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Association of Alcohol Consumption and Ideal Cardiovascular Health among South Asians: The Mediators of Atherosclerosis in South Asians Living in America (MASALA) Study

Short Title: Alcohol Consumption and Ideal Cardiovascular Health

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Abstract

Background: Observational studies have shown that alcohol consumption above the recommended limit is associated with increased cardiovascular disease (CVD), although its association in South Asians is unclear. Less is known regarding the association between alcohol consumption and cardiovascular health (CVH), assessed by the American Heart Association's Life's Simple 7 (LS7) health metrics among those with South Asian ancestry.

Methods: This analysis included 701 participants without CVD from the Mediators of Atherosclerosis in South Asians Living in America (MASALA) cohort (2015-2018). Based on a personal history questionnaire, participants were divided into never, former, and current drinkers. The current drinking category was further classified into 1-3 drinks/week, 4–7 drinks/week, and >7 drinks/week. The consumption of 5 or more drinks on 1 occasion in the past month was defined as binge drinking. Each LS7 component was given a point score of 0, 1, or 2. The total score was categorized into 0 to 6, 7 to 10, and 11 to 14 to represent poor, intermediate, and ideal CVH, respectively. We use multinomial logistic regression to examine the association between alcohol consumption and CVH.

Results: In the MASALA cohort (mean age=59 y, 43% female), participants consuming >7 drinks/week had the lowest mean CVH score. Compared with never drinkers, male participants consuming >7 drinks/week were less likely to have intermediate CVH [0.44 (0.08, 0.91)] and ideal CVH [0.23 (0.03, 0.96)]. Binge drinking was associated with significantly lower odds of ideal CVH compared to never drinkers.

Conclusion: We found evidence of an inverse association of moderate to heavy alcohol consumption and ideal CVH in South Asian men. These findings further underscore the important relationship between alcohol consumption and CVH in this unique population of South Asians.

Introduction

Health behaviors play a significant role in maintaining and modifying disease processes. While some health behaviors may lead to improvement of health, such as exercise for hypertension (Pescatello et al., 2015), others can lead to deterioration of health (Kelly and Barker, 2016). Still, other health behaviors can be more complex. For instance, moderate alcohol consumption is associated with reduced risk of cardiovascular disease (CVD) and mortality, while excess consumption has been associated with increased risk (Polsky and Akturk, 2017). A study with more than 5000 participants with baseline vascular disease or diabetes revealed a U-shaped relationship between alcohol consumption and all-cause mortality, vascular mortality, and amputation. It also showed that compared with abstainers, 1-2 alcoholic drinks per day was associated with reduced all-cause mortality, vascular death, the risk of congestive heart disease, and stroke (Beulens et al., 2010). Despite multiple studies revealing the benefits of low to moderate alcohol consumption, a recent analysis from the study of nearly 600,000 individuals revealed that more than 1 drink per day was associated with increased all-cause mortality (Wood et al., 2018). A

systematic review and meta-regression analysis, including 28 million individuals aged 15 to 49 years demonstrated that the risk of all-cause mortality increased with increasing levels of alcohol consumption, and the level of consumption that minimized health loss was zero standard drinks/week (Griswold et al., 2018). An explanation for these conflicting results is unclear. Randomized controlled trials assessing the causality of alcohol and cardiovascular disease are impossible to perform. However, a recent Mendelian randomization study provides evidence of a causal relationship between higher alcohol consumption and increased risk of stroke and peripheral artery disease (Larsson et al., 2020).

In 2010, the American Heart Association (AHA) declared its strategic impact goal, which stated: "By 2020, to improve the cardiovascular health of all Americans by 20% while reducing deaths from cardiovascular diseases and stroke by 20%." To help achieve this goal, the concept of "ideal cardiovascular health" was created and defined by 7 metrics (healthy diet, physical activity, body mass index, smoking, blood pressure, blood glucose, and total cholesterol) called Life's Simple 7 (LS7) which is a combination of health risk behaviors and intermediate measures of CVD (Lloyd-Jones et al., 2010). Alcohol consumption can have a differential effect on these behaviors and measures of CVD. The cardioprotective effect of alcohol via increased HDL is well established; however, there is weak evidence on its effect on other lipid components (Rimm et al., 1999). A sample of adults representative of the U.S. population suggested that alcohol consumption and physical activity are positively correlated (French et al., 2009). A study of more than 15,000 U.S. adults found that increased alcohol consumption was associated with decreased diet quality (Breslow et al., 2010). While low to moderate alcohol consumption is associated with lower diabetes risk, heavy alcohol consumption has been linked to higher blood glucose levels (Gerard et al., 1977, Koppes et al., 2005). The studies examining the association between alcohol and BMI have shown conflicting results (Shelton and Knott, 2014, Traversy and Chaput, 2015). Numerous studies, including meta-analysis, have established the association between excessive alcohol consumption and HTN (Briasoulis et al., 2012, Fuchs et al., 2001). However, there are conflicting reports of the association of mild to moderate alcohol consumption with HTN (Klatsky et al., 1977, Criqui et al., 1981, Santana et al., 2018, Aladin et al., 2019). Rather than focusing on individual measures, our study examines the relationship between alcohol and LS7, which allows us to explore the association between alcohol and combined measures of behavioral and cardiovascular health factors.

The population of South Asians is rapidly growing in the United States, and their high risk of CVD is unable to be accounted for by traditional risk factors alone (Kanaya et al., 2013). Given the size of their population, the high incidence of CVD in this ethnic group presents a major public health crisis. For many years, researchers have examined Asians as a unitary ethnicity; nevertheless, studies have shown that South Asians have a higher risk of CVD than other Asian groups (Volgman et al., 2018). A

recent AHA review concluded that a majority of the CVD risk in South Asian can be explained by the increased prevalence of known risk factors and that no unique risk factors have been found in this population(Volgman et al., 2018). Even though there are high CVD event rates in South Asians, only a few prospective cohort studies in the world have focused on determining the risk factors associated with CVD. The cardioprotective effects of low to moderate alcohol consumption vary substantially among different ethnicities/races (Kerr et al., 2011). Low to moderate alcohol consumption was found to be associated with a lower risk of all-cause mortality among Caucasian and Hispanic but not among the Chinese or Indian population (Kerr et al., 2011, Yusuf et al., 2004, O'Keefe et al., 2018). The studies examining the relationship between alcohol consumption and subclinical atherosclerosis among different ethnicities/races have also shown inconsistent results (McClelland et al., 2008, Pletcher et al., 2005). A recent study from the South Asian population found different associations of alcohol consumption with surrogate markers of subclinical atherosclerosis (Chevli et al., 2020). Thus, studies to increase our understanding of the association of alcohol consumption with health behaviors factors affecting CVD are of paramount importance. From public health perspectives, achieving and maintaining cardiovascular health behaviors and factors in South Asians could have significant effects on reducing CVD incidence and mortality. Very few studies have examined alcohol consumption and its association with cardiovascular health (CVH) using LS7 metrics, of which none included South Asian participants (Ogunmoroti et al., 2019, Piano et al., 2018). The Mediators of Atherosclerosis in South Asians Living in America (MASALA) study is the only longitudinal study of South Asians in the United States and can contribute to the knowledge of the association of alcohol consumption and other health behaviors that can influence cardiac risk. The objective of this cross-sectional study from the MASALA cohort was to examine the association between alcohol consumption and ideal cardiovascular health using AHA's LS7 metrics among asymptomatic South Asians age 45-90 years in the U.S. We postulated that higher alcohol consumption would be inversely associated with ideal CVH.

Methods

Study participants

The original MASALA study eligibility and recruitment methods have been reported previously (Kanaya et al., 2013). The MASALA study is a community-based prospective cohort study of South Asian men and women, free of CVD at baseline, recruited from 2 clinical sites (San Francisco Bay Area at the University of California, San Francisco, and the greater Chicago area at Northwestern University).

A total of 906 South Asians were enrolled between October 2010 and March 2013. From September 2015 through March 2018, all surviving cohort participants were invited for the second clinical examination, and 749 (83%) participants completed this examination (Kanaya et al., 2019). We decided to use more recent data from the second clinical examination. The analytical sample was 701 after the exclusion of 48 participants with missing data for one or more LS7 metrics. The institutional review boards of the University of California, San Francisco, and Northwestern University approved the protocol.

Alcohol consumption

Alcohol consumption was assessed based on the personal history questionnaire. Each participant was asked, "Have you ever consumed alcoholic beverages?" If yes, then the following question was, "Do you presently drink alcoholic beverages?" The answers given to these 2 questions, categorized each participant into 3 categories: 1) never; 2) former; and 3) current drinkers. Current and former drinkers were asked, "For how many years did you drink alcoholic beverages?" Besides, they were asked about the usual number of drinks consumed per week (before they stopped drinking if they were former drinkers). These questions were used to make mutually exclusive categories of current drinkers as 1) 1-3 drinks/week; 2) 4–7 drinks/week; and 3) >7 drinks/week. Also, current drinkers were asked about the number of drinks consumed during the past 24 hours and the largest number of drinks consumed in 1 day in the past month. Participants were classified as binge drinkers if they had consumed ≥5 drinks in a single day in the past month. (Kanaya et al., 2013, Chevli et al., 2020)

Life's Simple 7 Metrics

AHA's LS7 metrics include 7 health behaviors and factors (Jin et al., 2016, Lloyd-Jones et al., 2010). An automated blood pressure monitor (V100 Vital sign monitor, GE Medical Systems, Fairfield, CT) was used to measure resting blood pressure three times in the seated position, and the average of the last two readings was used for analysis. Total Cholesterol was measured using enzymatic methods, and the hexokinase method was used to measure fasting plasma glucose. Typical Week's Activity Survey was used to assess the frequency of various physical activities, including walking for exercise, dance, conditional activities, and sports, and the Metabolic Equivalents (METs) of each activity were calculated (Ainsworth et al., 1999). We used the time spent in activities identified as either vigorous (>6 METs) or moderate (3–6 METs) in the derivation. The average time per week spent in all activities at either a

vigorous or moderate level was computed for each participant, and participants were then categorized based on the AHA criteria (Lloyd-Jones et al., 2010). The assessment of dietary intake was based on the Study of Health Assessment and Risk in Ethnic groups (SHARE) food frequency questionnaire (FFQ), which has been developed and validated for South Asians in Canada (Kelemen et al., 2003). A healthy diet contained adequate quantities of 5 items (fruits and vegetables, fish, whole grains, sodium, and sugar-sweetened beverages), as defined by the AHA. Height was measured using a stadiometer, and weight was measured using a standard balance-beam scale or a digital weighing scale. The BMI was calculated using weight (in kilograms) divided by height (in meters squared). The assessment of smoking status was based on a questionnaire (Kanaya et al., 2013). The details of the assessment of AHA's LS7 components are shown in Table S1.

A point score of 0, 1, or 2 was given to each LS7 metric to represent poor, intermediate, or ideal health, respectively (Lloyd-Jones et al., 2010). The sum of the individual metric scores was used to derive an overall CVH score, which could range from 0-14. The CVH score was classified as poor (0–6), intermediate (7–10), or ideal (11–14) CVH.

Measurement of covariates

Using standard questionnaires administered by trained interviewers, information on age, sex, education, and family income was obtained. We categorized education as having ≥ Bachelor's degree or <Bachelor's degree. Family income was categorized as having ≥ $75,000 or < $75,000 annually.

Statistical Analysis

The characteristics of the study population were compared across the categories of alcohol consumption (never drinker, former drinker, 1-3 drinks/week, 4–7 drinks/week, and >7 drinks/week). We summarized categorical variables as number (percentages) and continuous variables as mean (standard deviation) or median (interquartile range) depending on the normality of the data. To compare the baseline characteristics, we used analysis of variance (ANOVA) for continuous variables and the chi-squared test for categorical variables.

The prevalence of each LS7 metric was reported by alcohol consumption categories. We used multinomial logistic regression models to examine the cross-sectional association between alcohol

consumption categories and CVH. Odds ratios (ORs) and 95% CIs were calculated for intermediate CVH score (7-10) and ideal CVH score (11–14) across the categories of alcohol consumption. Model 1 was unadjusted, and model 2 was adjusted for age, sex, education, and family income. The reference groups were "never" categories for alcohol consumption and binge drinking (McClelland et al., 2008) and poor score for CVH categories (Ogunmoroti et al., 2019). We also examined the association between alcohol consumption categories and each LS7 metric as ideal or non-ideal (intermediate and poor) using binomial logistic regression analysis. Moreover, we examined whether age or sex modified the associations between alcohol consumption and CVH by inserting an interaction term in model 2.

Additionally, we performed subgroup analysis stratified by age (using 58 years as a cut point) and sex. A two-sided p-value of <0.05 was considered statistically significant, and all statistical analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, North Carolina).

Results

The baseline characteristics of the MASALA participants by alcohol consumption categories are shown in Table 1. Among 701 participants included in the analysis (aged 59 ± 9 years, 43% women), 198 (28%) were never drinkers, 247 (35%) were former drinkers, and 256 (37%) were current drinkers. Of the current drinkers, 147 (57%) reported consuming 1-3 drinks/week, 68 (27%) reported consuming 4-7 drinks/week, and 41 (16%) reported consuming >7 drinks/week. Also, 11% of current drinkers reported binge drinking in the past month. For the overall cohort, 10% (n=69) had poor CVH, 20% (n=141) had ideal CVH, and the remaining 70% (n=491) had intermediate CVH. Of note, only 5% of the female participants consumed >7 drinks/week. Figure 1 displays the mean CVH score by alcohol consumption categories. Participants consuming >7 drinks/week as well as those with binge drinking had lower mean CVH scores.

Table 2 shows the distribution of LS7 metrics by alcohol consumption categories. The proportion of participants consuming > 7 drinks/week who met the ideal criteria for smoking, total cholesterol, and blood glucose were significantly lower compared to never drinkers. For the overall cohort, only 4% of the participants met the ideal criteria for diet. Interestingly, the proportion of never drinkers who met the ideal criteria for the physical activity was lower than that for current drinkers who consumed more than 7 drinks/week.

Using multinomial logistic regression, we examined the association between levels of alcohol consumption and CVH, as shown in Table 3. For the multivariable model, alcohol consumption of >7 drinks/week was associated with lower odds of having intermediate (odds ratio [OR] (95% CI):0.31 (0.10-0.93), P = 0.037) or ideal (odds ratio [OR] (95% CI):0.14 (0.03-0.60), P = 0.008) CVH compared to never drinkers. Table 4 shows the association between binge drinking in the past month and CVH. Compared to never drinkers, participants who reported binge drinking had significantly lower odds of having ideal CVH (odds ratio [OR] (95% CI):0.03 (0.003-0.36), P = 0.005). In age-stratified analysis (Table S2), those who were ≥58 years and consumed >7 drinks/week had 74% lower odds of having intermediate CVH, and 88% lower odds of having ideal CVH, compared to never drinkers. There was no significant association between alcohol consumption and CVH in those who were <58 years. Evaluation of the association by sex was limited by sample size, especially among women (Table S3). Men with alcohol consumption of >7 drinks/week had 77% lower odds of having ideal CVH and 56% lower odds of having intermediate CVH.

We also examined the association between alcohol consumption and individual LS7 metrics (Table S4). Regardless of the category of alcohol consumption, participants had lower odds of achieving the ideal criteria for smoking compared to never drinkers. Participants consuming >7 drinks/week had 71% lower odds of having ideal criteria for total cholesterol. Also, those who reported 4-7 and >7 drinks/week had lower odds of achieving ideal blood pressure and blood glucose criteria.

We formally tested for the interaction of the associations by sex and age, even though results were stratified given a priori interest in the relation of alcohol consumption and CVH among subgroups. For the CVH scores, we did not find any significant interaction for alcohol consumption with sex or age.

Discussion

This United States community-based population study of CVD free South Asians revealed several important findings. First, compared to never drinkers, participants consuming >7 drinks/week were less likely to achieve intermediate or ideal CVH. Second, participants had lower odds of having ideal CVH if they reported binge drinking in the past month compared to never drinkers. Third, participants who consumed >7 drinks/week were less likely to achieve ideal criteria for smoking, total cholesterol, blood pressure, and blood glucose compared to never drinkers.

Although multiple epidemiological studies have explored the connection between alcohol consumption and CVD (O'Keefe et al., 2007, Rimm et al., 1999, Zhao et al., 2017, O'Keefe et al., 2018), very few studies have examined the connection between alcohol consumption and CVH. A recent study from the Multi-Ethnic Study of Atherosclerosis (MESA) (Ogunmoroti et al., 2019) showed that compared to never drinkers, participants consuming >14 drinks/week were less likely to have intermediate and ideal CVH. In comparison to the MESA study, our study found that alcohol consumption of >7 drinks/week was associated with lower odds of achieving intermediate or ideal CVH in South Asians. We could not examine the association of >14 drinks/week with CVH as very few participants in the MASALA cohort had drinking frequency in that range. Similar to our results, binge drinking in the MESA participants was also associated with unfavorable CVH. Moreover, the findings of an inverse relationship between heavy drinking and ideal CVH, as well as binge drinking, remained consistent throughout different racial/ethnic groups in the MESA. The cardioprotective effect of light or moderate drinking was found to be inconsistent among the different races and ethnicities (Schooling et al., 2008, Halanych et al., 2010, Nunez-Cordoba et al., 2009). The INTERHEART study, which included 27,000 people from 50 different countries, revealed regular alcohol intake reduced the risk of MI by 14%; however, this beneficial association was not evident in the Indian cohort (Yusuf et al., 2004). Our study also did not show any protective association between light drinking and CVH or any of the seven individual components of LS7 in this South Asian population. However, this could be due to a small sample size of our study.

In an age-stratified analysis, we found that among participants who consumed >7 drinks/week, participants who were ≥58 years had a lower odds of having intermediate and ideal CVH, but the association was not significant for those <58 years. This is in contrast with the results from MESA, where the inverse relationship of higher alcohol consumption with ideal CVH was consistent among those <65 years and ≥65 years. The finding of lower odds of achieving intermediate or ideal CVH among older cohort with consumption of >7 drinks/week could be due to the inability to maintain a healthy lifestyle or due to a higher prevalence of cardiovascular risk factors.

Health behaviors are influenced by an individual's "motives, self-regulation, resources, habits, and environmental and social influences (Kwasnicka et al., 2016)." Similarly, health behaviors can often influence other health behaviors. Regardless of the level of alcohol consumption, participants failed to achieve ideal criteria for smoking compared to never drinkers. Alcohol consumption has been shown to be associated with increased smoking behavior (McKee et al., 2006, King et al., 2009). Not only has alcohol been shown to reduce smoking resistance in an inverse dose-dependent fashion (Kahler et al., 2014), it has also been shown to be associated with more tobacco use on heavy drinking days (Jackson et al., 2013). One study showed that tobacco use was more prominent after approximately 3 drinks(Harrison

and Mckee, 2008). Moderate alcohol consumption is associated with increased high-density lipoprotein (HDL) cholesterol (Rimm et al., 1999). However, studies have also shown that heavy alcohol consumption may increase low-density lipoprotein (LDL) and triglyceride levels (Wakabayashi, 2013). We found that MASALA participants with >7 drinks/week were less likely to have ideal total cholesterol. This finding could be due to an increase in HDL, LDL, or triglyceride. Our study showed that consumption of 4-7 drinks/week and >7 drinks/week was associated with lower odds of achieving ideal blood pressure. A recent systematic review and dose-response meta-analysis conducted to examine the association between alcohol consumption and incident hypertension found that, regardless of gender, no quantity of alcohol consumption was associated with reduced risk of developing hypertension (Roerecke et al., 2018). Alcohol-induced hypertension is thought to be caused by the actions of angiotensin II on the endothelium resulting in inflammation and inhibition of endothelium-dependent nitric oxide production, which leads to loss of endothelial relaxation and elevated blood pressure (Husain et al., 2014). We also found that consuming >7 alcoholic drinks/week had 73% lower odds of having ideal blood glucose levels. Most alcoholic beverages have very high amounts of sugar. Alcohol-induced increase in blood glucose levels may result from its adverse effect on insulin secretion and insulin resistance (Emanuele et al., 1998). The systematic review and meta-analysis of 20 studies found a U-shaped relationship between average amount of alcohol consumed per day and risk of incident type 2 diabetes (Baliunas et al., 2009). The published literature has reported a positive relationship between physical activity and alcohol consumption (Dodge et al., 2017). For MASALA participants, we did not find any significant association between alcohol consumption and physical activity. The studies examining the association between alcohol consumption and body weight have revealed conflicting evidence. Overall, the majority of studies suggest that light-to-moderate alcohol consumption is not associated with weight gain, while heavy consumption is associated with weight gain (Traversy and Chaput, 2015). There was no association between alcohol consumption and BMI in MASALA participants. A cross-sectional study of 3,729 participants examined the association between alcohol and diet quality measured by the Healthy Eating Index (HEI) (Breslow et al., 2006). The results demonstrated that as the quantity of alcohol consumption increased from 1 to ≥3 drinks/day, diet quality worsened. However, there was no association between alcohol consumption and diet quality in our study.

From a public health perspective, we found no evidence of the benefit of low or moderate alcohol use among South Asian men and women. Moreover, among South Asian men with >7 drinks/week, there was some evidence of harm with respect to CVH. Alcohol consumption guidelines vary substantially across different countries (Kalinowski and Humphreys, 2016). The current drinking guidelines in the U.S. are based on research that did not include people of South Asian descent. Further research is needed to

understand whether the current recommendations also apply to this group, which may have different behavioral patterns with respect to alcohol use. A study from the National Epidemiologic Survey of Alcohol and Related Conditions, including 952 Asian-American adults, demonstrated that ethnic drinking cultures might significantly influence alcohol use(Cook et al., 2012). Also, the pattern of alcohol consumption among South Asians is impacted by religious prohibitions against alcohol use and gender norms that discourage drinking among women(Chowdhury et al., 2006). A better understanding of the pattern of alcohol consumption, the factor influencing alcohol use and its effect on CVH, would help design policies and interventions for this rapidly growing population.

Strengths and limitations

The strength of our study includes its community-based South Asian population, which is an understudied but fast-growing minority with high risk for cardiovascular disease, among other chronic diseases. Key variables were obtained using validated instruments in a culturally sensitive manner in the MASALA study, including diet. Study limitations include the cross-sectional analysis of the association between alcohol consumption and CVH, and, therefore, a causal relationship could not be established. The MASALA study has a relatively small cohort size obtained from only 2 United States geographic centers, which limits the generalizability of the findings. We were unable to make inferences regarding women with >7 drinks/week consumption and for binge drinking, given the small sample sizes in these categories. Alcohol consumption was based on questionnaire responses, and this may have led to the underreporting of the quantity of alcohol consumed by study participants. This, in turn, could attenuate the association due to misclassification. Lastly, we adjusted for several confounders, but there remains a possibility of residual confounding. For example, the observed association between alcohol consumption and CVH could be attributable to an unadjusted dietary pattern that is dependent on alcohol intake.

Conclusion

We observed an inverse association between alcohol consumption and CVH in South Asian men. These results further highlight the importance of healthy behaviors in maintaining ideal CVH. Future research can focus on the impact of these healthy behaviors on CVD and examine the association between alcohol consumption and incident CVD in the MASALA cohort.

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FIGURE LEGEND

Figure 1. Mean CVH score (and SE) for alcohol consumption categories

Table 1. Baseline Characteristics of MASALA Participants, 2015-2018

	Alcohol consumption (number of drinks/week)					
Characteristics Mean± SD or No. (%)	**Never** N=198	**Former** N=247	**1-3** N=147	**4-7** N=68	**>7** N=41	***P* value[a]**
Male, No. (%)	61 (30.8)	141 (57.1)	98 (66.7)	53 (77.9)	39 (95.1)	**<0.001**
Age (years)	60 ± 9.2	59.3 ± 9.1	58.4 ± 9.8	58.9 ± 8.3	60.9 ± 10.5	0.449
Education < Bachelor's degree (%)	39 (19.7)	20 (8.1)	8 (5.4)	6 (8.9)	2 (4.9)	**<0.001**
Family Income ≥ $75,000 per year (%)	126 (67)	193 (79)	118 (82)	59 (88)	30 (79)	**0.001**
LS 7 metrics						
Smoker Status, No. (%)						**<0.001**
Never	191 (96.5)	211 (85.4)	111 (75.5)	46 (67.7)	20 (48.8)	
Former	5 (2.5)	31 (12.6)	32 (21.8)	18 (26.5)	16 (39)	
Current	2 (1)	5 (2)	4 (2.7)	4 (5.9)	5 (12.2)	
BMI (kg/m^2)	26.4 ± 4	26.8 ± 4.2	26.4 ± 4.3	26.1 ± 3.3	26.1 ± 3.6	0.575
Total Cholesterol (mg/dL)	189 ± 38	184 ± 43	189 ± 41	182 ± 37	187 ± 42	0.506
Lipid-lowering medications, No. (%)	59 (29.8)	80 (32.4)	45 (30.6)	31 (45.6)	18 (43.9)	0.08
Systolic Blood Pressure (mm Hg)	127 ± 19	127 ± 18	127 ± 18	130 ± 13	131 ± 16	0.563
Diastolic Blood Pressure (mm Hg)	74 ± 10	75 ± 10	76 ± 9	78 ± 9	78 ± 10	**<0.001**
Antihypertensive medications, No. (%)	66 (33.3)	89 (36)	54 (36.7)	26 (38.2)	18 (43.9)	0.754

Fasting blood glucose (mg/dl)	108 ± 25	110 ± 24	105 ± 18	117 ± 26	113 ± 21	**0.004**
Diabetic medications, No. (%)	31 (15.7)	60 (24.3)	25 (17)	17 (25)	7 (17.1)	0.121
Diet Score	2.06 ± 0.91	2.12 ± 0.90	1.99 ± 0.90	1.99 ± 0.91	2.0 ± 0.92	0.604
Physical activity (MET-min per week)	1295 ± 1299	1545 ± 1537	1621 ± 1235	1912 ± 1633)=	1806 ± 1678	**0.016**
CVH Score, No. (%)						
Poor (0-6)	15 (7.6)	31 (12.6)	8 (5.4)	6 (8.8)	9 (21.9)	
Intermediate (7-10)	138 (69.7)	167 (67.6)	108 (73.5)	51 (75)	27 (65.9)	0.054
Ideal (11-14)	45 (22.7)	49 (19.8)	31 (21.1)	11 (16.2)	5 (12.2)	
Abbreviations: BMI, body mass index; CVH, Cardiovascular health; LS7, Life's Simple 7; MET, metabolic equivalent						
[a]P-value by ANOVA for continuous variables and chi-square for categorical variables						

Table 2. Distribution of Life's Simple 7 metrics by alcohol consumption

	Alcohol consumption (number of drinks/week)					
	Never N=198	**Former** N=247	**1-3** N=147	**4-7** N=68	**>7** N=41	***P* value[a]**
Smoking						
Poor	2 (1%)	5 (2%)	4 (3%)	4 (6%)	5 (12%)	**<0.001**
Intermediate	5 (3%)	31 (13%)	32 (22%)	18 (26%)	16 (39%)	
Ideal	191 (96%)	211 (85%)	111 (75%)	46 (68%)	20 (49%)	
Body Mass Index						
Poor	32 (16%)	43 (18%)	19 (13%)	7 (10%)	6 (15%)	0.736
Intermediate	94 (47%)	112 (45%)	63 (43%)	30 (44%)	19 (46%)	
Ideal	72 (37%)	92 (37%)	65 (44%)	31 (46%)	16 (39%)	
Total Cholesterol						
Poor	13 (6%)	24 (10%)	17 (11%)	3 (5%)	4 (10%)	**0.044**
Intermediate	110 (56%)	135 (54%)	79 (54%)	52 (76%)	25 (61%)	

Ideal	75 (38%)	88 (36%)	51 (35%)	13 (19%)	12 (29%)	
Blood Pressure						
Poor	46 (23%)	62 (25%)	29 (20%)	16 (23%)	11 (27%)	0.764
Intermediate	97 (49%)	119 (48%)	78 (53%)	38 (56%)	23 (56%)	
Ideal	55 (28%)	66 (27%)	40 (27%)	14 (21%)	7 (17%)	
Blood Glucose						
Poor	27 (14%)	43 (17%)	20 (13%)	19 (28%)	7 (17%)	**<0.01**
Intermediate	82 (41%)	108 (44%)	57 (39%)	33 (48%)	28 (68%)	
Ideal	89 (45%)	96 (39%)	70 (48%)	16 (24%)	6 (15%)	
Diet Quality						
Poor	61 (31%)	69 (28%)	49 (33%)	22 (32%)	12 (29%)	0.920
Intermediate	130 (66%)	163 (66%)	91 (62%)	42 (62%)	28 (68%)	
Ideal	7 (3%)	14 (6%)	7 (5%)	4 (6%)	1 (3%)	
Physical Activity						
Poor	28 (14%)	28 (11%)	8 (5%)	2 (3%)	6 (15%)	**0.029**
Intermediate	43 (22%)	41 (17%)	23 (16%)	12 (18%)	5 (12%)	
Ideal	127 (64%)	178 (72%)	116 (79%)	54 (79%)	30 (73%)	
[a]P-value by ANOVA for continuous variables and chi-square for categorical variables						

Table 3. Multivariable Odds Ratio and 95% CI of association between alcohol consumption and cardiovascular health

Alcohol Consumption	**Intermediate vs. Poor**		**Ideal vs. Poor**	
	Odds Ratio (95% CI)	***p-value***	***Odds Ratio (95% CI)***	***p-value***
Model 1[a]				
Never Drinker	*reference*		*reference*	
Former Drinker	0.59 (0.30, 1.13)	0.11	0.53 (0.25, 1.10)	0.09
1-3 drinks/week	1.46 (0.60, 3.59)	0.40	1.29 (0.49, 3.42)	0.60

4-7 drinks/week	0.92 (0.34, 2.5)	0.88	0.61 (0.19, 1.94)	0.40
>7 drinks/week	**0.33 (0.13, 0.82)**	**0.017**	**0.19 (0.05, 0.64)**	**0.008**
Model 2[b]				
Never Drinker	*reference*		*reference*	
Former Drinker	0.53 (0.26, 1.10)	0.09	0.46 (0.18, 1.15)	0.10
1-3 drinks/week	1.17 (0.44, 3.11)	0.76	0.93 (0.29, 3.00)	0.90
4-7 drinks/week	0.71 (0.24, 2.15)	0.55	0.36 (0.09, 1.51)	0.16
>7 drinks/week	**0.31 (0.10, 0.93)**	**0.037**	**0.14 (0.03, 0.60)**	**0.008**

[a]Model 1 unadjusted

[b]Model 2 adjusted for age, sex, education, and income

OR < 1 is interpreted as lower odds of having an ideal or intermediate cardiovascular health score

Table 4. Multivariable Odds Ratio and 95% CI of association between binge drinking and cardiovascular health

Binge drinking past month	**Intermediate vs. Poor**		**Ideal vs. Poor**	
	Odds Ratio (95% CI)	***p-value***	***Odds Ratio (95% CI)***	***p-value***
Model 1[a]				
No (Never) (n= 198)	*reference*		*reference*	
No (Current) (n=229)	0.94 (0.46, 1.92)	0.86	0.80 (0.37, 1.78)	0.60
Yes (n=27)	0.60 (0.18, 1.97)	0.40	**0.08 (0.01, 0.81)**	**0.03**
Model 2[b]				
No (Never) (n= 198)	*reference*		*reference*	

No (current) (n=229)	0.75 (0.34, 1.67)	0.49	0.46 (0.17, 1.20)	0.11
Yes (n=27)	0.39 (0.11, 1.38)	0.14	**0.03 (0.003, 0.36)**	**0.005**

Binge drinking was defined as ≥5 drinks in a single day in the past month.

No (Never): No binge drinking and never drinkers; No (Current): No binge drinking and current drinkers;

Yes: Binge drinking and current drinkers

[a]Model 1 unadjusted

[b]Model 2 adjusted for age, sex, education, and income

OR < 1 is interpreted as lower odds of having an ideal or intermediate cardiovascular health score

Figure-1 Mean CVH score (and SE) for alcohol consumption categories