

Beverage Intake and Metabolic Syndrome Risk Over 14 Years: The Study of Women's Health Across the Nation



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ABSTRACT

Background Alcohol and energy-dense beverages consumption have been implicated in cardiometabolic disease, albeit inconsistently.

Objective This study tested prospective associations between intakes of alcohol, energy-dense beverages, and low-calorie beverages and cardiometabolic risk in midlife women.

Design The Study of Women's Health Across the Nation is a 14-year, multisite prospective cohort study (1996–2011). Beverage intake and cardiometabolic risk factors that define the metabolic syndrome (hypertension, abdominal obesity, impaired fasting glucose, low high-density lipoprotein cholesterol level, and hypertriglyceridemia) were assessed throughout follow-up.

Participants/setting Participants (N=1,448) were African American, Chinese, Japanese, and non-Hispanic white midlife women from six US cities.

Main outcome measures The primary outcomes were incident metabolic syndrome and the individual metabolic syndrome components.

Statistical analyses performed Generalized linear mixed models tested associations between intakes within each beverage category and odds of meeting criteria for metabolic syndrome and each of the metabolic syndrome components.

Results Energy-dense beverage consumption was highest among African-American women and lowest among women with college degrees. Non-Hispanic white women consumed the largest quantities of alcohol. Independent of energy intake and potential confounders, each additional 355 mL energy-dense beverages consumed per day was associated with higher odds of developing metabolic syndrome in each successive year of follow-up (odds ratio [OR] 1.05, 95% CI 1.02 to 1.08). Greater energy-dense beverage intake was associated with more rapidly increasing odds of developing hypertension (OR 1.06, 95% CI 1.02 to 1.11) and abdominal obesity (OR 1.10, 95% CI 1.03 to 1.16) over time, but not with the other metabolic syndrome components. Intakes of alcohol and low-calorie coffees, teas, and diet cola were not associated with metabolic syndrome risk.

Conclusions Over 14 years of follow-up, energy-dense nonalcoholic beverage consumption was associated with incident metabolic syndrome in midlife women. The observed differences in intakes by ethnicity/race and education suggest that consumption of these beverages may contribute to disparities in risk factors for diabetes and cardiovascular disease.

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METABOLIC SYNDROME IS A CLUSTER OF co-occurring cardiometabolic risk factors¹ that affects roughly 22% of US women² and is strongly associated with cardiovascular disease, type 2 diabetes mellitus, and all-cause mortality.^{3,4} Dietary factors, including intake of various beverages, may promote the development of metabolic syndrome. Beverages are a major component of the US diet, with US adults obtaining 15% to 24% of their daily energy from beverages, or about 385 kcal/day.^{5,6} Roughly 7% of daily energy is obtained from

sugar-sweetened beverages alone,^{7,8} and another 4% to 6% from alcoholic beverages.⁹

A well-documented, curvilinear association exists between alcohol intake and risk for cardiovascular disease and diabetes, with the lowest risk levels observed at low-to-moderate levels (ie, 1 to 2 drinks per day) of alcohol intake.^{10,11} However, this association may be attributable to confounding by genetic or other factors,¹² and the effects of alcohol on the traditional cardiometabolic risk factors that may mediate its protective effects (eg, high-density

lipoprotein [HDL] cholesterol level, triglycerides level, and insulin sensitivity) have been inconsistent.^{11,13} Greater consumption of caloric beverages, particularly sugar-sweetened beverages, has been linked to higher incidence of hypertension,¹⁴ type 2 diabetes,^{15,16} and cardiovascular disease.^{17,18} The mechanism underlying this association may involve incomplete dietary compensation for caloric beverages, where solid food intake is not fully reduced to offset calories consumed in liquid form.^{19,20} In this scenario, caloric beverage intake would ultimately promote positive energy balance, obesity, and obesity-related chronic diseases.^{19,20} Conversely, consumption of water and low-calorie beverages such as unsweetened coffees and teas have been associated with decreased cardiometabolic risk,^{15,21} possibly because they displace caloric beverages from the diet. The specific role of artificially sweetened beverages in both obesity and cardiometabolic disease remains controversial, with cohort and intervention studies reporting both protective and harmful associations.²²⁻²⁴

This study tested the prospective associations between intakes of alcohol, energy-dense beverages, and low-calorie beverages and risk of incident metabolic syndrome over approximately 14 years of follow-up among women enrolled in the Study of Women's Health Across the Nation (SWAN). It was hypothesized that greater intake of energy-dense beverages, but not low-calorie beverages or alcohol, would be associated with greater odds of incident metabolic syndrome, independent of total energy intake.

METHODS

Participants

Participants were midlife women from seven US regions who were enrolled in SWAN, a multiethnic/racial, longitudinal study of aging and health determinants across the menopausal transition. SWAN's methodology is detailed elsewhere.²⁵ Procedures were approved by each site's institutional review board, and all participants provided written informed consent.

Women were recruited from five ethnic/racial groups: African American (Boston, MA; Chicago, IL; Detroit, MI, area; and Pittsburgh, PA); Chinese (Oakland, CA, area); Hispanic (Newark, NJ); Japanese (Los Angeles, CA); and non-Hispanic white (all sites). Eligibility criteria included being aged 42 to 52 years at enrollment (1996-1997), having an intact uterus and at least one ovary, not being pregnant or lactating, not using oral contraceptives or reproductive hormone therapy, and reporting at least one menstrual cycle during the prior 3 months. This report includes data collected at the baseline assessment (1996-1997) and annual follow-up assessments that occurred through 2011. Assessments occurred either in clinic settings or participants' homes. However, participants from the Newark site were excluded from this analysis due to high attrition and lack of dietary data after Visit 5. Of 2,870 enrolled women across the other six sites, 1,820 (63%) had at least 9 years of follow-up data on both beverage intake and the metabolic syndrome components. Women who met criteria for the metabolic syndrome at baseline (n=372; 20%) were excluded because this analysis focused on incident cases. The final analytic sample included 1,448 women.

Measures

Waist Circumference. Waist circumference was measured to the nearest 0.1 cm with a measuring tape placed horizontally around the participant at the narrowest part of the torso. Measurements were taken over light clothing at the end of a normal exhalation.

Blood Pressure. Blood pressure was measured on the right arm in a seated position after at least 5 minutes of rest using a mercury sphygmomanometer. Respondents had not smoked or consumed caffeine within the prior 30 minutes. Appropriate cuff size was determined based on arm circumference. Two sequential blood pressure values were completed at least 2 minutes apart and averaged.

Blood Assays. Blood was drawn after a 12-hour fast. Samples were frozen and shipped to either Medical Research Laboratories (baseline to Visit 7) or the University of Michigan Pathology Laboratory (after Visit 7), which are certified by the National Heart, Lung, and Blood Institute, Centers for Disease Control and Prevention Part III program.²⁶ Triglyceride levels were analyzed by enzymatic methods on a Hitachi 747 analyzer (Boehringer Mannheim Diagnostics). HDL cholesterol was isolated using heparin-2M manganese chloride. Glucose level was determined from fasting serum samples using a hexokinase-coupled reaction (Boehringer Mannheim Diagnostics).

Definition of Metabolic Syndrome Components and Status. Consistent with current diagnostic criteria,¹ metabolic syndrome was defined by the presence of at least three of the following five components: abdominal obesity (waist circumference ≥ 80 cm for Chinese and Japanese women and ≥ 88 cm for other ethnic/racial groups); hypertension (systolic blood pressure ≥ 130 mm Hg, diastolic blood pressure ≥ 85 mm Hg, or taking blood pressure medication); low HDL cholesterol level (< 50 mg/dL); hypertriglyceridemia (fasting triglycerides level ≥ 150 mg/dL); and impaired fasting glucose (fasting glucose level > 100 mg/dL or taking medication for impaired glucose regulation). Metabolic syndrome status and the total number of metabolic syndrome diagnostic components were determined at each time point.

Beverage and Total Calorie Intake. The SWAN Food Frequency Questionnaire (FFQ),²⁷ which is an adaptation of the 1995 version of the Block FFQ,²⁸ was completed at baseline, Visit 5, and Visit 9. The FFQ was interviewer-administered. Missing and double-marked items were not scored. The SWAN FFQ assesses the usual frequency and portion sizes consumed for 83 foods and 20 beverages over the past year or so. Due to the multiethnic/racial nature of SWAN, the FFQ was administered in English, Spanish, Chinese (Cantonese), and Japanese. The Cantonese and Japanese FFQ versions contained the same 103 core items as the English version, plus 12 to 16 additional ethnic foods specific to each group. To avoid underreporting of ethnic foods, the Chinese and Japanese ethnic food items were administered to all ethnic/racial groups at Visits 5 and 9. The FFQ yields an estimate of total daily energy intake. In addition, typical intakes of 20 beverages and beverage condiments were estimated by multiplying the reported portion sizes typically consumed by the

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