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Beverage intake and metabolic syndrome risk over 14 years in the Study of Women's Health Across the Nation

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Abstract

Background—Alcohol and energy-dense beverage 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, and hypertriglyceridemia) were assessed throughout follow-up.

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Participants/setting—Participants (N=1,448) were African-American, Chinese, Japanese, and non-Hispanic white midlife women from six U.S. 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 of energy-dense beverages consumed per day was associated with higher odds of developing metabolic syndrome in each successive year of follow-up (OR=1.05, 95%CI: 1.02, 1.08). Greater energy-dense beverage intake was associated with more rapidly increasing odds of developing hypertension (OR=1.06, 95%CI: 1.02, 1.11) and abdominal obesity (OR=1.10, 95%CI: 1.03, 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 non-alcoholic 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.

Keywords

Beverages; Alcoholic beverages; Metabolic syndrome; Hypertension; Type 2 diabetes; Midlife women

Introduction

Metabolic syndrome is a cluster of co-occurring cardiometabolic risk factors[1] that affects roughly 22% of U.S. women[2] 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 American diet, with U.S. adults obtaining 15-24% of their daily energy from beverages, or about 385 kcal/d.[5,6] Roughly 7% of daily energy is obtained from sugar-sweetened beverages alone, [7,8] and another 4-6% 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 (i.e., 1-2 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 (e.g., HDL cholesterol, triglycerides, 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; if solid food intake is not fully reduced to offset calories consumed in liquid form, 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 U.S. regions who were enrolled in the Study of Women's Health Across the Nation (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, Chicago, Detroit area, and Pittsburgh), Chinese (Oakland area), Hispanic (Newark), Japanese (Los Angeles), and non-Hispanic white (all sites). Eligibility criteria included being aged 42-52 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 in the prior three 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 6 sites, 1,820 (63%) had at least nine 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 as 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 two minutes apart and averaged.

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

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 ≥130 mmHg, diastolic ≥85 mmHg, or taking blood pressure medication), low HDL (<50 mg/dl), hypertriglyceridemia (fasting triglycerides ≥150 mg/dl), and impaired fasting glucose (fasting glucose>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 Food Frequency Questionnaire,[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 12-16 additional ethnic foods specific to each group. To avoid under-reporting 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. Additionally, typical intakes of 20 beverages and beverage condiments were estimated by multiplying the reported portion sizes typically consumed by the reported frequency of consumption. To account for the contribution of beverage condiments such as cream, milk, and sugar (3 FFQ items) on the energy densities of coffees and teas, calories from beverage condiments were evenly distributed into the total coffee and tea consumed by each participant. Low-calorie coffees and teas were defined by an energy density[29] below 0.165 kcal/g (approximately ≤59 kcal in a 12 fluid ounce serving), which corresponds to a natural breakpoint in the distribution of energy-densities of beverages consumed by free-living adult women, and below which fall artificially-sweetened beverages and coffee and tea drinks with minimal beverage

condiments.[19] Beverage intakes were aggregated into three non-overlapping categories: 1) energy-dense, non-alcoholic beverages (Kool-aid, Hi-C, or other drinks with added vitamin C; Snapple, Calistoga, or sweetened bottled waters or iced teas; regular cola soft drinks; coffee or tea consumed with condiments that collectively yield an energy density ≥0.165 kcal/g), 2) low-calorie teas, coffees, and diet cola (caffeinated coffee; green tea; black, English or Chinese tea; Chinese herbs made into or added to soup or tea; diet cola soft drinks), and 3) alcohol (ethanol contained in beer, wine or wine coolers, and liquor or mixed drinks). Though alcoholic beverages are also energy-dense, they were categorized separately in order to maintain orthogonality in the exposure variables and due to the fact that ethanol is the putative mechanism linking alcoholic beverage consumption to cardiometabolic risk.

Covariates—Covariates were chosen based on their potential to confound hypothesized associations. Study site (Pittsburgh, PA, Chicago, IL, Oakland, CA, Los Angeles, CA, Boston, MA, and Detroit-area Michigan), ethnicity/race (African-American, Chinese, Japanese, non-Hispanic white), age (derived from birth date), and education (less than high school, high school, some college, bachelor's degree, graduate degree) were documented at baseline. Time-varying covariates, assessed at annual follow-up visits, included smoking status (no/yes), the presence of clinically-elevated depressive symptoms based on a Center for Epidemiological Studies -Depression Scale[30] score ≥16, annual income ($0 - $19,999; $20,000 - $34,999; $35,000 -$49,999; $50,000 - $74,999; $75,000 - $99,999; $100,000 and higher), menopausal status (premenopausal or early perimenopausal vs. late perimenopausal or postmenopausal) determined through menstrual bleeding patterns,[31] current hormone therapy use (yes/no), and non-occupational physical activity (assessed on 5-point Likert and ordinal quantitative scales with total scores ranging from 3-15 and higher values indicating more frequent engagement in physical activity).[32,33]

Statistical Analyses

All analyses were performed in Stata 13.1 (StataCorp, LLC, College Station, TX; 2013)[34] with a type I error rate of α=.05. At each dietary assessment (baseline, visit 5, visit 9), intakes of energy-dense and low-calorie beverage categories were quantified in units of 355 ml servings (approximately 12 fluid ounces) per day, and alcohol was quantified in units of grams per day. To adjust for total energy intake, each beverage intake variable was regressed on total energy intake in the concurrent year, and the residuals from these models were used as measures of dietary exposure to beverage intake in that year.[35,36] To summarize total dietary exposure from baseline to visit 9, the area under the curve (AUC) of residualized beverage intake across time was calculated based on the trapezoidal method using Stata's “pkcollapse” command. This approach has the advantages of accommodating different numbers of complete follow-up assessments, and different time intervals between assessments. AUC was calculated based on either all three FFQ assessments (n=1,281), or the baseline and visit 9 assessments only (n=167). Finally, as total follow-up duration from baseline to visit 9 varied across participants, beverage intake values were converted to a rate by dividing the AUC values by each participant's follow-up duration. The resulting values corresponded to rates of energy-adjusted usual beverage intake, interpolated across 9 years of follow-up, in units of 355 ml servings/d for energy-dense and low-calorie beverage and g/d for alcohol. As analyses also adjusted for total energy intake across follow-up, the AUC

for total energy intake was calculated in the same fashion. To assess the potential relevance of beverage intake to disparities in cardiometabolic risk, ANOVA was used to test for differences in beverage and total energy intake by ethnicity/race and education.

Three sets of analyses tested associations between beverage intake and cardiometabolic risk markers, which were assessed at baseline and visits 1, 3, 5, 7, and 12. Generalized linear mixed models were used to model the odds of incident metabolic syndrome from the beverage intake by time interaction, along with the lower-order terms for beverage intake (AUC) and time, and covariates. Interaction terms involving the beverage intake variables and ethnicity/race, education, and physical activity levels were separately entered into the above models to test effect modification. Sensitivity analyses testing for non-linear (quadratic) associations involving alcohol intake were conducted. Finally, for any beverage intake category associated with incident metabolic syndrome, additional analyses tested associations with odds of developing each of the five individual metabolic syndrome components. These analyses included only women who did not meet criteria at baseline for the specific metabolic syndrome component being modeled. All models utilized mean and variance adaptive Gauss–Hermite quadrature integration with seven integration points, and included random effects for both intercepts and the effect of time (in years since baseline). Results from both crude and adjusted models are reported.

Results

Analyses included 8,256 observations from 1,448 women without metabolic syndrome at baseline. Sample characteristics are summarized in Table 1. The average follow-up duration in the analytic sample was 13.33 (SD=1.69) years. By the end of the follow-up period, 18.5% of women had developed metabolic syndrome. The average number of metabolic syndrome diagnostic components increased ($p<.001$) from baseline (mean=0.78, SD=0.79; median=1, interquartile range: 0-1) to visit 12 (mean=1.38, SD=1.23, median=1, interquartile range: 0-2).

Baseline beverage intakes are shown in Table 2. Overall, women consumed almost twice as much low-calorie tea, coffee, and diet cola than they did energy-dense, non-alcoholic beverages. However, significant ethnic/racial differences in baseline beverage intakes were present (Table 2). African-American women consumed substantially more energy-dense, non-alcoholic beverages, and less low-calorie beverages and alcohol, than the reference category of non-Hispanic white women. Chinese women had significantly lower intakes of all three beverage categories than non-Hispanic white women. Japanese women consumed more low-calorie beverages and less alcohol than non-Hispanic white women. Associations between education and beverage intake are also shown in Table 2. Relative to the reference category of women with some college education, women with a 4-year college or graduate degree had lower baseline intake of energy-dense, non-alcoholic beverages, and women with graduate degrees had higher intake of alcohol. At baseline, physical activity exhibited a weak negative association with energy-dense beverage intake ($r=-.05$, $p=.04$) and a weak positive association with alcohol intake ($r=.08$, $p<.01$), but was unrelated to intake of low-calorie beverages ($r=.03$, $p=.21$).

In correlation analyses with the energy-adjusted beverage intake variables (data not shown), usual intake of energy-dense non-alcoholic beverages was inversely associated with intake of low-calorie teas, coffee, and diet cola (r=-.23, p<.0001), and weakly associated with alcohol intake (r=-.08, p<.01). Intake of low-calorie teas, coffee, and diet cola was positively correlated with alcohol intake (r=.09, p<.001). Total energy intake was positively correlated with energy-dense non-alcoholic beverage intake (r=.24, p<.0001) and alcohol intake (r=.11, p<.0001), but was not correlated with low-calorie beverage intake (r=.05, p=.08).

Odds of incident metabolic syndrome increased across the duration of follow-up (Table 3). However, as reflected in a significant time by beverage intake interaction term, the odds of developing metabolic syndrome increased by 1.05 per year with each additional 355 ml of energy-dense beverages typically consumed (Table 3). Temporal changes in the odds of developing metabolic syndrome were unrelated to intakes of low-calorie beverages and alcohol (Table 3). This was also true when examining a quadratic term for alcohol intake (OR=1.00, 95% CI: 0.99, 1.01). There was no evidence of effect modification by ethnicity/race, education, and physical activity, as the three-way interactions of these variables with time and beverage intake were non-significant in all models (results not shown). No associations were observed in exploratory analyses predicting cardiometabolic outcomes solely from intake of diet cola (results not shown).

Secondary analyses tested whether intake of energy-dense, non-alcoholic beverages was associated with odds of developing each of the five metabolic syndrome components among women without these risk factors at baseline (Table 4). In both unadjusted and adjusted models, odds of developing abdominal obesity and hypertension increased at a faster rate across follow-up in women with higher intakes of energy-dense, non-alcoholic beverages. Beverage intake was unrelated to time-related changes in the odds of developing hypertriglyceridemia, low HDL, or impaired fasting glucose (Table 4).

Discussion

In this multiethnic cohort of midlife women, greater consumption of energy-dense, non-alcoholic beverages was associated with increased odds of incident metabolic syndrome during a follow-up period of approximately 14 years. These associations were primarily driven by hypertension and abdominal obesity. Energy-dense, non-alcoholic beverage intake was not significantly associated with the development of hypertriglyceridemia, low HDL, or impaired fasting glucose. It is noteworthy that the association with abdominal obesity was observed even in the presence of adjustment for total energy intake; however, it is widely known that FFQs substantially underestimate energy intake.[35] In addition to promoting positive energy balance and weight gain,[37] caloric beverages in the American diet are high in added sugars,[38] which may contribute to hypertension via mechanisms that remain to be delineated.[39,40]

The current study adds to an increasingly robust literature implicating energy-dense beverage consumption in the development of cardiometabolic risk. A recent modeling analysis estimated that intake of sugar-sweetened beverages accounts for 184,000 deaths per year worldwide, with the vast majority of these deaths from diabetes and cardiovascular

disease.[41] The observed association between energy-dense beverage intake and metabolic syndrome risk was similar across ethnic/racial groups and levels of educational attainment. However, consumption of these beverages, both in this sample of midlife women and in the U.S. population, varies by level of educational attainment and ethnicity/race.[7] Energy-dense beverage consumption may contribute to disparities in diabetes and cardiovascular disease, but strong evidence is currently lacking. Higher physical activity levels did not offset the risk associated with energy-dense beverage intake, which suggests that public health messaging (at least that which targets midlife women) should emphasize reducing energy-dense beverage intake rather than compensating for intake through physical activity.

Alcohol intake did not exhibit linear or non-linear associations with incident metabolic syndrome. Prior studies examining this association have been inconsistent, with some reporting protective benefits of moderate alcohol intake and others not.[42,43] It is notable that an earlier study from the SWAN cohort[44] reported that wine consumption was associated with lower risk of developing metabolic syndrome over 7 years of follow-up. The discrepant findings of the prior study may stem from its exclusive focus on wine consumption, shorter follow-up duration, or different analytic strategy.

Although both tea and coffee consumption have been linked to reduced metabolic syndrome and mortality risk in prior studies,[45-47] the present findings did not support this association. The putative health benefits of unsweetened coffees and teas may stem from certain compounds (e.g., antioxidants[48]), or because, like artificially sweetened beverages (e.g., diet soda), they may displace high-calorie beverages from the diet.[49] Indeed, intakes of energy-dense and low-calorie beverages were inversely associated in this sample. As individuals may increase their consumption of low-calorie and artificially sweetened beverages in order to lose weight or reduce cardiometabolic risk, observational research on this association is complicated by reverse causality. Consistent with this view, consumption of artificially sweetened beverages is common among successful weight losers in the National Weight Control Registry,[50] and adjusting for baseline obesity status typically negates any harmful associations of artificially sweetened beverages observed in cohort studies.[51,52] Experimental research can clarify the effect of replacing energy-dense beverages with low-calorie alternatives on cardiometabolic outcomes, provided that participants are able to adhere to prescribed intakes for prolonged periods.[53,54]

A key strength of this study is that SWAN is composed of a large, multi-ethnic sample of midlife women, and this study extends a literature that has been dominated by studies conducted with younger age groups and in cohorts composed of health professionals.[16,18] The SWAN cohort has been followed for approximately 14 years, which is among the longest follow-up periods in the published literature on this topic. The cardiometabolic outcomes examined were objectively assessed, and dietary exposure to beverages was assessed with a FFQ that was developed in multiple languages.[55] A weakness of this study stems from the vulnerability of FFQs to both recall bias and social desirability bias. Statistical adjustment for self-reported energy intake can partially mitigate the influence of response biases because the measurement error in both energy intake and beverage intake estimates are correlated,[35] but the extent of residual confounding in any single study is impossible to determine. An additional limitation is that the SWAN FFQ did not include

sports drinks or other beverages that may influence cardiometabolic risk. The current method of calculating beverage intake assumed that beverage condiments were equally distributed across all coffee and tea drinks reported, which has the potential to result in misclassification. Though SWAN is a multi-ethnic study, Hispanic women were not represented in this analysis due to insufficient dietary intake data. Findings may not generalize to Hispanic women. As SWAN is an observational study, causal interpretations of associations are precluded.

Conclusions

In conclusion, higher intake of energy-dense beverages, but not low-calorie tea, coffee and diet soda or alcohol was associated with greater odds of developing metabolic syndrome in midlife women. These associations were primarily driven by increases in odds of developing abdominal obesity and hypertension. Though the associations between dietary exposure and metabolic syndrome did not differ by ethnicity/race, physical activity, or education level, energy-dense beverages were consumed in greater quantities by African-American women and in lower quantities by women with higher educational attainment. Future research should evaluate whether interventions aimed at reducing energy-dense beverage intake can reduce socioeconomic and ethnic/racial disparities in risk factors for type 2 diabetes and cardiovascular disease.

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Table 1

Baseline characteristics of 1448[a] midlife women[b] in the Study of Women's Health Across the Nation.

	Mean (SD)
Age at baseline, years	45.9 (2.7)
Duration of follow-up, years	13.3 (1.7)
Physical activity at baseline[c] (n=1412)	7.9 (1.7)
	n (%)
Study site	
Pittsburgh, PA	222 (15.3)
Detroit area, MI	229 (15.8)
Chicago, IL	163 (11.3)
Oakland, CA	274 (18.9)
Boston, MA	221 (15.3)
Los Angeles, CA	339 (23.4)
Ethnicity/race	
African-American	356 (24.6)
Non-Hispanic white	736 (50.8)
Chinese	164 (11.3)
Japanese	192 (13.3)
Elevated depressive symptoms[d]	274 (18.9)
Current smoker at baseline (n=1439)	178 (12.4)
Education (n=1440)	
Less than high school	46 (3.2)
High school	199 (13.8)
Some college	460 (31.9)
College degree	350 (24.3)
Graduate degree	385 (26.7)
Annual income, $ (n=1406)	
$0 - $19,999	112 (8.0)
$20,000 - $34,999	207 (14.7)
$35,000 - $49,999	255 (18.1)
$50,000 - $74,999	358 (25.5)
$75,000 - $99,999	213 (15.2)
$100,000 and higher	261 (18.6)

[a] Not all subjects included in analyses provided complete data at baseline. The number of baseline observations per variable is noted when different from 1448.

[b] By design, all women were either premenopausal or early peri-menopausal and were not taking hormone therapy at baseline.

[c] Assessed on 5-point Likert and ordinal scales with total scores ranging from 3-15 and higher score representing more frequent engagement in physical activity.

[d]The presence of elevated depressive symptoms was based on a score of 16 or higher on the 20-item Center for Epidemiological Studies – Depression Scale, which has a possible range of 0-60.

Table 2

Baseline energy intake and energy-adjusted beverage[a] intakes [M (SD)] by ethnicity/race and education level among 1448 midlife women enrolled in the Study of Women's Health Across the Nation.

	Energy-dense, non-alcoholic beverages (355 ml/d)[b]	Low-calorie teas, coffee, and diet cola (355 ml/d)[c]	Alcohol (g/d)[d]	Total energy intake (kcal/d)
Overall (N=1448)	0.58 (1.01)	1.10 (1.31)	6.90 (14.19)	1831 (743)
Ethnicity/race[e]				
African-American (n=356)	0.96 (1.24)***	0.59 (1.10)***	5.08 (14.08)***	1970 (994)***
Chinese (n=164)	0.23 (0.48)***	0.91 (1.11)***	1.32 (4.64)***	1847 (764)
Japanese (n=192)	0.40 (0.85)	1.50 (1.38)*	6.02 (13.37)**	1819 (655)
Non-Hispanic white (n=736)	0.53 (0.96)	1.29 (1.34)	9.25 (15.32)	1763 (595)
Education (n=1440)[f]				
Less than high school (n=46)	0.55 (1.07)	0.73 (1.36)	3.27 (8.39)	1766 (830)
High school (n=199)	0.81 (1.24)	0.93 (1.31)	6.09 (16.65)	1805 (809)
Some college (n=460)	0.70 (1.12)	1.05 (1.35)	6.43 (13.35)	1864 (785)
College degree (n=350)	0.45 (0.78)***	1.23 (1.27)	6.59 (12.19)	1812 (684)
Graduate degree (n=385)	0.44 (0.87)***	1.17 (1.28)	8.64 (15.80)*	1822 (691)

[a] Beverage intake values reported in this table are energy-adjusted.

[b] The category “energy-dense, non-alcoholic beverages” included Kool-aid, Hi-C, or other drinks with added vitamin C; Snapple, Calistoga, or sweetened bottled waters or iced teas; regular cola soft drinks; coffee or tea consumed with condiments that collectively yield an energy density≥0.165 kcal/g.

[c] The category “low-calorie teas, coffee, and diet cola included caffeinated coffee; green tea; black, English or Chinese tea; Chinese herbs made into or added to soup or tea; and diet cola soft drinks.

[d] “Alcohol” is grams of alcohol from beer; wine or wine coolers; and liquor or mixed drinks.

[e] Asterisks indicate the significance level of ethnic/racial group differences in beverage intake (within each column) relative to the reference category of Non-Hispanic white. * p<.05, ** p<.01, *** p<.001.

[f] Asterisks indicate the significance level of education-based group differences in beverage intake (within each column) relative to the reference category of Some college. * p<.05, ** p<.01, *** p<.001.

Table 3

Unadjusted and adjusted[a] associations of beverage intake with odds[b] of meeting criteria for metabolic syndrome[c] across 14 years of follow-up in midlife women who did not have metabolic syndrome at baseline in the Study of Women's Health Across the Nation.

	Metabolic syndrome status	
	Unadjusted models (N=1448)	Adjusted models[a] (n=1401)
	OR (95% CI)	OR (95% CI)
Energy-dense, non-alcoholic beverages[d]		
Time[e]	1.04 (1.02-1.07)	1.13 (1.09-1.16)
Beverage intake[f]	0.89 (0.67-1.16)	0.67 (0.48-0.93)
Time by beverage intake interaction[g]	1.05 (1.01-1.08)	1.05 (1.02-1.08)
Low-calorie teas, coffee, and diet cola[h]		
Time[e]	1.05 (1.03-1.08)	1.12 (1.08-1.15)
Beverage intake[f]	1.07 (0.89-1.28)	1.12 (0.89-1.41)
Time by beverage intake interaction[g]	0.99 (0.97-1.02)	1.00 (0.97-1.02)
Alcohol[i]		
Time[e]	1.06 (1.03-1.08)	1.13 (1.09-1.17)
Beverage intake[f]	0.99 (0.98-1.00)	0.99 (0.97-1.01)
Time by beverage intake interaction[g]	1.00 (0.99-1.00)	1.00 (0.99-1.01)

[a]Adjusted models included age at baseline, ethnicity/race, study site, total energy intake, menopausal status, hormone therapy use, smoking status, depressive symptoms, education, income, and physical activity.

[b]Reported values are odds ratios (OR) and 95% confidence intervals (95% CI).

[c]Metabolic syndrome status is determined based on the presence of at least three of the following diagnostic components: impaired fasting glucose, abdominal obesity, hypertriglyceridemia, low high-density lipoprotein cholesterol, and hypertension.

[d]The category “energy-dense, non-alcoholic beverages” included Kool-aid, Hi-C, or other drinks with added vitamin C; Snapple, Calistoga, or sweetened bottled waters or iced teas; regular cola soft drinks; coffee or tea consumed with condiments that collectively yield an energy density≥0.165 kcal/g.

[e]This parameter represents the association between the passage of time, quantified in years since each woman's baseline assessment, and the odds of having each cardiometabolic outcome.

[f]Quantified as a rate of energy-adjusted usual beverage intake, interpolated across 9 years of follow-up using AUC. Values are in units of 355 ml/d (approximately 12 fl. oz. per day) for energy-dense, non-alcoholic beverages and low-calorie teas, coffee, and diet cola. Values are in units of g/d for alcohol. This parameter represents the association between overall beverage intake and women's overall odds of having each cardiometabolic outcome.

[g]This parameter reflects the degree to which time-related increases in the odds of having each cardiometabolic outcome varies as a function of beverage intake.

[h]The category “low-calorie teas, coffee, and diet cola included caffeinated coffee; green tea; black, English or Chinese tea; Chinese herbs made into or added to soup or tea; and diet cola soft drinks.

[i]“Alcohol” represents grams of alcohol from beer; wine or wine coolers; and liquor or mixed drinks.

Table 4

Unadjusted and adjusted[a] associations between intake of energy-dense non-alcoholic beverages[b] and odds[c] of meeting criteria for individual metabolic syndrome diagnostic components across 14 years of follow-up among midlife women[d] in the Study of Women's Health Across the Nation.

	Impaired fasting glucose	Abdominal obesity	Hypertri-glyceridemia	Low HDL[e]	Hypertension
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Unadjusted models	(n=1301)	(n=1096)	(n=1357)	(n=1161)	(n=1194)
Time[f]	1.10 (1.08-1.13)	1.07 (1.04-1.11)	1.04 (1.02-1.06)	1.03 (1.01-1.06)	1.27 (1.21-1.33)
Beverage intake[g]	0.70 (0.49-0.99)	0.91 (0.67-1.24)	0.89 (0.69-1.17)	1.27 (0.92-1.75)	0.93 (0.63-1.36)
Time by beverage intake interaction [h]	1.03 (0.99-1.07)	1.08 (1.03-1.14)	0.99 (0.96-1.03)	1.01 (0.97-1.05)	1.07 (1.03-1.13)
Adjusted models [a]	(n=1257)	(n=1059)	(n=1317)	(n=1122)	(n=1158)
Time[f]	1.11 (1.02-1.20)	1.11 (1.01-1.21)	1.02 (0.98-1.05)	1.04 (1.00-1.08)	1.23 (1.18-1.27)
Beverage intake[g]	0.58 (0.38-0.90)	0.66 (0.41-1.06)	1.03 (0.76-1.39)	1.00 (0.70-1.44)	0.72 (0.51-1.02)
Time by beverage intake interaction [h]	1.03 (0.99-1.08)	1.10 (1.03-1.16)	0.99 (0.96-1.03)	1.00 (0.96-1.04)	1.06 (1.02-1.11)

[a] Adjusted models included age at baseline, ethnicity/race, study site, total energy intake, menopausal status, hormone therapy use, smoking status, depressive symptoms, education, income, and physical activity.

[b] The category “energy-dense, non-alcoholic beverages” included Kool-aid, Hi-C, or other drinks with added vitamin C; Snapple, Calistoga, or sweetened bottled waters or iced teas; regular cola soft drinks; coffee or tea consumed with condiments that collectively yield an energy density≥0.165 kcal/g.

[c] Reported values are odds ratios (OR) and 95% confidence intervals (95% CI).

[d] Women did not have metabolic syndrome or the model-specific outcome at baseline.

[e] HDL= High-density lipoprotein cholesterol.

[f] This parameter represents the association between the passage of time, quantified in years since each woman's baseline assessment, and the odds of having each cardiometabolic outcome.

[g] Quantified as a rate of energy-adjusted usual beverage intake, interpolated across 9 years of follow-up using AUC, in units of 355 ml/d (approximately 12 fl. oz. per day). This parameter represents the association between overall beverage intake and women's overall odds of having each cardiometabolic outcome.

[h] This parameter reflects the degree to which time-related increases in the odds of having each cardiometabolic outcome varies as a function of beverage intake.