ORIGINAL RESEARCH

American Heart Association | American Stroke Association

Effects of Repeated Binge Drinking on Blood Pressure Levels and Other Cardiovascular Health Metrics in Young Adults: National Health and Nutrition Examination Survey, 2011-2014

Mariann R. Piano, PhD, RN; Larisa Burke, MPH; Minkyung Kang, PhD, RN; Shane A. Phillips, PhD, MPT

***Background*—**Binge drinking prevalence rates are highest in young adults; however, little is known about the effects of binge drinking on blood pressure (BP) and other cardiovascular health metrics in individuals between 18 and 45 years of age. The aim of this study was to determine the effects of regular binge drinking on BP, lipid and glucose levels and to determine if there were differences in these associations between men and women.

***Methods and Results*—**We analyzed data from NHANES (the US National Health and Nutrition Examination Survey) for men and women 18 to 45 years old who were non–binge drinkers, binge drank 1 to 12 times, or binge drank >12 times in the past year. After controlling for diet and physical activity, both categories of men binge drinkers compared with non–binge drinkers had higher systolic BP (121.8 and 119.0 mm Hg versus 117.5 mm Hg) and total cholesterol (215.5 and 217.9 mg/dL versus 207.8 mg/dL) values. There were no effects of binge drinking on systolic BP or total cholesterol in women. Binge drinking in men and women was associated with higher high-density lipoprotein-cholesterol values. The effects of binge drinking on glucose parameters in men and women were variable.

***Conclusions*—**Compared with young adult women, repeated binge drinking in men was associated with an elevated systolic BP, and greater frequency of binge drinking in men was associated with a more unfavorable lipid profile. In young adults with elevated systolic BP, practitioners should consider the possible role of binge drinking and address the importance of reducing alcohol intake as an important cardiovascular risk reduction strategy. **(*J Am Heart Assoc*. 2018;7:e008733. DOI: 10.1161/JAHA.118.008733.)**

Key Words: alcohol • binge drinking • blood pressure • cholesterol • young adults

In middle-aged and older adults, binge drinking is associated with an increased risk of myocardial infarction, stroke, and hypertension.[1-5] Binge drinking is also associated with an increased likelihood of developing prehypertension, previously defined as systolic blood pressure (SBP) between 120 and 140 mm Hg and diastolic blood pressure (DBP) between 70 and 90 mm Hg.[6] In nearly all population-based studies examining the effects of alcohol on blood pressure (BP) and other cardiovascular metrics, young adults (18-30 years) and those in middle adulthood (31-45 years) are underrepresented.[1,7] In the United States high rates of binge drinking are prevalent in both of these age cohorts.[8] Binge drinking is often defined as consuming 5 drinks or more in a row for men (≥4 drinks for women) per occasion within the past 30 days.[7]

Present-day young adults consume 6 to 7 drinks per binge-drinking episode (exceeding the current binge threshold of 4+/5+ drinks per episode) and binge drink several times a week.[9-12] Compared with previous generations, the intensity (ie, 6-7 drinks) and regularity (several times per week) of binge drinking may place today's young adults at greater risk for more profound rates of alcohol-related harm, such as elevated BP and increased prevalence of other cardiovascular risk factors. In particular, elevated BP is one of the strongest, most modifiable risk factors for cardiovascular disease.[13] Even among normotensive individuals, small reductions in average BP may have a marked impact on the future development of cardiovascular disease.[14] The new High Blood Pressure Clinical Practice Guideline defines "elevated BP" as a

From the Center for Research Development and Scholarship, Vanderbilt University School of Nursing, Nashville, TN (M.R.P.); Office for Research Facilitation, College of Nursing (L.B.), Department of Physical Therapy (S.A.P.), University of Illinois at Chicago, IL; College of Nursing, Keimyung University, Daegu, South Korea (M.K.).

Correspondence to: Mariann R. Piano, PhD, RN, Vanderbilt University, SON 415 Godchaux Hall, 461 21st Avenue South, Nashville, TN 37240. E-mail: mariann.r.piano@vanderbilt.edu

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Clinical Perspective

What Is New?

- Young adult men (18-45 years) with a repeated history of binge drinking have higher systolic blood pressure and total cholesterol levels compared with non–binge drinkers, whereas in women no effect of binge drinking was found on these parameters.
- In men and women, binge drinking was associated with higher high-density lipoprotein-cholesterol levels, and glucose levels were higher in binge-drinking women but lower in binge-drinking men.

What Are the Clinical Implications?

- In young adulthood, binge drinking may be associated with an elevated blood pressure; therefore, young adults need to be screened and counseled about alcohol misuse, including binge drinking, and advised on how binge drinking may affect their cardiovascular health.

systolic BP between 120 and 129 mm Hg and diastolic >80 mm Hg.[15] In the United States it is estimated that alcohol consumption may account for close to 10% of the population burden of hypertension.[15]

The aim of this study was to investigate the association between repeated binge drinking and BP as well as lipid and fasting glucose levels in adults between 18 and 45 years of age. We also sought to determine if there were differences in these associations between men and women. We analyzed data from NHANES (the US National Health and Nutrition Examination Survey) for male and female 18- to 45-year-olds who were non–binge drinkers, binge drank 1 to 12 times, or binge drank >12 times in the past year.[16]

Methods

Study Population

NHANES uses a multistage stratified probability sampling approach to identify participants and allows for the generation of nationally representative estimates. NHANES is conducted in 2-year cycles, and we used data from the 2 most recent NHANES cycles (2011-2012 and 2013-2014).[17,18] Survey data include interview, physical examination, and laboratory measurement of serum lipids and glucose levels.[19] NHANES is publicly available, and our study/analysis was determined to be exempt by the University of Illinois Institutional Review Board.

We restricted our analysis to include young adult and mid-adulthood examinees (18-45 years old). Exclusion criteria included those with a diagnosis of cardiovascular disease (ie, coronary artery disease/myocardial infarction, heart failure, stroke) or who were pregnant. Because we were interested in the effects of binge drinking on BP, those with hypertension or actual BP values exceeding 140/90 mm Hg were included, along with those reporting use of antihypertensive medications.

Definition of Binge Drinking

We categorized responses into those who reported binge drinking 1 to 12 times or ≥12 times in the past year through the question: "In the past 12 months, how many days did you have 4/5 or more drinks of any alcoholic beverage?" The answer could be given in days per week, month, or year.

Measurement of Blood Pressure and Other Variables

Per the NHANES analytic protocol, SBP and DBP were measured using a sphygmomanometer after participants had rested in a seated position for 5 minutes. Once the participant's maximum inflation level had been determined, 3 consecutive BP readings were obtained.[20] The mean of the 3 readings was calculated and used for the BP outcomes. Enzymatic analytic techniques are used for the measurement of total cholesterol, triglycerides (TG), high-density lipoprotein-cholesterol (HDL-c) and apolipoprotein B.[20] Fasting lipid samples were measured in the morning in examinees who had fasted for at least 8.5 hours but less than 24 hours. Low-density lipoprotein-cholesterol (LDL-c) was calculated using total cholesterol, TG, and HDL-c values, according to the Friedewald calculation. Methods for the measurement of fasting glucose were unchanged between the above NHANES cycles.[20] Detailed specimen collection and processing instructions are described in the *NHANES Laboratory Procedure Manual*.[20]

Ideal Cardiovascular Metrics

As recommended by the American Heart Association, ideal cardiovascular metrics include untreated SBP/DBP <120/<80 mm Hg and fasting blood glucose <100 mg/dL.[21] For blood lipids, ideal status includes total cholesterol ≤200 mg/dL, LDL-c ≤100 mg/dL, HDL-c ≥50 mg/dL, TG ≤200 mg/dL, and apolipoprotein B ≤130 mg/dL.[21]

Statistical Analysis

The analysis was performed using STATA 14.2 (StataCorp LLC, College Station, TX). Pooling of 2011-2012 and 2013-2014 data was performed to provide stable estimates of all cardiovascular outcomes. Following NHANES analytic and reporting guidelines, all statistical tests were conducted using STATA survey analysis statistics and weights to account for the

complex survey design (including oversampling), survey nonresponse, and poststratification. When a sample is weighted in NHANES, it is representative of the US Census civilian noninstitutionalized population. Dietary interview subsample weights were used, excepting measures of LDL-c, TG, and fasting glucose, which used fasting subsample weights. The sample sizes for the measures that required fasting are smaller because fewer participants had fasted at the time of examination. A subsample of all participants meeting the inclusion criteria was designated with the STATA software for all analyses to ensure correct study-design weighting. Dietary covariates for each participant were drawn from 2 days of NHANES dietary interview data. "Estimates of total intake of energy, nutrients, and nonnutrient food components from foods and beverages that were consumed during the 24-hour period before the interview (midnight to midnight)" were collected from participants.[16] Dietary covariates were calculated using an average of total values for the 2 days of dietary interview data. In addition, as a further measure of dietary intake/practices, we calculated the DASH (Dietary Approaches to Stop Hypertension) adherence score using nutrient targets reported by Kim and Andrade,[22] which resulted in a DASH adherence score ranging from 0 to 9. A greater DASH adherence score indicates greater DASH diet compliance. Binge drinking was analyzed as a categorical exposure because of its nonnormal distribution and the nonlinear relationship between binge drinking and cardiovascular outcomes. Survey design–adjusted multinomial regression models were used to assess differences in demographic characteristics by frequency of binge drinking (Table 1). Survey design–adjusted linear and logistic regression analyses were used to analyze differences in physical activity, dietary, and cardiovascular measures by frequency of binge drinking. Dietary models were adjusted for age, sex, race, body mass index, smoking status (nonsmoker, former smoker, current smoker), survey year, moderate or vigorous recreational exercise per week (yes or no), hours of sedentary activity per day, number of hours watching TV or videos per day, number of meals not home prepared in the past week, sodium intake, and DASH adherence score. Lipids, apolipoprotein B, and glucose levels were adjusted for the presence of hypertension. Hypertension was defined as an average SBP ≥140 mm Hg, an average DBP ≥90 mm Hg, a diagnosis of hypertension, or a current prescription of hypertension medication.

Results

Combining data from the NHANES 2011-2012 and 2013-2014 surveys gave us an unweighted sample size of 5554 individuals aged 18 to 45 years with medical examination data. After application of the exclusion criteria, the sample size was reduced to 5329 (4% decrease). The final sample size of 4710 resulted from those who met the inclusion criteria and had alcohol use data. Participants with dietary interview data totaled 3964 (16% decrease), and participants with dietary and fasting medical examination data totaled 1990 (50% decrease). Weighting was applied matching the applicable subsample of each analysis.

Table 1 displays the demographic characteristics of the sample. High-frequency binge drinking (>12 times a year) was reported by 25.1% of men and 11.8% of women. Binge drinking 12 times a year or less was reported by 29.0% of men and 25.1% of women. Older women had lower rates of binge drinking. Black men and women participants and Hispanic women had lower rates of binge drinking than their white counterparts. Men with lower family income had higher rates of binge drinking, as did women with higher education levels. Underweight men had a lower rate of midfrequency binge drinking (12 times per year or less), and obese men had lower rates of high-frequency binge drinking. Men and women binge drinkers were more likely to be current or past smokers than non–binge drinkers (Table 1).

Women who binge drank 1 to 12 times in the past year reported higher rates of moderate or vigorous recreational activity. Women who binge drank 12+ times in the past year reported more hours sedentary than non–binge-drinking women and more hours watching TV or videos per day compared with women who binge drank less or not at all (Table 2). Men who binge drank 1 to 12 times in the past year reported less time watching TV or videos. Men and women binge drinkers ate fewer meals prepared at home compared with non–binge drinkers. Overall, participants far exceeded the recommended daily values for sodium intake (2300 mg). Men who binge drank 12+ times per year consumed more sodium than non–binge-drinking men and more calories than men who binge drank less or not at all.

For men, compared with non–binge drinkers, binge drinking was associated with a higher SBP, whereas binge drinking had no effects on DBP (Table 3). SBP for men was also higher in higher-frequency binge drinkers compared with lower-frequency binge drinkers (P=0.04; Table 3). The relationship of binge drinking with SBP was significantly different for men compared with women as represented by the significant interaction effects in these models. No effects of binge drinking on SBP were found in women; however, women who binge drank ≤12 times per year had lower DBP compared with higher-frequency binge drinkers and non–binge drinkers (Table 3). For men, compared with non–binge drinkers, binge drinking was associated with a higher total cholesterol (TC) levels. TC levels were significantly different for men compared with women as represented by the significant interaction effects in these models (Table 3). Men who binge drank ≥12 times in the past year had higher LDL-c and apolipoprotein B levels, whereas no effects of drinking status were found on these lipid parameters for women. In men and women, there

Table 1. Demographic and Clinical Characteristics by Binge-Drinking Frequency

		Men (52.2%)				Women (47.8%)				
		Binge Drank >12 Times Per Year	Binge Drank ≤12 Times Per Year	Non–Binge Drinker			Binge Drank >12 Times Per Year	Binge Drank ≤12 Times Per Year	Non–Binge Drinker	
Characteristic	n	25.1%	29.0%	45.9%	*P* Value	n	11.8%	25.1%	63.0%	*P* Value
Survey year	2431				0.41	2279				0.7
2011-2012 (ref)		27.2%	29.2%	43.5%			12.8%	25.8%	61.5%	
2013-2014		23.0%	28.8%	48.1%			11.0%	24.5%	64.5%	
Age	2431				0.09	2279				<0.01*
≥18 and <27 (ref)		31.0%	28.0%	41.1%			15.2%	28.9%	56.0%	
≥27 and <36		22.0%	31.0%	47.0%			13.6%	24.2%	62.2%	
≥36 and ≤45		21.7%	28.3%	50.0%			7.3%†	22.2%†	70.4%	
Race	2431				<0.01*	2279				<0.01*
White, non-Hispanic (ref)		26.6%	31.9%	41.5%			13.3%	30.6%	56.1%	
Black, non-Hispanic		21.5%†	17.1%†	61.5%			11.0%†	16.0%†	73.0%	
Hispanic		25.9%	31.4%	42.7%			8.9%†	18.0%†	73.2%	
Other, non-Hispanic		18.1%†	19.6%†	62.3%			9.9%†	18.9%†	71.2%	
Family income	2327				<0.01*	2198				0.46
Less than 20 000 (ref)		30.6%	26.2%	43.3%			14.6%	24.6%	60.8%	
20 000 or more		23.6%†	29.9%	46.4%			11.2%	25.6%	63.2%	
Education	2431				0.07	2278				<0.01*
<High school (ref)		26.5%	26.1%	47.4%			9.8%	13.6%	76.7%	
High school		26.9%	24.7%	48.4%			9.3%	19.0%	71.8%	
Some college		27.4%	28.3%	44.3%			13.6%†	27.8%	58.6%	
≥College graduate		19.7%	35.6%	44.6%			12.1%†	30.7%	57.2%	
BMI	2417				0.02*	2256				0.13
Underweight		25.2%	17.9%†	56.8%			8.4%	25.9%	65.7%	
Normal weight (ref)		28.0%	27.5%	44.5%			13.7%	29.7%	56.6%	
Overweight		25.5%	30.6%	43.9%			12.6%	20.3%	67.1%	
Obese		21.6%†	29.6%	48.7%			9.7%	23.8%	66.6%	
Smoking status	2281				<0.01*	2143				<0.01*
Nonsmoker (ref)		17.4%	28.6%	54.0%			8.8%	22.1%	69.1%	
Past smoker		25.7%†	35.3%†	39.0%			10.9%	34.7%†	54.4%	
Current smoker		42.3%†	26.3%†	31.4%			22.5%†	29.1%†	48.4%	

BMI indicates body mass index; ref, reference value.

*Indicates statistically significance omnibus test (test of overall association between binge drinking and demographic/clinical characteristic) at $P<0.05$ level.

†Category significantly different from non–binge drinkers. For example, significant difference in the proportion of 27- to 36- vs 18- to 27-year-olds for those who binge drank >12 times per year compared with non–binge drinkers.

were no differences in TG levels among the 3 groups. HDL-c was higher for men and women binge drinkers compared with non–binge drinkers. Men who binge drank >12 times per year had lower glucose levels than non–binge-drinking men. Women who binge drank 1 to 12 times per year had higher glucose levels than non–binge-drinking women.

Discussion

The major findings of this study are as follows: (1) Men (18-45 years) with a repeated history of binge drinking have higher SBP and TC levels compared with non–binge drinkers, even after higher levels of sodium intake and lower physical activity profiles have been taken into account. (2) Higher HDL-

Table 2. Diet and Physical Activity by Binge-Drinking Frequency

		Men						Women						
		3. Binge drank >12 imes tper year	2. Binge drank ≤12 times per year	1. Non-binge drinker	1 vs 2	1 vs 3	2 vs 3	3. Binge drank >12 times per year	2. Binge drank ≤12 times per year	1. Non-binge drinker	1 vs 2	1 vs 3	2 vs 3	Inter-action
Metric	n	Mean (SE)	Mean (SE)	Mean (SE)	*P* Values			Mean (SE)	Mean (SE)	Mean (SE)	*P* Values			
Moderate/vigorous recreational activity**	4710	61.6 (2.9)	60.7 (3.5)	56.7 (3.4)	0.27	0.20	0.60	56.8 (3.6)	62.6 (3.9)	50.1 (2.7)	<0.01*	0.06	0.25	0.20
Hours sedentary per day	4699	6.4 (0.2)	6.6 (0.3)	6.8 (0.2)	0.63	0.08	0.31	7.4 (0.3)	7.1 (0.2)	6.7 (0.2)	0.08	0.01*	0.28	<0.01†
Hours of TV or video per day	4708	2.2 (0.1)	1.9 (0.1)	2.1 (0.1)	0.01*	0.39	<0.01*	2.3 (0.2)	1.9 (0.1)	2.0 (0.1)	0.38	0.01*	0.01*	0.13
Number of meals not prepared at home	4697	5.3 (0.2)	4.4 (0.3)	3.8 (0.3)	0.03*	<0.01*	0.03*	3.8 (0.3)	3.5 (0.4)	2.7 (0.3)	<0.01*	0.01*	0.43	0.41
24-hour dietary intake														
Sodium (1000 mg/d)	3964	4.5 (0.1)	4.2 (0.1)	4.1 (0.1)	0.42	<0.01*	0.09	3.2 (0.1)	3.1 (0.1)	3.1 (0.1)	0.63	0.31	0.60	0.46
Kcal (1000/d)	3964	2.7 (0.1)	2.5 (0.1)	2.5 (0.1)	0.84	<0.01*	0.02*	1.9 (0.1)	1.9 (0.0)	1.8 (0.0)	0.36	0.13	0.40	0.44
Total fat (g/d)	3964	98.3 (3.4)	94.4 (3.1)	93.9 (2.8)	0.86	0.15	0.35	69.5 (3.8)	68.9 (2.3)	70.2 (2.1)	0.61	0.85	0.87	0.34
Total carbohydrates (g/d)	3964	297.9 (13.1)	279.8 (11.0)	301.7 (10.8)	0.04*	0.75	0.22	211.8 (10.1)	226.9 (6.3)	223.2 (8.4)	0.62	0.31	0.16	0.04†
Protein (g/d)	3964	107.0 (3.5)	103.1 (2.2)	100.0 (2.3)	0.27	0.07	0.37	75.4 (3.4)	71.2 (2.5)	71.5 (1.4)	0.93	0.22	0.19	0.62
DASH adherence (0-9)	3964	2.8 (0.1)	2.7 (0.1)	2.7 (0.1)	0.98	0.51	0.64	2.5 (0.1)	2.4 (0.1)	2.4 (0.1)	0.77	0.44	0.35	0.89

Results were adjusted for age. DASH indicates Dietary Approaches to Stop Hypertension, TV, television.
*Indicates statistically significant difference at $p<0.05$ level.
†Indicates significant interaction between binge drinking and sex.
**Proportion (SE) reported.

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Table 3. Blood Pressure and Cardiovascular Metrics by Binge-Drinking Frequency

		Men						Women						
		3. Binge Drank >12 Times per Year	2. Binge Drank ≤12 Times per Year	1. Non–Binge Drinker	1 vs 2	1 vs 3	2 vs 3	3. Binge Drank >12 Times per Year	2. Binge Drank ≤12 Times per Year	1. NonBinge Drinker	1 vs 2	1 vs 3	2 vs 3	Interaction
Metric	n	Mean (SE)	Mean (SE)	Mean (SE)	*P* Values			Mean (SE)	Mean (SE)	Mean (SE)	*P* Values			
SBP, mm Hg	3629	121.8 (0.8)	119.0 (0.7)	117.5 (0.6)	0.04*	<0.01*	0.04*	112.2 (0.9)	112.0 (1.1)	111.8 (0.5)	0.89	0.72	0.76	0.03†
DBP, mm Hg	3629	71.6 (1.0)	70.4 (0.7)	70.2 (0.6)	0.72	0.23	0.54	69.5 (0.9)	67.6 (0.8)	69.2 (0.5)	0.05*	0.77	0.24	0.25
TC, mg/dL	3546	215.5 (3.7)	217.9 (2.2)	207.8 (2.4)	<0.01*	0.01*	0.09	210.3 (4.3)	207.4 (2.9)	207.6 (2.7)	0.94	0.46	0.92	0.01†
LDL-c, mg/dL	1817	134.0 (2.2)	121.7 (2.4)	126.5 (2.5)	<0.01*	0.63	0.04*	122.4 (4.3)	128.0 (3.3)	121.3 (3.1)	0.91	0.87	0.84	0.08
TG, mg/dL	1849	163.4 (8.3)	138.0 (12.3)	159.9 (7.2)	0.68	0.72	0.93	135.3 (8.8)	163.2 (8.0)	131.5 (9.3)	0.37	0.75	0.67	0.69
HDL-c, mg/dL	3546	52.3 (0.7)	50.6 (1.1)	47.0 (0.9)	<0.01*	<0.01*	0.54	65.3 (2.4)	59.5 (1.2)	56.6 (1.0)	0.01*	<0.01*	0.02*	0.29
Apo B, mg/dL	1849	104.9 (1.8)	95.5 (1.6)	100.0 (2.1)	0.04*	0.16	0.32	95.4 (2.6)	102.9 (2.3)	94.2 (2.0)	0.56	0.97	0.71	0.11
Glucose, mg/dL	1861	102.5 (1.3)	100.9 (1.5)	104.7 (1.0)	0.07	0.04*	0.89	101.8 (2.4)	102.2 (1.4)	97.1 (1.0)	0.01*	0.71	0.26	0.12

Results adjusted for age, sex, race, body mass index, smoking status, survey year, moderate or vigorous recreational activity, minutes sedentary activity, number of hours watching TV or videos, number of meals not home prepared, sodium intake, and DASH (Dietary Approaches to Stop Hypertension) diet adherence. Lipids, Apo B, and glucose levels were adjusted for presence of hypertension. Apo B indicates apolipoprotein B; DBP, diastolic blood pressure; HDL-c, high-density lipoprotein-cholesterol; LDL-c, low-density lipoprotein-cholesterol; SBP, systolic blood pressure; TC, total cholesterol; TG, triglyceride.

*Indicates statistically significant difference at $P<0.05$ level.

†Indicates significant interaction between binge drinking and sex.

c levels were associated with binge drinking for both men and women. Finally, (3) glucose levels were higher in binge-drinking women but lower in binge-drinking men.

In young and mid-adulthood individuals, few studies have examined the effects of repeated binge drinking on BP levels and other cardiovascular parameters. In a combined sample of men and women (mean age 43 years), Abramson and colleagues found binge drinking (5 or more drinks on at least 1 occasion per month) was associated with 24-hour ambulatory SBP and daytime SBP values that were 5 and 6 mm Hg greater than those of non–binge drinkers.[23] The "acute" (or "1-time" effect) of binge drinking on BP has been examined in healthy men aged 22-33 years.[24-26] In these studies, subjects consumed >4 to 5 standard drinks over a short period of time (ie, 2- to 5-hour period). Data from these studies indicated that a "1-time" binge episode was associated with increases in BP that ranged 4 to 7 mm Hg for SBP and 4 to 6 mm Hg for DBP.[24-26] Data also support that a history of binge drinking in young adulthood is associated with higher BP values. Wellman and colleagues examined the relationship between BP and current and past binge drinking among young adults (men and women, mean age 24 years).[27] Binge drinking was defined as consuming 5 or more drinks on 1 occasion. Subjects were recruited in 1999 (mean age 12 years), and follow-up was 2007-2008 (mean age 20 years) and 2011-2014 (mean age 24 years). Among 24-year-old subjects, both monthly and weekly binge drinkers had SBP values 2.61 and 4.03 mm Hg greater, respectively, than non–binge drinkers (similar BP increase findings were found in the 20-year-old subjects).[27]

Among men in our cohort, frequency of binge drinking (more than 12 times in the past year) was associated with higher increases in SBP compared with less frequent binge drinking (1-12 times in the past year). In our study, men who binge drank (binge drank >12 times in past year) had elevated BP (121.8±0.8 mm Hg) as defined by the new High Blood Pressure Clinical Practice Guidelines.[15] Using data from the 1999-2004 NHANES, Fan et al found that in men (not women; mean age 38 years), binge drinking was associated with a greater prevalence of prehypertension (defined as SBP between 120 and 140 mm Hg and DBP between 70 and 90 mm Hg).[6] In addition, SBP values were greater in men who reported binge drinking more than once a week (123.1±0.8 mm Hg) compared with SBP values (120.4±1.0 mm Hg) in those who reported binge drinking less than once a week.[6] In women, SBP values were nearly identical across groups,[6] which is similar to our current findings.

Few studies have specifically examined the effects of binge drinking on lipid parameters. We found that binge drinking affected plasma lipids and that the effects were different in men and women. For men, compared with non–binge drinkers, binge drinking was associated with higher TC and

LDL-c levels, whereas no effects of binge drinking were found in young adult women. Galan and colleagues examined different drinking patterns and lipid profiles among Spanish participants (age range 45-51 years) in the ENRICA study (N=10 356).[28] Binge drinking was defined as ≥80 g of alcohol for men and ≥60 g for women in any given drinking session during the preceding 30 days. Drinking patterns were also qualified as "regular moderate" (≤40 g/day for men and ≤24 g/day for women) and "regular heavy" (≥40 g/day for men and ≥24 g/day for women). These investigators found that, compared with nondrinkers, all levels of drinkers (including binge) had lower TC and LDL-c levels.[28] These findings differ from our findings, and although they are not completely understood, they may be related to age and to the different ethnicities of our populations.

We found no significant effect of binge drinking status on TG levels in men or women. Similarly, Galan and colleagues found that TG levels were not different among drinking groups, although levels tended to be higher in both heavy drinkers and heavy binge drinkers.[28] Among Japanese subjects (N=31 295), Wakabayashi found that "regular (every day)" and "occasional (sometimes)" heavy drinkers (defined as >66 g ethanol/day) had significantly greater TG levels compared with nondrinkers. As noted above, differences among studies may be related to age and to the different ethnicities of our populations.

It is important to note that in our study LDL-c values in both young adult binge drinkers and non–binge drinkers were above the AHA recommended target of 100 mg/dL. Pletcher and colleagues found that young people (18-30 years) with even modestly elevated TC levels are more likely to develop coronary artery calcium and atherosclerosis later in life.[29] In men, binge drinking may contribute to higher TC and LDL-c levels. Although TG levels were within normal range, TG levels tended to be higher in frequent male binge drinkers. Others have also shown that young adults with higher TG levels (but within the normal TG range) may still be at risk for premature cardiovascular disease. For example, in a young adult cohort (mean age 28 years), Grebe and colleagues found that TG levels were positively correlated with carotid intima-media thickness (a surrogate marker of early atherosclerosis).[30] Urbina et al also reported that among young adults (mean age 19 years), arterial stiffness, a measure of increased cardiovascular risk propensity (measured as higher brachial artery dispensability and carotid-femoral pulse wave velocity), increased with TG/HDL-c ratios among low-, mid-, and high-TG/HDL-c ratio groups (0.8, 1.3, and 2.7 ratios, respectively).[31] Although the reason for higher lipid levels may be multifactorial, all young adults need to be counseled about the importance of diet and exercise and how adverse lipid profile levels can increase the risk of future cardiovascular events.

Increased levels of HDL-c in young adults have been associated with a reduced cardiovascular risk later in life.[29] The role of HDL-c, however, has been brought into question by negative findings from clinical drug trials and negative Mendelian randomization studies.[32] In our study binge drinking was associated with higher HDL-c levels, and in all groups HDL-c levels were greater than 50 mg/dL.

Few studies have examined the effect of binge drinking on metabolic parameters, such as fasting glucose. In our study fasting glucose was decreased for binge-drinking men compared with non–binge drinkers but higher in binge-drinking women compared with non–binge-drinking women. Importantly, in our analysis we included potential confounders related to diet and physical activity, parameters that can affect glucose levels. Increased fasting glucose is a feature of metabolic syndrome.[33] Using NHANES data, others have reported that frequent binge drinking (once or more per week) (mean age 42 years) was associated with an increased adjusted odds ratio for developing metabolic syndrome.[34] However, impaired (or increased) fasting glucose was not one of the metabolic abnormalities associated with the increased odds for metabolic syndrome.[34] Similar to our findings and after controlling for body mass index and smoking, Nygren and colleagues found that higher alcohol consumption together with binge drinking was associated with the highest fasting plasma glucose levels in women but not in men.[35] These data are from the Northern Swedish prospective longitudnial (27 years) cohort study, which enrolled subjects at 16 years of age and included follow-up to 43 years of age.[35]

In the present study we also examined male-female differences in the association of binge drinking and BP, lipids, and glucose levels. Over the past decade, long-standing differences in drinking patterns between men and women have been converging, such that prevalence rates of binge drinking are rising in women while they remain unchanged in men.[36] Studies that have examined the effects of binge drinking on cardiovascular parameters, such as BP have included men and women, but not all of these have determined the potential interaction effect of sex.[2,27] More research is needed to ascertain sex differences in the effects of binge drinking on the cardiovascular system and metabolic parameters in young adult men and women.

Our results should be viewed in the context of the study design, which, because of the cross-sectional nature of the NHANES, disallows conclusions about causal relationships. Even though the NHANES cohort allowed for the inclusion of a large sample size and is representative of young adults in the United States, the findings of this study may not be generalizable to other geographic areas outside the United States. To our knowledge, this is the first study to examine the adverse effects of binge drinking on cardiovascular

metrics in young adults and with adjustment for dietary and physical activity profiles that could confound results between nondrinkers and binge drinkers. Future research should include prospective and longitudinal analysis of cardiovascular metrics as well as the measurement of parameters, such as carotid intima-media thickness and brachial-ankle pulse wave velocity that reflect early subclinical cardiovascular changes.

We found that binge drinking was associated with higher SBP levels in binge drinkers compared with non–binge drinkers, and frequent binge drinking had additional unfavorable effects on lipid values. Our findings have important public health relevance for young adults because recent evidence suggests that development of elevated BP before the age of 45 years is associated with significantly higher risks of cardiovascular death later in life compared with those who develop hypertension later in life.[37] Rates of hypertension in young adults are increasing, and rates of hypertension awareness and control are lowest in this group.[38] As highlighted in several other recent publications, targeting elevated BP and implementing lifestyle interventions to reduce BP in early adulthood may be an important strategy to prevent cardiovascular disease later in life.[13,39] Young adults need to be screened and counseled about alcohol misuse, including binge drinking, and advised on how binge drinking may affect their cardiovascular health.

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Effects of Repeated Binge Drinking on Blood Pressure Levels and Other Cardiovascular Health Metrics in Young Adults: National Health and Nutrition Examination Survey, 2011 –2014

Mariann R. Piano, Larisa Burke, Minkyung Kang and Shane A. Phillips

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