1.5	236.3±1.5	239.7±2.8	0.9046
Protein (g) [Mean±SE]	62.2±0.6	62.5±0.6	61.9±1.2	0.9144
Fat (g) [Mean±SE]	49.0±0.6	50.2±0.6	50.1±1.1	0.1504
Percent of EER[1] [%]	80.8	87.3	97.2	<.0001
Percent of RNI[2] [%]				
Thiamin	115.0	122.0	144.0	<.0001
Riboflavin	97.9	101.3	109.6	0.0055
Niacin	100.6	111.3	131.5	<.0001
Vitamin C	70.4	77.0	105.9	<.0001
Calcium	54.4	56.8	60.8	0.0063
Phosphorus	92.5	98.1	106.9	<.0001
Iron	91.8	111.3	133.9	0.0005
Total Sugar (g) [Mean±SE]	47.4±1.0	53.2±1.0	68.6±1.9	<.0001
Total Sugar (% of Energy)	11.5	12.9	16.1	<.0001

1) EER (Estimated Energy Requirements) 2) RNI (Recommended Nutrient Intake)

3) SSB intakes were categorized into two groups: those who drank SSB < 200 mL and SSB ≥ 200 mL per day among SSB drinkers.

4) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, maternal education and physical activity and energy intake, with the exception of energy intake models.

Table 14-1. Mean daily percent energy from food groups of each gender according to sugar-sweetened beverage intake

Food group (% of energy from food group)	Sugar-sweetened beverage (SSB) intake[1)]			
	Non-drinker	< 200 mL/day	≥ 200 mL/day	*P* for trend
Boys (n=1,048)	←	Mean±SE	→	
White rice	34.5±0.7	29.2±0.7	28.0±1.1	<.0001
Other grain	5.1±0.3	5.0±0.3	4.5±0.5	0.2181
Noddle and dumpling	8.0±0.5	8.1±0.5	6.4±0.8	0.0680
Flour and bread	4.6±0.4	5.7±0.4	4.8±0.6	0.5122
Pizza and hamburger	1.1±0.3	2.5±0.3	4.6±0.5	<.0001
Cereals and snack	3.0±0.3	3.0±0.3	4.0±0.5	0.0704
Potatoes and starch	1.2±0.2	1.6±0.2	1.7±0.3	0.0606
Sugars and sweets	1.7±0.1	1.9±0.1	2.5±0.2	<.0001
Legumes	2.0±0.1	1.5±0.1	1.4±0.2	0.0053
Nuts and seeds	0.4±0.1	0.4±0.1	0.4±0.1	0.8789
Vegetables	1.9±0.1	1.9±0.1	1.6±0.1	0.0082
Kimchi	0.7±0.0	0.6±0.0	0.5±0.0	0.0006
Mushrooms	0.1±0.0	0.1±0.0	0.1±0.0	0.3440

1) SSB intakes were categorized into two groups: those who drank SSB < 200 mL and SSB ≥ 200 mL per day among SSB drinkers.

2) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, energy intake, maternal education and physical activity.

Table 14-2. Mean daily percent energy from food groups of each gender according to sugar-sweetened beverage intake

Food group (% of energy from food group)	Sugar-sweetened beverage (SSB) intake[1) Non-drinker	< 200 mL/day	≥ 200 mL/day	*P* for trend
Boys (n=1,048)	←	Mean±SE	→	
Fruits	1.7±0.2	2.1±0.2	2.1±0.3	0.1970
Meats	12.3±0.5	13.5±0.5	12.8±0.8	0.4153
Eggs	2.3±0.1	2.0±0.1	2.0±0.2	0.2499
Fishes and shellfishes	4.3±0.2	4.0±0.2	3.7±0.3	0.0735
Seaweeds	0.4±0.0	0.2±0.0	0.2±0.1	0.0027
Milk	4.6±0.3	4.1±0.3	3.6±0.4	0.0176
Flavored milk	0.3±0.1	0.5±0.1	0.6±0.2	0.0812
Dairy products	0.6±0.1	0.8±0.1	0.7±0.2	0.2601
Ice cream and frozen confections	1.8±0.2	2.1±0.2	2.2±0.4	0.3516
Sugar-sweetened beverages	0.1±0.1	2.1±0.1	5.6±0.2	<.0001
Brewed coffee and tea	0.2±0.0	0.2±0.0	0.2±0.1	0.6356
Seasonings	2.8±0.1	2.6±0.1	2.1±0.2	<.0001
Oils	4.5±0.2	4.2±0.2	3.8±0.3	0.0117
Others	0.1±0.0	0.1±0.0	0.1±0.1	0.7737

1) SSB intakes were categorized into two groups: those who drank SSB < 200 mL and SSB ≥ 200 mL per day among SSB drinkers.

2) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, energy intake, maternal education and physical activity.

Table 14-3. Mean daily percent energy from food groups of each gender according to sugar-sweetened beverage intake

Food group (% of energy from food group)	Sugar-sweetened beverage (SSB) intake[1)			
	Non-drinker	< 200 mL/day	≥ 200 mL/day	*P* for trend
Girls (n=1,551)	←	Mean±SE	→	
White rice	31.0±0.5	28.0±0.5	25.4±1.0	0.7435
Other grain	5.6±0.3	5.5±0.3	4.6±0.5	0.0659
Noddle and dumpling	7.7±0.4	7.4±0.4	6.5±0.7	0.0997
Flour and bread	5.6±0.3	6.2±0.3	6.3±0.6	0.1185
Pizza and hamburger	0.8±0.2	2.3±0.2	4.0±0.4	<.0001
Cereals and snack	4.0±0.3	4.0±0.3	4.9±0.5	0.1266
Potatoes and starch	1.4±0.1	1.7±0.1	1.7±0.3	0.0992
Sugars and sweets	2.6±0.1	2.5±0.1	2.4±0.3	0.4771
Legumes	1.6±0.1	1.6±0.1	1.3±0.2	0.0881
Nuts and seeds	0.4±0.1	0.5±0.1	0.4±0.1	0.3308
Vegetables	2.0±0.1	2.0±0.1	1.8±0.1	0.0304
Kimchi	0.7±0.0	0.7±0.0	0.6±0.0	0.0241
Mushrooms	0.1±0.0	0.1±0.0	0.1±0.0	0.8850

1) SSB intakes were categorized into two groups: those who drank SSB < 200 mL and SSB ≥ 200 mL per day among SSB drinkers.

2) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, energy intake, maternal education and physical activity.

Table 14-4. Mean daily percent energy from food groups of each gender according to sugar-sweetened beverage intake

Food group (% of energy from food group)	Sugar-sweetened beverage (SSB) intake[1)] Non-drinker	 < 200 mL/day	 ≥ 200 mL/day	 *P* for trend
Girls (n=1,551)	←	Mean±SE	→	
Fruits	2.9±0.2	2.4±0.2	2.9±0.3	0.4230
Meats	10.6±0.3	11.0±0.3	12.3±0.6	0.0091
Eggs	2.4±0.1	2.4±0.1	2.0±0.2	0.0356
Fishes and shellfishes	4.4±0.2	4.2±0.2	3.0±0.3	<.0001
Seaweeds	0.3±0.0	0.3±0.0	0.2±0.0	0.0010
Milk	5.0±0.2	4.3±0.2	3.4±0.4	<.0001
Flavored milk	0.4±0.1	0.5±0.1	0.6±0.1	0.1191
Dairy products	0.9±0.1	0.9±0.1	1.0±0.2	0.8779
Ice cream and frozen confections	2.5±0.2	2.6±0.2	2.3±0.4	0.6584
Sugar-sweetened beverages	0.0±0.1	2.0±0.1	5.9±0.2	<.0001
Brewed coffee and tea	0.1±0.0	0.1±0.0	0.1±0.1	0.7822
Seasonings	2.7±0.1	2.7±0.1	2.4±0.2	0.0232
Oils	4.2±0.1	4.2±0.1	3.9±0.2	0.3691
Others	0.1±0.0	0.1±0.0	0.0±0.1	0.5442

1) SSB intakes were categorized into two groups: those who drank SSB < 200 mL and SSB ≥ 200 mL per day among SSB drinkers.

2) All values were tested using a generalized linear model (GLM) after adjusting for age, study number, energy intake, maternal education and physical activity.

5) Comprehensive associations of dietary sugar and sugar-sweetened beverage intake with obesity

Figure 4 shows comprehensive associations of dietary sugar (total sugar, sugar intake from milk and fruits and sugar from processed foods) and SSB intake with pediatric obesity according to prior results from multivariate adjusted logistic regression after adjusting confounding variables. Total sugar intake were inversely associated with obesity only in girls (OR for highest quartile, 0.53; 95% CI, 0.29-0.96; *p* for trend=0.0301). Divided total sugar into sugar from milk and fruits and that from processed foods, significantly inverse association was observed between sugar intake from milk and fruits and obesity in girls (OR for highest quartile, 0.47; 95% CI, 0.25-0.87; *p* for trend=0.0225). However, there were no significant association with sugar intake from processed foods. With regard to SSB intake, boys who drank ≥200 mL/day had a lower prevalence of obesity (OR, 0.53; 95% CI, 0.27-1.07; p for trend=0.0355) compared to non-drinkers, whereas no significant association was observed in girls.

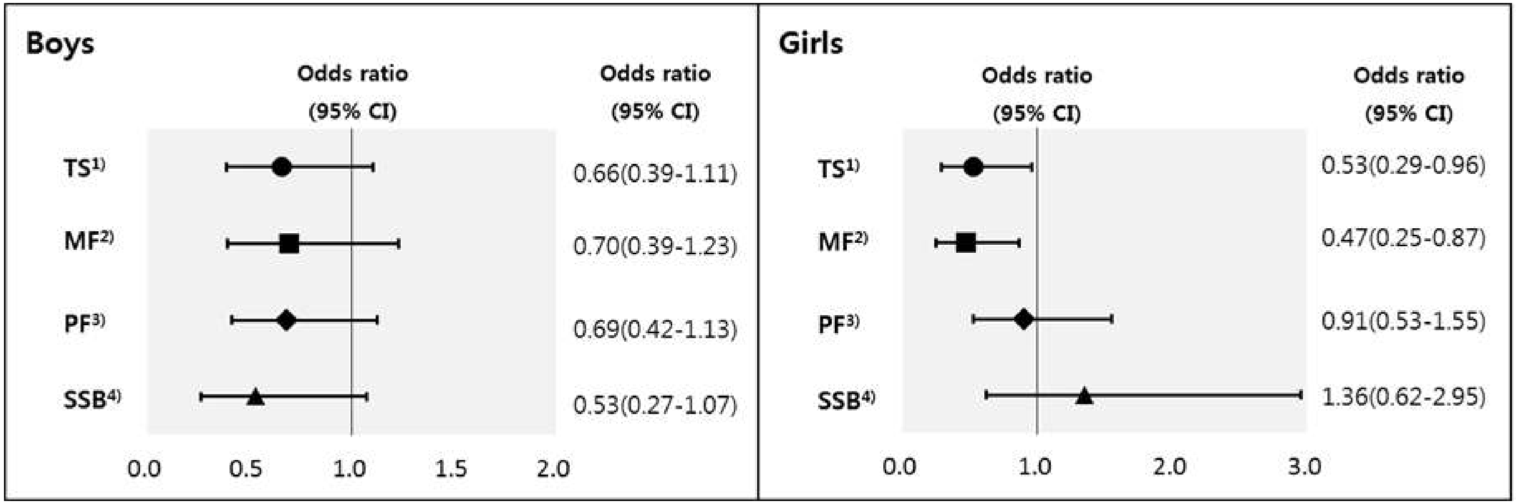

Figure 4. Multivariate adjusted odds ratio (ORs) and 95% confidence intervals (CIs) for pediatric obesity across dietary sugar and sugar-sweetened beverage intake by multivariate adjusted logistic regression

1) OR for highest quartile for total sugar intake

2) OR for highest quartile for sugar intake from milk and fruits

3) OR for highest quartile for sugar intake from processed foods

4) OR for subjects who drank ≥200 mL/day

Ⅳ. DISCUSSION

In the large sample study of 2,599 Korean children and adolescents 9-14 years of age, it was found that total dietary sugar intake and its contribution to total energy intake remained relatively low although the sugar intake from processed foods comprised more than half of the percent of total sugar intake. Total sugar intake was inversely associated with obesity in girls. Regarding dietary sugar intake based on food sources, only sugar from milk and fruits was inversely associated with pediatric overweight as well as obesity among girls.

The average daily sugar intake from 3 or more days of dietary records was 51.4 g in this study and was comparable with 61.3 g reported among 6-11-year-old Korean children from a 1-day 24-h recall data in a national nutrition survey[13]. However, this level of dietary sugar is considerably lower than that of children and adolescents in Western countries. The daily sugar intake reported was 139 g in 1-18-year-old subjects in the United States[16], 107.1 g in 11-18 year-old subjects in the UK[17], and 172 g in boys 14-18 years of age in Canada[18].

SSB intake was also reported to be lower in an Asian population compared to a Western population. In this study, the mean SSB intake was 63 mL/day, which was lower than the 127 mL/day reported in a study of Australian children and adolescents 2-16 years of age[23]. The mean energy from SSBs in the present study was 27 kcal/day, which is lower than in children and adolescents in United States with the values of 141 kcal/day for boys and 112 kcal/day for girls among 6-11-year-old subjects and 273 kcal/day for boys and 171 kcal/day for girls among 12-19-year-old subjects[24]. Unexpectedly, total sugar intake or sugar from processed foods was not associated with pediatric overweight or obesity. Conversely, high SSB intake was associated with the reduced OR of obesity in boys.

Reportedly, high SSB intake is associated with weight gain and obesity, and a recent meta-analysis confirmed this positive relationship; however, all of the studies were conducted in Western children[12,25]. Only a few studies investigating the association between SSB and obesity in Asian children were performed; however, the results were inconsistent.

SSBs not only contain high amounts of added sugar that lead to adverse health outcomes but also are associated with unhealthy food patterns or eating behaviors[26]. In terms of dietary patterns or eating behaviors among people who consume high amounts of SSB, Asian children and adolescents may have different dietary practices. With the rapid economic growth and adaptation to Western lifestyle, the traditional pattern has shifted to the modified pattern in which high animal foods or sweets (including SSBs) were introduced to the traditional diet[11]. According to studies conducted in Korea and China, higher consumption of SSBs was associated with higher socioeconomic status[27,28].

In terms of different dietary practices in Asia, the mixed findings regarding the relationship between SSBs and obesity can be in part explained. SSB drinkers consumed more total energy and showed a higher prevalence of obesity in Chinese children[21] and Korean boys 7-12 years of age[29]. Conversely, sugar intake from SSB and snacks was not significantly associated with weight status in Japanese and Cambodian children[22].

In general, total energy intake in Asian children and adolescents is lower than in Western children and adolescents. In this study, the average percent of energy intake compared to age- and gender-specific EER was approximately 85% in girls and even less in boys (< 80%).

Contrary to expectations, total dietary sugar and SSB did not increase the risk of obesity in this study. According to dose-response meta-analyses of Western prospective studies, SSB consumption was linearly associated with the risk of hypertension and type II diabetes[30,31], though results were not applied to weight gain or obesity. Total dietary sugar intake as well as total energy intake of Korean children and adolescents were lower than those of Western population, so that total dietary sugar might not be positively associated with obesity in this study. Due to the lack of evidences, it is difficult to confirm the association of dietary sugar with obesity at low intake. Thus, further studies such as a dose-response analysis between dietary sugar and weight gain and continuous monitoring dietary sugar intake of Korean children and adolescents should be required.

Dietary sugar intake from different food sources might be related to dietary pattern. Major distinction was not found in this study.

However, higher consumption of sugar from milk and fruits was significantly associated with lower percent energy from noddle & dumpling and pizza & hamburger, while higher consumption of sugar from processed foods was associated with higher percent energy from flour & bread and pizza & hamburger which are representative foods of Western diet. Therefore, children and adolescents who consumed more sugar from processed foods might prefer unhealthy foods which were high in carbohydrate and fat and also have undesirable dietary pattern. Although sugar from processed foods were not associated with pediatric obesity in this study, further longitudinal studies are necessary to investigate the effects of added sugars on childhood obesity and their dietary pattern.

A significant and inverse association of sugar from milk and fruits was observed only in girls. Due to the absence of an added sugar database in Korea, it was unable to evaluate added or free sugar intake. Alternatively, this study evaluated dietary sugar intake from various food sources; only sugar from milk and fruits showed a positive effect on weight. Milk and fruits have protective effects on weight gain and obesity in children[32-34]. However, this study showed that even sugar intake from milk and fruits has positive effects on obesity, especially in girls, and should be considered when developing strategies for weight management in Korea. Korean girls seek a slim body image and most have tried dieting at least once[35,36]. Due to the current increased focus on dietary sugar intake, fruits are often misunderstood as a source of a high level of simple sugars.

As children and adolescents grow, they can develop undesirable dietary behaviors in this complex food environment. Among subjects less than 19 years of age, mean energy from added sugar linearly increased with age in United States children[37] and total sugar intake in Korean children showed a similar increasing trend with age[13]. In addition, Canadian adolescents 9-18 years of age consumed more added sugar, conversely, children 1-8 years of age consumed sugar from natural food sources[38]. Lee et al.[29] reported that SSB intake was inversely associated with milk, fruit and vegetable intake in Korean children and adolescents. Additional analysis of this study showed lower sugar intake from milk and fruits and higher sugar intake from processed foods in subjects 12-14 years of age compared to those 9-11 years of age. Therefore, monitoring not only dietary sugar intake but also the food source is important, and effective nutrition education or policies should be implemented to maintain low sugar intake in Korean children and adolescents.

This study had several limitations. First, the sample was pooled from five previous studies. Although this study collected all core information, such as 3 or more days of dietary records and anthropometric measurements, discrepancy between studies may exist. To minimize this bias, the study number was used as a covariate in all analyses. Second, SSB intake data in this study were from the previous decade rather than current because the five original studies were conducted from 2002 to 2011. Due to the rapid growth in the SSB market in Asian countries[20,39], the current SSB intake is expected to increase considerably; thus the association with obesity will differ. Third, confounding variables which were related to socioeconomic status and lifestyle factors were limited due to the pooled design of this study as mentioned above. Thus, statistical adjustments might not be sufficient to control the possible effect of other confounders on childhood obesity. However, physical activity level which has been known to influence obesity considerably was adjusted in this study. Finally, this study was cross-sectional in design, making it difficult to determine a causal relationship between dietary sugar intake and the risk of obesity.

Despite these limitations, this study had several strengths. To the best of our knowledge, this is the first study to estimate dietary sugar intake and the food sources thereof using multiple days of dietary records in a large sample of Asian children and adolescents. Since daily sugar intake or SSB intake was calculated individually from 3 or more days of dietary records, it should be representative of the usual intake.

V. SUMMARY AND CONCLUSION

This study evaluated dietary sugar intake and its food sources and examined the association of dietary sugar intake and its food source with obesity in Korean children and adolescents using data obtained from five studies conducted between 2002 and 2011.

In the large sample study of 2,599 Korean children and adolescents 9-14 years of age, the mean intake of total sugar was 51.4 g (11.8%

of total energy) and girls had higher sugar intakes than boys (54.3 g for girls and 46.6 g for boys). This study found that total dietary sugar intake and its contribution to total energy intake remained relatively low although the sugar intake from processed foods comprised more than half of the percent of total sugar intake. With the exception of processed foods, fruits were the major food source that contributed to total sugar intake followed by milk in all subjects.

Total sugar intake was inversely associated with obesity in girls. Regarding sugar intake based on food sources, only sugar from milk and fruits was significantly associated with a decreased risk of lower prevalence of pediatric overweight as well as obesity among girls. However, there was no significant association with sugar from processed foods.

In conclusion, dietary sugar or SSB intake in Korean children and adolescents is lower than in Western children and adolescents. Sugar from milk and fruits has a beneficial effect on obesity in Asian girls. Therefore, dietary sugar intake should be monitored continually and further prospective studies examining the relationship between dietary sugar intake and obesity are necessary.

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Ⅶ. KOREAN ABSTRACT

한국 아동 및 청소년의 당류 및 가당음료 섭취와 비만과의 관련성

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전 세계적으로 비만이 심각한 건강문제로 여겨지고 있는 가운데 특히 아동 및 청소년의 비만이 증가하고 있는 추세이다. 또한, 당류 및 가당음료(Sugar-sweetened beverages, SSBs)의 섭취와 아동 및 청소년의 비만과의 관련성에 대한 우려가 높아지고 있다. 그러나 아시아인은 서양에 비하여 상대적으로 낮은 당류 섭취량을 보고하고 있으며, 아시아의 아동 및 청소년을 대상으로 당류 섭취와 비만과의 관련성을 수행한 연구는 부족한 실정이다. 따라서 본 연구는 한국 아동 및 청소년의 당류 섭취량 및 당류 섭취량과 과체중 및 비만의 관련성을 파악하고자 하였다.

본 연구는 2002-2011년에 한국 아동 및 청소년을 대상으로 수행한 다섯 개의 연구 자료를 수집하였다. 이 중 3일 이상의 식사기록자료와 신체계측자료를 보유하고, 성별, 연령, 신체활동 수준 등의 혼란변수에 대한 정보가 있는 대상자를 선정하여 최종적으로 2,599명을 본 연구에 포함하였다. 신장과 체중을 이용하여 체질량 지수(BMI, kg/m^2)를 산출하였고, 한국 소아청소년 발육곡선의 성·연령별 BMI percentile 기준에 따라

85th percentile 이상 95th percentile 미만을 과체중으로 분류하였고, 95th percentile 이상이거나 BMI가 25 kg/m^{2}이상일 경우 비만으로 분류하였다.

본 연구에 포함된 2,599명의 총 당류 섭취량은 51.4 g(총 에너지 섭취량의 11.8%)으로 나타났으며, 여성의 총 당류 섭취량은 54.3 g으로 남성의 총 당류 섭취량이 46.6 g인 것에 비하여 높았다. 총 당류는 여성의 비만과 유의한 음의 상관관계를 가지는 것으로 나타났다(OR for obesity, 0.53; 95% CI, 0.29-0.96; *p* for trend=0.0301). 주요 식품 급원에 따라 당류를 분류하였을 때, 우유와 과일을 통한 당류에서만 유의한 상관관계가 발견되었으며 우유와 과일을 통한 당류 섭취량이 증가할수록 여성의 과체중 및 비만의 유병률이 유의하게 감소하였다(OR for overweight, 0.54; 95% CI, 0.34-0.86; *p* for trend=0.0275 and OR for obesity, 0.47; 95% CI, 0.25-0.87; *p* for trend=0.0225). 그러나 가공식품을 통한 당류섭취는 남성과 여성에서 모두 유의한 상관관계가 없었다. 가당음료는 남성의 10.7%와 여성의 7.7%가 하루에 200 mL 이상 섭취하고 있었으나 가당음료의 에너지 기여율은 남성에서 5.8%, 여성에서 6.0%인 것으로 나타났다. 가당음료의 섭취는 여성에서는 유의한 상관관계를 보이지 않았으나 남성의 비만과 유의한 음의 상관관계를 나타내었다(OR for obesity, 0.53; 95% CI, 0.27-1.07; *p* for trend=0.0355).

본 연구는 한국인의 아동 및 청소년의 총 당류와 가당음료의 섭취량이 상대적으로 아직 낮은 수준이며, 우유와 과일을 통한 당류 섭취는 여성의 과체중과 비만에 보호적인 효과를 나타냄을 시사한다.

주요어: 당류 섭취, 가당음료, 우유와 과일을 통한 당류 섭취, 비만, 아동, 청소년

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