

# **ASSOCIATIONS BETWEEN ALCOHOL CONSUMPTION AND CARDIO-METABOLIC RISK FACTORS IN YOUNG ADULTS**

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## Abstract

**Introduction:** The benefits of alcohol consumption for cardiovascular and metabolic health may have been overstated due to inappropriate comparisons with abstainers and inadequate control for confounding factors including physical activity and mental health. We examined alcohol consumption and cardio-metabolic health in a cohort of young Australian adults overcoming these limitations.

**Methods:** Cross-sectional data of a cohort of 2,200 participants (age range 25-36 years) from the 2004-06 Childhood Determinants of Adult Health (CDAH) were used. Alcohol consumption was assessed from questionnaire and cardio-metabolic risk factors were measured in clinics. Linear and log binomial regression were used to examine total alcohol consumption (categories: none 0g/day; light >0-10g/day [reference]; moderate >10-20g/day; heavy >20-30g/day; very heavy >30g/day) against dichotomous metabolic syndrome (MetS) and its components: waist circumference, triglycerides, high-density lipoprotein (HDL) cholesterol, blood pressure (BP) and glucose. Covariates included socio-demographics, smoking, diet, physical activity, fitness, depression and anxiety.

**Results:** Of the 2,220 participants (48% males, mean [SD] age 29.5[2.5] years), most were classified in the 'light drinking' group (54.2%), less were in the 'non-drinking' (13.2%), 'heavy' (5.2%) or 'very heavy' (5.5%) drinking groups. Only moderate drinking was associated with a significantly lower prevalence of MetS (prevalence ratio=0.64,  $p<0.05$ ) compared with light drinking. Higher levels of alcohol consumption were associated with higher HDL cholesterol ( $\beta=0.05$ ,  $p_{\text{trend}}<0.001$ ). Very heavy compared to light drinkers had higher systolic ( $\beta=3.01$  mmHg,  $p<0.01$ ) and diastolic ( $\beta=2.07$  mmHg,  $p<0.05$ ) blood pressure.

**Conclusion:** Moderate alcohol consumption was associated with more favourable levels of some, but not all, cardio-metabolic risk factors even when compared to light consumption and with account for a range of confounding factors.

Keywords: cardio-metabolic risk factors, metabolic syndrome, alcohol consumption, epidemiology, lifestyle, cardiovascular diseases

## Introduction

There have been concerns that the apparent beneficial effects of moderate alcohol consumption on health outcomes have been over-stated due to the use of abstainers as the reference group (1, 2). Authors for a recent systematic review of studies investigating alcohol use and mortality suggested using occasional drinkers as the comparator instead of abstainers because abstainers often include former drinkers and people who stop drinking due to health issues, creating a bias that made light drinkers appear healthier in comparison. (2). A further issue with existing studies (3-5) is the limited control for the potential confounding effects of dietary intake, physical activity, cardiorespiratory fitness and mental health, which are strongly associated with alcohol consumption (6, 7) and cardio-metabolic risk factors (8).

There is a need for greater evidence on the effects of alcohol consumption on young adults' cardio-metabolic health as young adults are the most likely to drink alcohol at levels associated with long-term risk of harm (9), and cardiovascular diseases are often 'silent' in the young (10). The effects of alcohol on individual cardiovascular and metabolic risk factors in young adults are inconclusive. Authors have reported that alcohol consumption is associated with risk factors such as blood pressure in a J-shaped association (11) or insulin sensitivity in a positive linear association (12) among studies focused on young adults. Other risk factors such as waist circumference, triglycerides or high-density lipoprotein cholesterol (HDL-C) have not been fully examined for their relationship with alcohol consumption in young adults.

Few investigators have examined the association between alcohol consumptions and the overall profile of cardio-metabolic risk factors in young adults, for example with a combined indicator such as the presence of metabolic syndrome. Most authors have focused on older individuals finding that alcohol consumption has a positive (13), negative (14, 15) or J-

shaped relationship (4) with metabolic syndrome. The differing results could be due to several reasons including the focus on older individuals in whom the recall of alcohol consumption across the life course might be unreliable (16) and that co-morbid diseases may influence associations (1).

Studying the relationship between alcohol consumption and cardio-metabolic risk factors in younger populations is therefore important to provide more precise estimates of the association and also to potentially improve health messaging related to alcohol consumption to younger people. We therefore investigated the relationship between alcohol consumption and metabolic syndrome among a cohort of young Australian adults with consideration of a wide range of potential confounders.

## **Methods**

### **Participants**

This is a cross-sectional analysis of 26-36 year olds from the 2004-2006 follow-up of the Childhood Determinants of Adult Health (CDAH) study. This is a 20-year follow-up of participants in the 1985 Australian Schools Health and Fitness Survey (ASHFS), which comprised a nationally representative sample of school children aged 7-15 years. A detailed description of the cohort has been published elsewhere (17). The flow of participants from baseline to follow-up is described in Figure 1.

### **Measurements**

#### *Alcohol consumption*

We collected information about alcohol consumption from a food frequency questionnaire. Each participant reported his or her frequency of intake (options: never or <1/month, 1-3 times/month, once/week, 2-4 times/week, 5-6 times/week, once/day, 2-3 times/day, 4-5 times/day, and >6 times/day) of alcoholic beverages (options: light, medium or full strength

beer; red, white and sparkling wine; wine cooler, spirits/liqueurs, spirit-based mixed drinks, sherry/port, and other) over the last 12 months. The estimated amount of alcohol consumed per day for each type of beverage was determined by multiplying the frequency of drinking by the estimated grams of alcohol for each beverage type. The total amount of alcohol consumed per day was defined as the sum of the amount of alcohol consumed for each type of beverage (18).

Individuals were classified into five groups according to daily alcohol intake: 0 drinks/day (Non-drinkers), >0-1 drink/day (Light drinkers), >1-2 drinks/day (Moderate drinkers), >2-3 drinks/day (Heavy drinkers) and >3 drinks/day (Very heavy drinkers), based on Australian guidelines (19). Beer, wine, and spirits were classified into 3 –categories: 0g/day, >0-10g/day, >10g/day). Further categorization of the types of alcohol was not possible due to small numbers in higher consumption groups.

A subsample of 2,170 participants (97.7% of total sample) had a 12-month DSM-IV-based alcohol use disorders (AUDs) diagnosis (e.g. alcohol dependence and/or alcohol abuse) by the Composite International Diagnostic Interview (CIDI) (20).

#### *Cardio-metabolic risk factors*

Height, weight and waist circumference were measured with BMI calculated. Fasting blood samples were used to measure serum triglycerides (mmol/L), total cholesterol, HDL-cholesterol (mmol/L), and fasting insulin ( $\mu$ IU/L) concentrations. Fasting plasma glucose (mmol/L) was measured enzymatically. Blood pressure (BP) was measured using a digital automatic monitor. A detailed description of the measurements is provided in the supplement.

#### *Definition of MetS*

The primary outcome was metabolic syndrome (MetS) and its components defined by the Adult Treatment Panel III of the National Cholesterol Education Program (NCEP/ATP-III)

(21). MetS is defined as 3 or more of the 5 risk factors: abdominal obesity (waist circumference (WC) >102 cm in men; >88 cm in women), hypertriglyceridemia (triglycerides (TG)  $\geq 150$  mg/dL), low level of high-density lipoprotein cholesterol (HDL-C) (i.e. HDL-C <40 mg/dL (1.08 mmol/L) in men and <50 mg/dL (1.3 mmol/L) in women), high blood pressure (BP) (BP  $\geq 135/85$  mmHg) and high levels of fasting plasma glucose (GL) (i.e. GL  $\geq 110$  mg/dL ( $\geq 5.6$  mmol/L)). MetS was also expressed in a continuous MetS risk score which was computed from weighted principle components and gender specific cut-offs as a continuous outcome, described in details by Wijndaele et al (22). The mean value was used in the analysis.

### *Covariates*

The covariates and their measurement are described in full in the supplement. In brief, the following covariates were considered: age, sex, socio-economic (SES) quartile base on area of residence, region of residence, education level, occupation, marital status and smoking status measured by questionnaires; physical activity determined by the International Physical Activity Questionnaire (IPAQ) (23); cardiorespiratory fitness (CRF) estimated as physical work capacity (PWC) (24); dietary intake assessed using a food frequency questionnaire (FFQ), and then derived as a Dietary Guideline Index (DGI) score; childhood alcohol consumption, health-related quality of life (HRQoL) (SF-12 physical and mental component scores), and depression and anxiety from the aforementioned CIDI (20).

### **Statistical analysis**

We examined the association between alcohol consumption categories and dichotomous metabolic syndrome using multivariable log binomial regression (prevalence ratios [PR] and 95% confidence intervals [CIs]), and with each individual cardio-metabolic risk factor using multivariable linear regression (predicted means values and/or  $\beta$  coefficients and 95% CIs).

Light drinkers group were chosen as the reference category. We also examined associations with beer, wine, and spirits categorised as in the abovementioned session.

Potential covariates were included in the models in accordance with purposeful model building procedures (25). Models are presented adjusted for socio-demographics including sex, age, region, SES status, educational level, occupation, marital status (model 1); model 1 plus behavioural risk factors including smoking, dietary intakes, physical activity (model 2); model 2 plus cardiorespiratory fitness (model 3); model 3 plus mental health, i.e. depression and anxiety (model 4). Interaction terms between covariates and alcohol consumption were entered into final regression models to test effect modification. There was no evidence of effect modification by sex (see online Supplementary material), so results for men and women are presented together.

The following sensitivity analyses were performed: (1) using the non-drinkers (abstainers) group as the reference category, (2) excluding participants who had been diagnosed positive for alcohol abuse or dependence, and (3) to examine the effect of loss to follow-up. Multiple imputation (MI) using chained equations with 30 estimations was used to replace missing data on covariates. Details are provided in the supplement. The threshold for significance was  $p \leq 0.05$  (two-tailed). Analyses were performed in Stata 12.0.

## **Results**

### **Characteristics of study population**

Of 2,220 participants, the majority were light and moderate drinkers, while less were abstainers, heavy or very heavy drinkers who consumed alcohol daily (Table 1). Compared to light drinkers, non-drinkers were less often male, less likely to have reported drinking in childhood, less likely to be smokers at adulthood, less often had an alcohol use disorder in adulthood, had a higher dietary guideline index score, had lower physical and mental



HRQoL, more often lived in a low socio-economic postcode, were more often married, less physically active and had lower daily step counts. The overall prevalence of MetS was 7%. It was highest in non-drinkers (8%) and lowest in heavy drinkers (3%) (Table 2).

## **Association between Alcohol Consumption and individual Cardio-Metabolic Risk**

### **Factors**

Individual multivariable models examining alcohol consumption and each risk factor are presented in the supplement (Table 1-6). In Model 4, compared to light drinkers, non-drinkers had a significantly higher waist circumference ( $\beta=1.88$  (0.41, 3.36),  $p<0.05$ ) and lower HDL cholesterol ( $\beta=-0.06$  (-0.10, -0.01),  $p<0.01$ ); moderate ( $\beta=0.09$  (0.06, 0.13),  $p<0.001$ ) and heavy drinkers ( $\beta=0.20$  (0.14, 0.26),  $p<0.001$ ) had significantly higher HDL cholesterol; and very heavy drinkers had significantly higher systolic ( $\beta=3.01$  (0.90, 5.12),  $p<0.01$ ) and diastolic BP ( $\beta=2.07$  (0.33, 3.81),  $p<0.05$ ) (Figure 2, Table 1-6).

People who did not drink beer (0g/day) had significantly higher waist circumference ( $\beta=1.46$  (0.36, 2.55),  $p<0.01$ ) and significantly lower HDL cholesterol ( $\beta=-0.08$  (-0.11, -0.05),  $p<0.001$ ) compared to those who drank light amounts of beer (>0-10g/day) (see online Supplementary Table 1, 3)<sup>1</sup>. High consumption of wine (>10g/day) was associated with a significantly higher systolic ( $\beta=2.40$  (0.87, 3.94),  $p<0.01$ ) and diastolic BP ( $\beta=1.65$  (0.39, 2.92),  $p<0.05$ ) compared to light consumption of wine (>0-10g/day) in the fully adjusted models (see online Supplementary Table 4, 5).

Analyses using non-drinkers instead of light drinkers as the reference category made little difference to the findings (see Supplementary Figure 2.1, Figure 3.1 and Table 19).

Sensitivity analyses excluding those with an alcohol use disorder mostly strengthened the associations (see online Supplementary Table 9). Applying inverse probability weights did not change the results (online Supplementary Table 11-16).

## **Association between Alcohol Consumption and Metabolic Syndrome**

Compared to light drinkers, non-drinkers had a non-significantly higher prevalence of MetS; whereas moderate drinkers and heavy drinkers had a lower prevalence of MetS, and very heavy drinkers had a higher prevalence of MetS in unadjusted analyses (Figure 3, Table 7). Model 4 showed that only moderate drinkers had a significantly lower prevalence of MetS (PR=0.64 (0.41, 0.99),  $p<0.05$ ) compared to light drinkers. Demographic factors including SES status constituted most but insignificant modification (model 1) while other lifestyle and health behaviours including smoking, dietary intakes and physical activity accounted for significant change (model 2) compared to the unadjusted model. These results were not markedly changed in the 2 further adjusted models with cardio-respiratory fitness and mental health (see online Supplementary Table 7).

The analyses using non-drinkers instead of light drinkers as the reference category made only modest difference in the findings (see Supplementary Figure 3.1 and Table 20).

Beer, wine and spirits had different associations with the prevalence of MetS. There was a significantly higher prevalence of MetS in people who did not drink beer compared to those who drank light amounts of beer (PR=1.62 (1.14, 2.32),  $p<0.01$ ), and in people who did not drink wine compared to those who drank little amounts of wine (PR=1.59 (1.12, 2.25),  $p<0.01$ ) (see online Supplementary Table 7). The analyses with the types of alcoholic beverage as continuous measures instead of the categorical ones showed that there were no statistically significant association between types of alcoholic beverages and prevalence of MetS (see online Supplementary Table 8.2).

Similar results were found when using the non-drinkers instead of the light drinkers as the reference group. There was no evidence of interactions between alcohol and other variables in the final adjusted models. Sensitivity analyses showed similar associations after excluding

those with an alcohol use disorder (see online Supplement Table 10). Applying inverse probability weights made the results for the heavy drinkers somewhat stronger (Supplementary Table 17).

Increasing levels of alcohol consumption were associated with a reduction in the continuous MetS risk score (see Figure 3 and Supplementary Tables 8). The association between higher levels of alcohol consumption and lower continuous MetS risk score were not significantly changed by further adjustment (see Figure 3 and Supplementary Tables 8).

## **Discussion**

Our results suggested a lower burden of cardio-metabolic risk factors among moderate drinkers compared to light drinkers in this sample of young adults. Results were significant after adjusting for potential confounders, including physical activity, cardio-respiratory fitness and mental health that have not been explored in previous studies. There was evidence of higher systolic and diastolic blood pressure in those with very high alcohol consumption.

Our findings on the association between moderate alcohol consumption and lower MetS prevalence are consistent with the only other study focused on young adults (26) and some studies in populations with a wider age range (4, 15, 27), but in contrast to other reports of no association between alcohol drinking and MetS (14, 28) or that heavy drinking increased the risk of MetS (5). Other health behaviours including smoking, dietary intake and physical activity were significantly associated with alcohol consumption and caused most of the change in the magnitude of the association between alcohol consumption and MetS in adjusted models. This suggests that inadequate control for confounders may have led to an overestimation of the association between alcohol consumption and MetS in previous studies of young adults. In terms of the individual components of the metabolic syndrome we

found that increasing levels of alcohol consumption had a favourable association with high-density lipoprotein cholesterol (HDL-C), whereas it was associated with higher levels of blood pressure and waist circumference in young adults. The dose-dependent association of alcohol and HDL-C levels is among limited findings observed in young adults but consistent with a number of previous studies in populations with a wider age range (29, 30).

There were important differences between light drinkers and non-drinkers in this cohort of young adults. Non-drinkers had lower levels of physical activity, met fewer dietary guidelines, had poorer cardiorespiratory fitness, and had a higher prevalence of depression and/or anxiety but a lower prevalence of smoking compared to light drinkers. However, using non-drinkers instead of light drinkers as the reference group made only a modest difference to the associations. Using non-drinkers as the comparator was not problematic in this sample of young adults but the differences in the health profile of non-drinkers versus drinkers supports the suggestions of other investigators to use light drinkers as the reference category in examinations of alcohol and markers of health.

A higher prevalence of metabolic syndrome (MetS) and higher mean continuous MetS risk scores were observed among non-beer and non-wine drinkers but not non-spirit drinkers, compared to people that drink light amounts of those beverages. People that did not drink beer had significantly higher waist circumference and lower HDL cholesterol compared to those that drank light amounts of beer; whereas people that consumed greater amounts wine had significantly higher systolic and diastolic BP compared to those that drank lower levels of wine. Others have also suggested a lower prevalence of MetS in consumers of beer and wine, but not in those consuming spirits compared to never-drinkers (14, 31). The analyses with the types of alcoholic beverage as continuous instead of categorical measures in this study showed that there were no statistically significant associations between types of alcoholic beverages and prevalence of MetS. Those results indicated that alcohol

consumption was associated with lower MetS only in those who consumed light to moderate amounts of beer or wine, but not irrespective of all types of beverages consumed. While most studies of the relationship between alcohol and cardio-metabolic health in young adults did not analyse the effect of beverage type, our results indicated that young adults who drank light amounts of beer and/or wine might have better health than those consuming higher amounts of these types or other types of alcohol.

The biological mechanisms relating alcohol consumption to each component of metabolic syndrome are complex. Alcohol intake may increase HDL-C either by synthesis or clearance of HDL-C or by effects on enzymes and proteins influencing HDL metabolism (32). The association of very heavy drinking with higher blood pressure is in agreement with one previous study in young adults and populations with a wider age range (33, 34). Several possible mechanisms regarding the effects of alcohol consumption on blood pressure have been proposed such as impacts on the central nervous system, sympathetic nervous system, renin-angiotensin system or aldosterone system (35, 36).

The apparent favourable association between wine, particularly red wine with its higher levels of bioflavonoids and antioxidant polyphenols, and cardiovascular health has also been reported in previous studies (37, 38). In this study, beer and wine showed similar relationships with cardio-metabolic risk factors perhaps suggesting that the common components of these drinks, such as ethanol, account for the favourable effects. There remains the possibility that the associations are due to residual confounding. There are a number of factors associated with the type of alcohol consumed, such as socioeconomic status, dietary intakes, physical activity and fitness, and cardio-metabolic risk factors which were not taken into consideration in previous studies. In our study, by taking these covariates into consideration, the favourable association between drinking wine and beer and cardio-metabolic health remained significant although the magnitude was small.

Current guidelines recommended “responsible alcohol consumption”, no more than two standard drinks per day on average, to avoid health risks associated with drinking alcohol. (19). We found that most people in our cohort were consuming alcohol at or below this level. This suggests that current guidelines were mainly adhered, at least in younger, somewhat higher socioeconomic status adults similar to our cohort. Nonetheless, recent Australian data revealed that people in their 40s are now more likely to drink at lifetime risky levels than any other age group (9). Therefore, health promotion messages should convey both the positive and negative effects on the cardio-metabolic and general health of young people.

The strengths of this study include the large sample that provided sufficient power to investigate our hypotheses. We took into account a wide range of potential confounders previously unexplored in studies of young (12, 39) and even older (3, 40) populations, including depression and anxiety, cardiorespiratory fitness, physical activity and diet. Although each of these factors were strongly associated with levels of drinking, socio-demographic factors, smoking status, diet and physical activity were the main confounders of the association. The sample also provided sufficient factors allowing investigation of the associations across all levels of alcohol consumption. In particular, there were important differences between the very heavy drinking group and other groups in terms of outcomes and characteristics. There are also several limitations. The cross-sectional design means we are unable to examine casual associations between alcohol consumption with the metabolic syndrome. Our young healthy sample with few co-morbid diseases and our ability to exclude those with alcohol use disorders addressing potential issues with reverse causation is a strength of our study. Misclassification of alcohol intake may have occurred due to self-report. However, self-report recall methods have been reviewed to offer a reliable and valid approach to measuring alcohol consumption. Self-reported alcohol intake has been shown to be significantly associated with gamma-glutamyltransferase (GGT), which is a useful marker

in the prediction of hypertension and cardiovascular disease (41). It is possible that the discrepancies between our findings and others are related to measurement and classification of alcohol consumption. Authors use different methods to classify type of alcoholic beverages. For example, Djousse et al. (14) identified alcohol categories of 0.1 to 7 and >7 drinks/week for each types of alcoholic beverage (beer, wine and spirits), while Slagter et al. (42) classified beverage-specific consumption if that beverage type accounted for >70% of their alcohol consumption. One difficulty is how to account for the fact that people likely drink several different types of alcoholic beverages and how to quantify these overall patterns of alcohol consumption. Combining individual alcohol types into overall patterns of consumption, therefore could provide novel insights into these associations but these analyses were beyond the scope of this study.

We had substantial loss to follow-up since childhood, which may affect the generalisability of our findings to other populations. However, a comparison of the CDAH sample (n=2,200) with population data for Australian adults aged 25-34 showed that the proportion of participants who were current drinkers was very similar to that in the general population (86% vs. 83%) (9). The proportion who drank two drinks per day or more (the 'heavy drinkers') was similar to previous findings on high risk alcohol consumption in young adults (11% vs. 13%) (43). Furthermore, sensitivity analysis showed small differences after applying the inverse probability weighting from the adulthood and childhood data to deal with loss to follow-up (Supplement Table 11 to Table 18). Thus, the loss to follow-up does not appear to have had a great effect on our results. Despite the large sample size we still had inadequate power to examine types of alcohol in detail. There were not enough participants consuming >20g/day for each type of beverage to allow us to examine specific alcohol types and each individual risk factors in detail. The 'very heavy alcohol consumption' group covers a wide range of drinking with the average consumption in this group being more than 50g per

day (>5 drinks/day). However, it is difficult from this data to determine where risk truly increased.

## **Conclusion**

Moderate alcohol consumption was associated with a lower prevalence of MetS and some of its components even when compared to light drinkers instead of non-drinkers and with account for a range of confounding factors. Although alcohol consumption plays an important role in social and culture life, health promotion messages must convey both its positive and negative effects on the cardio-metabolic health of young people.

## **Supplementary material**

Supplementary material is available at [European Journal of Preventive Cardiology](#) online.



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**Authorship:** DD, RB, TD, AV and SG contributed to the conception or design of the work.

DD, RB, TD, AV and SG contributed to the acquisition, analysis, or interpretation of data for the work. DD and SG drafted the manuscript. DD, RB, TD, AV and SG critically revised the manuscript. All gave final approval and agree to be accountable for all aspects of work ensuring integrity and accuracy.

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