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Higher consumption of sugar-sweetened soft drinks increases the risk of hyperuricemia in Korean population: The Korean Multi-Rural Communities Cohort Study

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ABSTRACT

Objective: The clinical implication of sugar-sweetened soft drinks on the risk of hyperuricemia has increased, especially in Western population studies. The aim of this study is to clarify the association between sugar-sweetened soft drinks and fruit drinks made from oranges and apples and the risk of hyperuricemia in the Korean Multi-Rural Communities Cohort.
Methods: A total of 9400 subjects were enrolled in the Korean Multi-Rural Communities Cohort Study, and a cross-sectional analysis was performed. Five quintiles (Q1–Q5) according to consumption of soft drinks and other fruit/fruit juices were classified and then categorized into three groups (Q1–Q3, Q4, and Q5) to assess the risk of hyperuricemia. Information on dietary intake was collected by well-trained interviewers using validated food frequency questionnaires.
Results: Higher consumption of sugar-sweetened soft drinks (Q5) increased the risk of hyperuricemia in males (adjusted OR = 1.35, 95% CI: 1.07–1.71) with a linear trend (p for trend = 0.01) and in females (adjusted OR = 1.40, 95% CI: 1.03–1.90) with no linear trend (p for trend = 0.09), compared to lower consumption (Q1–Q3). However, there were no significant differences of serum uric acid level according to the three categories of soft drink consumption, Q1–Q3, Q3, and Q5, in males ($p = 0.21$) or in females ($p = 0.16$), whereas all subjects showed statistical significance of serum uric acid level within the categories ($p < 0.001$). Estimated amount of soft drink intake was associated with serum uric acid level in males ($\beta = 0.001$; $p = 0.01$) but not in females ($\beta = 0.0005$; $p = 0.10$).
Conclusion: Higher consumption of sugar-sweetened soft drinks increased the risk of hyperuricemia in the Korean population, showing a differential linear trend for hyperuricemia according to gender.

Introduction

Hyperuricemia occurs as a result of overproduction or aberration of renal processing of uric acid, a final catabolite of purine derived from DNA and RNA in humans [1]. The prevalence of hyperuricemia has gradually increased during the past several decades according to diverse demographic population studies, with an increased trend of serum uric acid level between observation periods [2]. Clinical significance of hyperuricemia is associated with risk factors related to diverse systemic diseases including obesity, diabetes mellitus, metabolic syndrome, gout, and cardiovascular diseases [3,4]. High-purine diets from meat and seafood consumption and alcohol intake have been traditionally considered important risk factors for the development of increased serum uric acid level [5,6]. Therefore, restriction of purine and alcohol has been recommended to prevent the development of hyperuricemia.

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Recently, several epidemiological studies using United States national data have found that sugar-sweetened soft drinks were significantly associated with increased serum uric acid level [7–9]. Furthermore, prospective data suggested that consumption of sugar-sweetened soft drinks has the potential to increase the risk of hyperuricemia and gout in males [10]. Basically, sugar, or sucrose, is chemically a disaccharide composed of two monosaccharides such as fructose and glucose. Among them, fructose, unlike glucose, can play a role as a source of intracellular uric acid production and results in increased serum uric acid level [11]. Epidemiological studies suggest that fructose consumption may contribute to increased risk of hyperuricemia and gout [7,10,12]. Based on these studies, the non-pharmacological guideline for the management of gout from the American College of Rheumatology recommends avoidance of high-fructose corn syrup-sweetened drinks [13].

Increased trends of prevalence in hyperuricemia were consistently found in various ethnic and racial study groups [2]. However, some discrepancies in the prevalence of hyperuricemia were also observed in various populations, as illustrated in the data derived from the Third US National Health and Nutritional Examination Survey (NHANES-III) [14] and the Nutritional and Health Survey in Taiwan [15], which could potentially be due to different dietary patterns and lifestyle. In addition, serum uric acid level may be affected by genetic and environmental influences [2]. Limited data regarding the association between sugar-sweetened soft drinks and serum uric acid level in the Asian population exists, although several epidemiologic results originating from residents in North America have been reported. Therefore, in this study, we assessed the association between sugar-sweetened soft drinks and other drinks originating from fruits such as orange and apple and the risk of hyperuricemia in the Korean Multi-Rural Communities Cohort.

Subjects and methods

Study population

The Korean Multi-Rural Communities Cohort Study has been conducted as a part of the Korean Genome Epidemiology Study since 2004. The Korean Multi-Rural Communities Cohort is a multi-center prospective cohort designed to identify risk factors for cardiovascular diseases in the Korean population. This community-based cohort targeted residents aged ≥ 40 years living in one of three rural areas, Yangpyeong (located in the eastern part of Seoul, the capital of South Korea), Namwon (located in the southwestern part of South Korea), and Goryeong (located in the southeastern part of South Korea). The total number of participants recruited in the cohort from January 2005 to August 2009 was 9697. Among the participants, those with missing data on dependent (serum uric acid level) or independent variables and subjects with implausible self-reports on dietary intake (total energy intake < 500 or > 4000 kcal/day; more than 10 missing food items; or missing data on rice, the staple food for most Koreans) were excluded from the eligible population. As a result, a total of 9400 participants were used for the final analyses. This study was performed in adherence with the guidelines of the Declaration of Helsinki and approved by the Institutional Review Boards of Hanyang University, Chonnam National University Hospital, and Keimyung University in Korea.

Data collection

In order to ensure uniform data collection methods at each study center, we used standardized protocols for questionnaire survey and examination procedures. Baseline data on the study participants were obtained by in-person interviews using a structured questionnaire. Information on demographic characteristics (i.e., age, gender, education, and marital status), medication history (i.e., anti-hypertensive medication), and lifestyle factors such as cigarette smoking, alcohol consumption, and physical activity was obtained by trained interviewers.

Data were also obtained by body measurements (i.e., height, weight, waist circumference, and systolic and diastolic blood pressures) and laboratory evaluations [i.e., uric acid, creatinine, triglyceride, high-density lipoprotein (HDL) cholesterol, and fasting serum glucose]. Height was measured using a standard height scale and recorded to the nearest 0.1 cm. Weight was measured using a metric weight scale, which was zero-balanced before each study participant was weighed and recorded to the nearest 0.01 kg in light clothing without shoes. Body mass index (BMI) was calculated as the weight in kilograms divided by the square of the height in meters. Waist circumference was measured midway between the inferior border of the lowest rib and the superior border of the iliac crest and recorded to the nearest 0.1 cm. Blood pressure was measured from the right arm by auscultation utilizing a standard mercury sphygmomanometer with a connected inflatable cuff. Two consecutive blood pressure measurements were obtained after at least 5 min of sitting and recorded to the nearest 2 mmHg. The average values of the two systolic and diastolic measurements were used for the analyses. If the difference between the two measurements was greater than 5 mmHg, a third measurement was conducted, and the average values of the second and third systolic and diastolic measurements were used for the analyses. Blood samples were obtained after an overnight fasting (at least 8 h of fasting) and analyzed for biochemical markers the same day. Serum uric acid, creatinine, triglyceride, HDL cholesterol, and fasting serum glucose levels were determined using the ADVIA1800 Auto Analyzer (Simens Medical Solutions USA, Inc., Malvern, PA). Glomerular filtration rate (GFR) was calculated using the simplified equation of the Diet Modification in Renal Disease Study [16]: GFR (mL/min/1.73 m^2) = 186 $\times$ [serum creatinine level (mg/dL)]$^{-1.154}$ $\times$ (age)$^{-0.203}$ $\times$ (0.742, if female).

Dietary assessment

For the assessment of dietary intake, a semi-quantitative food frequency questionnaire (FFQ) was administered by trained interviewers. The validation of the FFQ was conducted, and the results have been reported in detail elsewhere [17]. In brief, the FFQ was administered twice at one-year interval, and diet records were collected for 12 days during the four seasons. Nutrient intakes from the diet records were compared with those from the two FFQs. Among dietary variables used for the analysis, total energy estimated by the diet records was lower than that estimated by the two FFQs; whereas, estimated vitamin C intakes by the diet record and the two FFQ were not significantly different.

The average frequency (nine categories ranging from 'never or rarely' to 'three times per day') and portion size (three specified portion sizes) of consumption of 106 food items over the past year were identified using the FFQ. For the consumption of seasonal food items, each participant was also asked to mark one of the following four duration categories: 3, 6, 9, or 12 months. The average daily intake of each food item (i.e., intake of soft drink, orange/orange juice, apple/apple juice, meat, seafood, dairy food, coffee, and tea) was estimated using the weighted frequency per day and the portion size per unit of each food item. In order to convert food intake into nutrients (i.e., total energy and vitamin C), we used the seventh edition of the Food Composition Table, a nutrient database produced by the Korean Nutrition Society [18].