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Sweet Preference Associated with the Risk of Hypercholesterolemia Among Middle-Aged Women in Korea

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Aims: Sweet preference has been reported to be associated with various health problems. This study examined the influence of sweet taste preference on the risk of dyslipidemia in Korean middle-aged women.

Methods: The study selected 3,609 middle-aged women from the Korean Genome and Epidemiology Study (KoGES) and classified them into two groups on the basis of whether or not they preferred sweet taste. Dietary intake was analyzed using a semiquantitative food frequency questionnaire. Serum lipid profiles and anthropometric variables were measured.

Results: Subjects who preferred the sweet taste had significantly higher intakes of sugar products and sweet drink than those who did not prefer the sweet taste. Subjects who preferred the sweet taste showed higher carbohydrate and fat intake and less fiber intake than those who did not prefer the sweet taste. The serum concentrations of total cholesterol and low-density lipoprotein (LDL) cholesterol were significantly higher in subjects who preferred the sweet taste than those who did not prefer. Furthermore, subjects who preferred the sweet taste showed a significantly higher odds ratio (OR) for hypercholesterolemia (OR 1.22; 95% CI (1.01–1.45)) and hyper-LDL cholesterolemia (OR 1.33; 95% CI (1.11–1.60)) than those who did not prefer the sweet taste.

Conclusion: Our results suggested that preference for sweet taste may increase the consumption of sugar products and sweet drinks, which is partially linked to the risk of hypercholesterolemia and hyper-LDL cholesterolemia in Korean middle-aged women.

Key words: Sweet preference, Sugar product, Hypercholesterolemia, Hyper-LDL cholesterolemia

Introduction

Dyslipidemia is considered as one of the most significant cardiovascular risk factors, including increased concentrations of total cholesterol, low-density lipoprotein (LDL) cholesterol, and triglycerides and decreased concentrations of high-density lipoprotein (HDL) cholesterol[1]. Each increase per 10 mg/dL in total cholesterol levels was correlated with an increase of 5% in overall mortality and 9% in cardiovascular disease mortality[2]. It is well known that the first line of therapy for individuals with dyslipidemia is lifestyle modification involving diet[3, 4].

Taste is an important determinant of food intake control. Sweet taste is one of the five basic modalities and improves pleasure of meals and snacks, thereby encouraging the choice of foods high in energy and carbohydrates[5]. Preference for sweet taste has been positively associated with a high consumption of energy-dense food[6, 7]. Excessive intake of sweet energy-dense food is thought to be a main contributor to a number of health problems such as overweight, obesity, and cardiovascular disease[8-10].

Results from the Multi-Ethnic Study of Atherosclerosis showed a significant effect of sugar-sweetened beverages on hypertriglyceridemia[11]. High consumption of added sugars in American adults was associated with high odds of low HDL cholesterol levels[12]. Sweet preference is supposed to encourage the consumption of sugar-rich foods, which can affect the risk of dyslipidemia. In particular, sweet preferences were found to be more sensitive and greater among women than

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men[13, 14], and the management to reduce serum lipids to prevent cardiovascular disease is essential for middle-aged adults. However, the influence of preference for sweet taste on serum lipid profiles in middle-aged women has yet to be investigated.

The objective of this study was to evaluate the association of preference for sweet taste with dietary intake and the risk of serum lipid abnormalities in Korean middle-aged women.

Materials and Methods

Participants

The study subjects were participants in the Korean Genome and Epidemiology Study (KoGES) in 2001[15]. The population was collected from two different communities in South Korea, the Ansan cohort representing an urban community and Ansung cohort representing a rural community. The initial cohort included 10,038 participants between 39 and 70 years old, and 8,840 (4,182 men and 4,658 women) data were released in public. This study's subjects were restricted to middle-aged women who completed the survey (n=3,984). The records with implausibly low or high energy intake (<500 or > 4,000 kcal) were excluded (n=191). Because of the possibility of change in serum lipid profile post medication, subjects who had received treatment for dyslipidemia were excluded from the study (n=184). Finally, the total number of study subjects used in our analyses was 3,609. The present study was approved by the Institutional Review Board of Ewha Womans University (85-4, December 2014), and the procedures followed were in accordance with the Helsinki Declaration of 1975, as revised in 2009.

Assessment of Preference for Sweet Taste

Food intake was obtained by well-trained interviewers using a semiquantitative food frequency questionnaire (SQFFQ). The SQFFQ was developed and evaluated for validity by the KoGES[16, 17]. Briefly, the dietary data for designing the SQFFQ were obtained from the Korea National Health and Nutrition Examination Survey (KNHANES) in 1998[16]. Two hundred and forty-nine food items, which were selected on the basis of their 0.9 cumulative percent contribution, and 254 items, which were selected on the basis of their 0.9 cumulative multiple regression coefficients, respectively, were classified into 97 food groups according to their nutrient contents. Because of the seasonality of the survey, several popular Korean foods that were missing from the list were included. Finally, 103 food items were included in the questionnaire. The food list in the SQFFQ covered 84.8% of the intake of 17 nutrients (energy, protein, carbohydrate, fat, fiber, calcium, phosphorus, iron, sodium, potassium, vitamin A, retinol, β-carotene, vitamin B_1, vitamin B_2, niacin, and vitamin C). The SQFFQ consisted of questions over a period of 12 months (on nine categories of "almost never," "once a month," "twice or three times a month," "once or twice a week," "twice or three times a week," "five or six times a week," "once a day," "twice a day," and "three times a day") and the average amount of intake (on three portion sizes of small, medium, and large). Sweet foods were selected from the list of SQFFQ and were categorized into five items based on previous articles[18]. Sweet foods included sugar products, such as cookies, candies/chocolates, breads (cake, chocolate pie, bread with small red beans, red bean steamed bun, and other breads), and ice cream/yogurts, and sweet drinks (soft drinks, soy milk, and other drinks). The average daily nutrient intake of each food item was calculated using a weighted frequency per day and a portion size per unit. The nutrient database of the Korean Nutrition Society was used to convert food intake into 23 nutrients[19]. Nutrient intakes obtained by the SQFFQ were found to be slightly lower in protein and fat than in the dietary record, but total energy and carbohydrate intake were not significantly different[17]. Correlation between the nutrient intakes collected by these two methods was significant except in the case of iron, and the average correlation coefficient between them was 0.22 ranging from 0.33 for energy to 0.11 for iron[17]. Preference for sweet was obtained by asking whether they liked the sweet food[20]. Subjects were categorized as Preferred (like and very like) or Non-preferred (neither dislike nor like, dislike, and very dislike) depending on whether they prefer the sweet taste or not.

Definition of Lipid Abnormalities

Lipid abnormalities were defined according to the criteria of the Korean Society of Lipidology and Atherosclerosis[21]. Total cholesterol levels over 230 mg/dL were defined as hypercholesterolemia, HDL cholesterol levels under 40 mg/dL were defined as hypo-HDL cholesterolemia, LDL cholesterol levels over 150 mg/dL were defined as hyper-LDL cholesterolemia, and triglyceride levels over 200 mg/dL were defined as hypertriglycemia.

General Characteristics, Anthropometric Measurements, and Biochemical Variables

General information on age, exercise (metabolic equivalent task hours/d), alcohol intake (g/d), smoking status (current smoker or non-current smoker), and education (<high school or ≥ high school) was collected by using an interview administered through

Table 1. General characteristics of participants according to sweet taste preference

	Non-preferred (n=2,399)	Preferred (n=1,210)	P	Adjusted P
Age (year)	49.5 ± 0.1	52.0 ± 0.2	<0.0001	
Height (cm)	154.4 ± 0.1	154.3 ± 0.1	0.543	0.026
Weight (kg)	59.3 ± 0.2	59.6 ± 0.2	0.373	0.245
Waist circumstance (cm)	80.5 ± 0.2	81.4 ± 0.3	0.003	0.653
BMI (kg/m^2)	24.9 ± 0.1	25.0 ± 0.1	0.192	0.857
Blood pressure (mmHg)				
Systolic	114.4 ± 0.4	116.7 ± 0.6	0.001	0.736
Diastolic	72.7 ± 0.2	73.7 ± 0.3	0.023	0.646
Exercise (MET-h/day)	3.4 ± 0.1	3.4 ± 0.2	0.999	0.843
Alcohol intake (g/day)	1.5 ± 0.1	1.1 ± 0.1	0.073	0.180
Current smokers (%)	3.3	3.3	0.913	0.892
High school education (%)	38.5	33.3	0.002	0.326

Values are mean ± SE or percentage. BMI = body mass index; KRW = Korean Won; MET = metabolic equivalent task. P was conducted by Student's t-test and chi-square tests. Adjusted P was obtained from general linear model analysis and Cochran-Mantel-Haenszel analysis with adjustment for age.

a questionnaire. Body weight and height of the subjects were measured using a standardized procedure. Weight in light clothes with no shoes was measured with a metric scale to the nearest 0.01 kg, and height was measured with a stadiometer to the nearest 0.1 cm. Blood pressures were measured with the subjects in a lying position after 5 min of rest. Blood samples were taken after having fasted for more than 8 h. Concentrations of total cholesterol, HDL cholesterol, and triglyceride were measured using biochemical assays performed by a central laboratory (Seoul Clinical Laboratories, Seoul, Republic of Korea). LDL cholesterol levels were calculated by the following equations described by Friedewald for subjects with triglyceride concentrations <400 mg/dL[22]: LDL cholesterol = Total cholesterol (mg/dL) − {HDL cholesterol (mg/dL) − (Triglycerides (mg/dL)/5)}.

Statistical Analysis

Data were expressed as mean ± standard error for continuous variables and as percentages for categorical variables, and the P value was obtained through Student's t-test and chi-square test. To determine the differences in means and distribution of general characteristics, dietary intakes, and biochemical variables, the general linear model and the Cochran–Mantel–Haenszel analysis was used with adjustment. Adjustment was performed for potential confounding variables that were either statistically significant in univariate analyses or known to be potentially important factors related to sweet taste preference and risk of lipid abnormalities, such as age, body mass index (BMI), exercise, alcohol drinking, smoking, education, and total energy intake. Multivariate logistic regression analysis was applied to obtain odds ratio (OR) and 95% confidence interval (CI) for the risk of lipid abnormalities. All statistical analyses were performed by using SAS v9.4 (SAS Institute Inc., Cary, NC, USA), and a P value of 0.05 was considered to be statistically significant.

Results

The general characteristics of participants are listed in Table 1. Subjects who preferred the sweet taste were older than those who did not prefer the sweet taste. There were no significant differences in body weight, waist circumstance, BMI, blood pressure, exercise, alcohol intake, smoking status, and education level between the two groups.

Dietary intake of participants classified by their preference for sweet taste is shown in Table 2. After adjustment of age, BMI, exercise, alcohol drinking, smoking, education, and total energy intake, the Preferred group showed higher consumption of sugar products, such as cookies, candies/chocolates, breads, ice cream/yogurts, and sweet drink compared with the Non-preferred group. Subjects who preferred the sweet taste had significantly higher energy, carbohydrate, protein and fat intake and lower fiber intake. In the Preferred group, the carbohydrate energy ratio and fat energy ratio were higher, whereas the protein energy ratio was not significantly different from the Non-preferred group.

Biochemical variables according to preference for sweet taste are shown in Table 3. The serum levels of

Table 2. Dietary intakes of participants according to sweet taste preference

	Non-preferred (n=2,399)	Preferred (n=1,210)	P	Adjusted P
Sugar products (g/day)	52.2±1.4	66.0±2.2	<0.0001	<0.0001
Cookies	4.2±0.2	6.6±0.4	<0.0001	<0.0001
Candies/chocolates	1.2±0.1	2.6±0.2	<0.0001	<0.0001
Breads	8.4±0.3	12.3±0.6	<0.0001	<0.0001
Ice cream/yogurts	38.4±1.2	44.4±1.9	0.007	0.014
Sweet drink (g/day)	33.8±1.3	42.1±2.3	0.002	0.002
Energy (kcal/day)	1827.4±11.4	1879.4±15.9	0.008	0.0002
Carbohydrate (g/day)	325.9±2.0	335.0±2.7	0.009	0.042
Protein (g/day)	62.3±0.5	62.9±0.7	0.469	0.048
Fat (g/day)	28.6±0.3	30.1±0.5	0.010	0.0002
Fiber (g/day)	7.0±0.1	6.9±0.1	0.267	0.041
Carbohydrate energy ratio (%)	71.7±0.1	71.9±0.2	0.584	0.021
Protein energy ratio (%)	13.5±0.05	13.3±0.06	0.0003	0.053
Fat energy ratio (%)	13.7±0.1	13.9±0.1	0.386	<0.0001

Values are mean±SE. P was conducted by Student's t-test. Adjusted P was obtained from the generalized linear model with adjustment for age, BMI, exercise, alcohol drinking, smoking, education, and total energy intake.

Table 3. Biochemical profiles of participants according to sweet taste preference

	Non-preferred (n=2,399)	Preferred (n=1,210)	P	Adjusted P
Total cholesterol (mg/dL)	195.8±0.7	202.8±1.1	<0.0001	0.004
HDL cholesterol (mg/dL)	51.3±0.2	51.1±0.3	0.597	0.980
LDL cholesterol (mg/dL)	118.7±0.6	124.6±1.0	<0.0001	0.003
Triglyceride (mg/dL)	131.3±1.9	138.2±2.5	0.025	0.671

HDL-cholesterol=high density lipoprotein cholesterol; LDL-cholesterol=low density lipoprotein cholesterol. Values are mean±SE. LDL-cholesterol was measured in 2,365 individuals with the 'Non-preferred' and 1,187 with the 'Preferred'. P was conducted by Student's t-test. Adjusted P was obtained from general linear model analysis with adjustment for age, BMI, exercise, alcohol drinking, smoking, education, and total energy intake.

total cholesterol and LDL cholesterol were significantly higher in the Preferred group than in the Non-preferred group, after adjustment of age, BMI, exercise, alcohol drinking, smoking, education, and total energy intake. There were no significant differences in HDL cholesterol and triglyceride between the two groups.

We examined the association between sweet taste preference and risk of lipid abnormalities (**Table 4**). The prevalence of hypercholesterolemia and hyper-LDL cholesterolemia in the Preferred group was significantly higher than the Non-preferred group. Moreover, OR (95% CI) comparing the Preferred group versus the Non-preferred group for hypercholesterolemia and hyper-LDL cholesterolemia were 1.21 (1.01–1.45), and 1.33 (1.11–1.60), respectively, after adjustment of age, BMI, exercise, alcohol drinking, smoking, education, and total energy intake.

Discussion

Preference for sweetness is positively linked to energy-dense foods[6, 7], which may affect dyslipidemia. This study investigated the influence of sweet taste preference on the odds for dyslipidemia in relation to dietary intake among Korean middle-aged women.

Subjects who preferred the sweet taste showed higher consumption of sugar products and sweet drinks compared with those who did not prefer the sweet taste. These results are in line with a previous work[6] in French adults that showed an association between the liking for sweets and intake of sugary products and sugar-sweetened soft drinks. In general, sugar is known to increase blood lipid levels[23]. Sugar-sweetened drinks were reported to be positively associated with the risk of dyslipidemia[24, 25]. Taken together, these results indicate that the preference for sweet taste

Table 4. Association between sweet taste preference and risk of lipid abnormalities

	Non-preferred (n=2,399)	Preferred (n=1,210)	P
Hypercholesterolemia			
Prevalence (%)	16.8	22.3	<0.0001
Crude OR (95% CI)	1.0	1.42 (1.19 - 1.68)	
Adjusted OR (95% CI)	1.0	1.21 (1.01 - 1.45)	
Hypo-HDL cholesterolemia			
Prevalence (%)	14.8	16.3	0.243
Crude OR (95% CI)	1.0	1.12 (0.93 - 1.35)	
Adjusted OR (95% CI)	1.0	1.02 (0.84 - 1.24)	
Hyper-LDL cholesterolemia			
Prevalence (%)	15.1	21.0	<0.0001
Crude OR (95% CI)	1.0	1.49 (1.25 - 1.78)	
Adjusted OR (95% CI)	1.0	1.33 (1.11 - 1.60)	
Hypertriglycemia			
Prevalence (%)	13.9	15.3	0.269
Crude OR (95% CI)	1.0	1.12 (0.92 - 1.36)	
Adjusted OR (95% CI)	1.0	0.99 (0.80 - 1.21)	

OR=odds ratio; CI=confidence interval; HDL=high density lipoprotein; LDL=low density lipoprotein. OR (95% CI) was conducted by logistic regression model. Adjusted OR (95% CI) was obtained after adjustment for age, BMI, exercise, alcohol drinking, smoking, education, and total energy intake.

may increase sugar-rich food intake, which is partly related to the risk of lipid abnormalities.

Sugar products usually produce most of their calories from two main ingredients, carbohydrate and fat[26]. Ice cream is composed of carbohydrate 47% and fat 46%, and milk chocolate is composed of carbohydrate 44% and fat 50%[27]. These sugar products derive large amounts of their calories from fat, even though they are commonly viewed as carbohydrate-rich foods. Our study demonstrated that subjects who preferred the sweet taste showed significantly higher fat intake compared with those who did not prefer the sweet taste. It can be suggested that the increased fat intake in subjects who preferred the sweet taste may be due to increased consumption of sugar products.

Dietary fat consumption was reported to be associated with serum concentrations of total cholesterol and LDL cholesterol[1]. Sugar products, such as cookies, chocolates, and ice cream, contain large amounts of fat[26]. Major dietary sources of fat in the United States are full-fat dairy products, such as cheese and butter, and red meat[28]. However, Korean middle-aged women tend to have considerably low consumption of these full-fat dairy products and red meat[29]. Sugar products are supposed to be able to supply a significant amount of fat in Korean middle-aged women. The fat intake in the current subjects was lower than that of KNHANES[29]. However, there is a report on the association between fat intake and hypercholesterolemia in Iranian population with low fat intake[30]. This report showed undesirable lipid profiles of the subjects, even though their dietary fat intake was within the recommended daily allowance limits. We speculated that increased fat intake in subjects who preferred the sweet taste may have partially contributed to elevated concentrations of total and LDL cholesterol.

Subjects who preferred the sweet taste showed significantly lower intake of dietary fiber. These were similar to a previous report[31] that a high-sugar intake was negatively associated with dietary fiber intake in American subjects. According to the analysis of 67 controlled clinical trials[32], high-fiber diets can decrease total and LDL cholesterol. Dietary fiber binds to cholesterol during intraluminal formation of micelles[33]. The resulting reduction in the cholesterol content of liver cells induces LDL receptor upregulation and thus increased clearance of LDL cholesterol. If such results are taken into consideration, it is postulated that low intake of dietary fiber in subjects who preferred the sweet taste may be partially associated with high risk of hypercholesterolemia and hyper-LDL cholesterolemia.

This study has several limitations. Because the relation between preference for sweet taste and serum lipid abnormalities was analyzed with a cross-sectional study design, it was not possible to establish a cause–effect. Our data may be used only to assess direction-

ality or temporality of the associations observed. Another limitation was that dietary intake was analyzed through the SQFFQ and thus may be inaccurate quantifications of real consumption amounts. Although well-trained interviewers with a validated SQFFQ and pictures of portion sizes, measurement errors in dietary intake seems unavoidable. Despite these limitations, this is the first study in our knowledge to assess the association between preference for sweet taste and the risk of dyslipidemia.

Conclusions

The present study used data from the KoGES to demonstrate that preference for sweet taste is linked to the risk of hypercholesterolemia and hyper-LDL cholesterolemia among middle-aged women. In addition, subjects who preferred the sweet taste showed higher consumption of sugar products and sweet drinks compared with those who did not prefer the sweet taste. These findings suggested that the preference for sweet taste may increase sweet food intake, which is related to the risk of hypercholesterolemia and hyper-LDL cholesterolemia in Korean middle-aged women.

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Conflict of Interest Disclosure

The authors declared no conflict of interest.

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