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Moderate alcohol intake is related to increased heart rate variability in young adults: Implications for health and well-being

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Abstract

Epidemiological literature indicates that the relationship between alcohol consumption and health outcomes reflects a J-shaped curve such that moderate alcohol consumption confers a protective effect in comparison to abstinence, while heavy consumption is associated with poorer health. While heart rate variability (HRV) may underpin the relationship between drinking and poor health in heavy drinkers, it is unclear whether HRV is increased in moderate, habitual drinkers relative to nonhabitual drinkers. HRV and drinking habits were assessed in 47 volunteers. Results supported hypotheses suggesting that moderate, habitual drinking increases HRV. Although not supported by a significant interaction between drinking group and sex, planned follow-up analysis also revealed that these findings may be specific to males. Regardless, results highlight HRV as a candidate mechanism for the findings reported in the epidemiological literature.

Descriptors: Heart rate variability, Alcohol, Autonomic nervous system

Moderate alcohol consumption is associated with a significantly reduced risk of sudden cardiac death (Albert et al., 1999), coronary heart disease (CHD; Rimm, Williams, Fosher, Criqui, & Stampfer, 1999), heart failure (Abramson, Williams, Krumholz, & Vaccarino, 2001), and myocardial infarction (Gaziano et al., 1993; Yusuf et al., 2004). It contributes to better cardiovascular health outcomes such as an increase in high-density lipoproteins (Mukamal et al., 2007), a reduction of coagulatory factors such as fibrinogen and plasma viscosity (Mukamal et al., 2001), and a reduction of systemic inflammation (Sierksma, Van Der Gaag, Kluft, & Hendriks, 2002). Moderate alcohol intake is also associated with reduced overall mortality (Di Castelnuovo et al., 2006) and a reduced risk of CHD in younger adults, although this risk is smaller compared to older adults (Hvidtfeldt et al., 2010). Along with improved physical health, moderate alcohol consumption has also been associated with positive mental health outcomes in comparison to abstainers, with research reporting reductions in stress, anxiety, depression, and improved general psychological well-being (Baum-Baicker, 1985; Lipton, 1994; Peele & Brodsky, 2000; Skogen, Harvey, Henderson, Stordal, & Mykletun, 2009). Together, these studies on both physical and mental health underpin a J-shaped curve such that moderate alcohol consumption appears to confer health benefits in comparison to abstinence, while heavy alcohol consumption is associated with significantly poorer health outcomes in comparison to both moderate intake and abstinence (Corrao, Bagnardi, Zambon, & La Vecchia, 2004; Lipton, 1994).

An important factor that may contribute to the relationship between moderate alcohol intake and improved health outcomes is cardiac autonomic control, indexed by heart rate variability (HRV; Janszky et al., 2005; Masters, Stevenson, & Schaal, 2004). HRV is a measure of beat-to-beat temporal changes in heart rate and has been demonstrated to be a relatively pure index of parasympathetic control (Berntson et al., 1997). Spectral analysis of R-R intervals (Berntson et al., 1997) allows for the high frequency (HF) peak (0.15–0.4 Hz) to be determined; this is a relatively pure index of parasympathetic activity, which may reflect vagal tone (Akselrod et al., 1981; Lane et al., 2009). HRV is a reliable predictor of overall health (Bigger, Fleiss, Rolnitzky, & Steinman, 1993); it is negatively associated with coronary heart disease (Liao et al., 1997) and sudden cardiac death (La Rovere et al., 2003) indicating that increases in HRV may be associated with cardioprotective benefits. HRV is also reduced in mental illnesses such as

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depression (Kemp, Quintana, Felmingham, Matthews, & Jelinek, 2012; Kemp et al., 2010), anxiety (Alvares et al., 2013; Kemp et al., 2012), and alcohol dependence (Quintana, McGregor, Guastella, Malhi, & Kemp, 2013) providing a potential explanation for the frequent comorbidity between mental and physical illness. Research also highlights an important role of autonomic cardiac control in the maintenance of alcohol dependence and alcohol craving, in particular (Garland, Franken, & Howard, 2011; Quintana, Guastella, McGregor, Hickie, & Kemp, 2013). Furthermore, research indicates that females have higher resting state HRV (Koskinen et al., 2009; Ryan, Goldberger, Pincus, Mietus, & Lipsitz, 1994; Sztajzel, Jung, & Bayes de Luna, 2008), consistent with a lower risk of their developing coronary heart disease. Reported sex differences in HRV and CHD also highlight the importance of considering sex when evaluating the impact of moderate alcohol consumption on HRV.

While there is evidence that moderate alcohol intake increases HRV in a population of older women (Masters et al., 2004), the impact of moderate intake on healthy, relatively young adults and the moderating effects of sex remain to be explored. An advantage of selecting healthy, young participants without a history of serious physical disease is that it helps rule out “sick quitters” (i.e., people who abstain from drinking due to illness) as an explanation for why nonhabitual drinkers may have reduced HRV in comparison to moderate drinkers. Younger people also display increased HRV in comparison to older people (Agelink et al., 2001), so any increases in HRV due to moderate alcohol consumption would be interesting as this would be more difficult to achieve given potential ceiling effects. Another important consideration is the difference between the impact of acute versus chronic drinking on HRV. It is well established that HRV decreases following acute administration of alcohol (Gonzalez Gonzalez, Mendez Llorens, Mendez Novoa, & Cordero Valeriano, 1992; Koskinen, Virolainen, & Kupari, 1994; Reed, Ohel, David, & Porges, 1999; Vaschillo et al., 2008). Results of a more recent study, however, highlight the importance of dose effects (Spaak et al., 2010); compared to baseline, one drink of alcohol (approximately 15 g of alcohol) did not alter HF HRV, whereas two drinks reduced it. Although this study provides evidence that lower doses of acutely administered alcohol do not reduce HRV in young adults, research is yet to explore the impact of chronic drinking behaviors in this population. The aim of the present study, therefore, was to assess the impact of longer-term moderate drinking behavior on HRV and to determine whether sex moderates this effect. In light of the J-shaped relationship between health outcomes and alcohol consumption, we hypothesized that moderate drinkers would demonstrate increased HRV in comparison to those who, for all intents and purposes, abstain from alcohol. This study has important implications for our understanding of the relationship between moderate alcohol consumption and well-being.

Method

Participants

Forty-seven volunteers (28 females, 19 males) with a mean age of 20.51 (*SD* ± 5.4) were recruited from a pool of undergraduate psychology students. Participants received university course credit for their participation and gave written informed consent in accordance with National Health and Medical Research Council guidelines. The University of Sydney Human Research Ethics Committee provided ethical approval for this research. Exclusion criteria included self-reported current or past psychiatric illness, psychotropic medications, regular cigarette smoking, or self-reporting of any other serious medical condition, such as cardiovascular diseases or diabetes. We relied on self-report, rather a clinical examination, for cardiovascular disease given its low incidence in young people (Yusuf, Reddy, Ounpuu, & Anand, 2001) and the logistical challenge of organizing a separate appointment with a specialist. No participants had AUDIT-C scores that were indicative of heavy drinking (i.e., males ≥ 7, females ≥ 5; Aalto, Alho, Halme, & Seppä, 2009).

Instruments

Participants completed a number of questionnaires that measured demographic information and anxiety in social interactions (Social Interaction Anxiety Scale [SIAS]; Mattick & Clarke, 1998). Physical activity levels were indexed by the International Physical Activity Questionnaire (IPAQ; Craig et al., 2003), which calculates the energy cost of physical activities over the course of the previous week via the calculation of a metabolic equivalent of task (MET) minutes per week score (available at https://sites.google.com/site/theipaq/questionnaire_links). Higher scores on this measure represent greater levels of physical activity. The Depression, Anxiety and Stress Scale (DASS; Lovibond & Lovibond, 1995) indexed severity of depression, stress, and anxiety (available at: http://www2.psy.unsw.edu.au/dass/down.htm). Participants also completed the Alcohol Use Disorder Identification Test Consumption subscale (AUDIT-C), a widely used index of alcohol intake (Bush, Kivlahan, McDonell, Fihn, & Bradley, 1998), which consists of the first three questions from the AUDIT (Saunders, Aasland, Babor, de la Fuente, & Grant, 1993; available at: http://whqlibdoc.who.int/hq/2001/who_msd_msb_01.6a.pdf). Research has demonstrated that the AUDIT-C performs better than the AUDIT in identifying risky drinking (Bush et al., 1998). Currently, there is no consensus on the definition of moderate drinking (Dufour, 2000). For the purposes of the present paper, nonhabitual drinkers were classified as those people who scored 1 or less on the AUDIT-C. This score corresponds to the consumption of 2 or fewer standard drinks over the course of the entire past month (e.g., a toast at a celebration). Moderate, habitual drinkers were classified as those individuals who scored between 2–5 on the AUDIT-C (e.g., someone who may have 1 standard drink 5 days a week). Height and weight were also measured to calculate body mass index (BMI).

Interbeat intervals (IBI) were measured for 5 min using the Polar RS800CX heart rate monitoring system (Polar Electro Oy, Kempele, Finland) at 1000 Hz, which wirelessly receives HR data from a chest strap (two-lead) worn by participants. Although there has been some debate as to the utility of the Polar monitoring system (Quintana, Heathers, & Kemp, 2012; Wallén, Hasson, Theorell, Canlon, & Osika, 2011), the reliability and validity of Polar monitors to measure R-R intervals has been confirmed against electrocardiogram (ECG; Weippert et al., 2010). Raw data were extracted as a text file and imported into Kubios (v. 2.0, 2008, Biosignal Analysis and Medical Imaging Group, University of Kuopio, Finland, MATLAB). Samples were filtered with the low automatic filter, and visually inspected for artifacts. Kubios was then used to calculate normalized HF HRV values. HF HRV represents a rhythmic fluctuation of heart rate in the respiratory frequency band reflecting parasympathetic control (Berntson et al., 1997).

Procedure

All participants were tested in the morning (0900–1200 h) to avoid potential confounding effects of the circadian rhythm. Participants completed a questionnaire that measured demographic information, along with the IPAQ, DASS, and the SIAS. Height and weight were also measured to calculate BMI. Following these tasks, participants' IBIs were recorded for 5 min while they were in a relaxed seated position after a preceding resting period of 5 min. Respiration rate does not markedly influence HRV during resting state recordings (Denver, Reed, & Porges, 2007); therefore, participants were breathing spontaneously for the duration of the recording.

Data Analysis

Polar IBI data were extracted as a text file and imported into Kubios. Samples were filtered with the low automatic filter and visually examined for artifacts by one of the investigators (DSQ). Following this, Kubios was used to calculate HF HRV (0.15–0.4 Hz; normalized units) using the fast Fourier transform. Given that the total power of the spectral signal is heterogeneous from person to person, HF data were presented as normalized values consistent with previously published recommendations (Pagani et al., 1986). Participants were divided into two groups based on their AUDIT-C scores: nonhabitual drinkers: 0–1 (14 females, 8 males); habitual, moderate drinkers: 2–5 (14 females, 11 males). *T* tests were conducted to determine if nonhabitual drinkers differed from moderate, habitual drinkers on characteristics known to influence HRV, including BMI, age, and physical activity. As nonhabitual drinkers tend to be more socially withdrawn than those who drink moderate amounts of alcohol (Cook, Young, Taylor, & Bedford, 1998), and given our recent findings indicating that HRV reductions may be particularly sensitive to anxiety (Kemp et al., 2012), we also examined whether groups differed on a measure of SIAS. Although participants did not have a history of psychiatric illness, depression, anxiety, and stress lie on a continuum of severity, so we further examined whether groups differed on these measures. Correlations between SIAS scores, depression, anxiety, stress, and HRV (and alcohol consumption) were examined. We also conducted a chi-squared test to determine if the sex distribution differed across groups. To answer our primary research question on the impact of moderate alcohol consumption and moderation by sex, a two-way (drinking group and sex) between-group analysis of variance (ANOVA) on HF HRV was conducted. According to the Kolmogorov-Smirnov statistic, HF HRV was normally distributed indicating that analyses conformed to parametric assumptions.

Results

Participant Characteristics

T tests revealed no significant differences between the nonhabitual and moderate habitual drinking groups on age, BMI, social interaction anxiety, depression, or anxiety (see Table 1). While the difference in stress between groups was on the threshold of a statistically significant effect ($p = .05$), HF HRV did not correlate with depression ($p = .43$), anxiety ($p = .38$), stress ($p = .29$), or social interaction anxiety ($p = .67$; as measured by the SIAS). Importantly, alcohol consumption did not correlate with depression

Table 1. *Participant Characteristics*

	Nonhabitual drinkers ($n = 22$)	Habitual drinkers ($n = 25$)	
Variable	Mean (*SD*)	Mean (*SD*)	*p* value
Age (years)	20.68 (5.36)	20.36 (5.46)	0.84
BMI	22.22 (4.7)	22.38 (2.99)	0.89
Physical activity	(3539.91)	(1931.88)	0.51
SIAS	18.05 (10.96)	18.96 9.46)	0.76
Depression	2 (2.25)	1.89 (1.9)	0.84
Anxiety	1.68 (2.17)	1.92 (2.72)	0.74
Stress	3.55 (3.14)	5.44 (3.18)	0.05

Note. Physical activity = International Physical Activity Questionnaire – Metabolic Equivalent Task; BMI = body mass index; SIAS = Social Interaction and Anxiety Scale. Depression, anxiety, and stress scores were derived from the DASS.

($p = .64$), anxiety ($p = .97$), stress scales ($p = .14$), or social interaction anxiety ($p = .87$). A chi-squared test also revealed no difference in the sex distribution across drinking groups, $\chi^2(1) = .28$, $p = .6$.

Impact of Moderate Alcohol Consumption on HRV

The two-way, between-group ANOVA revealed a statistically significant main effect for alcohol intake, $F(1,43) = 4.68$, $p = .04$, indicating that the moderate alcohol intake group had higher HF HRV than abstainers (Figure 1). There was also a statistically significant main effect for sex, $F(1,43) = 7.62$, $p = .01$, indicating that females had higher HF HRV than males. However, there was no significant interaction between sex and alcohol intake, $F(1,43) = 2.38$, $p = .13$. Planned follow-up analyses to examine each sex individually revealed that, while male moderate drinkers had higher HF HRV than abstainers, $F(1,17) = 9.27$, $p = .01$, there was no difference between female drinking groups, $F(1,26) = .194$, $p = .66$.

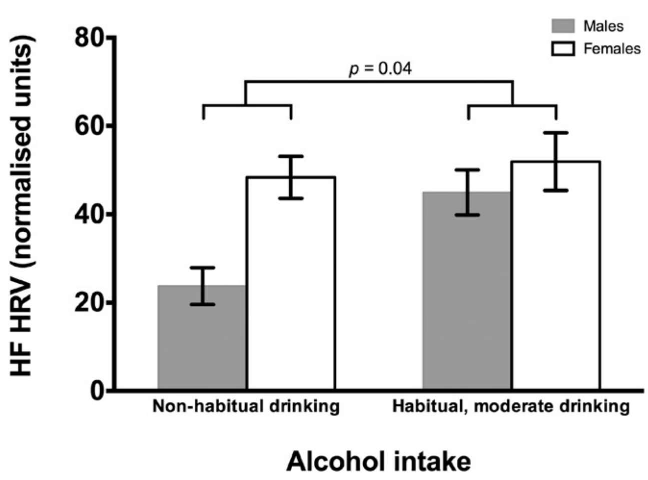

Figure 1. Impact of alcohol intake on HF HRV in male and female participants. Error bars represent the standard error.

Discussion

As hypothesized, this study demonstrates that habitual, moderate drinkers of alcohol display increased levels of HF HRV relative to nonhabitual drinkers. Importantly, alcohol consumption groups did not differ on a number of factors known to influence HRV, including physical activity levels, sex distribution, and BMI. Furthermore, groups did not differ on depression, anxiety, stress, or social interaction anxiety, indicating that the key finding of increased HRV in moderate drinkers is unlikely to be driven by negative mood or anxiety in abstainers. Planned analyses revealed that findings were specific to males in our sample, although this observation was not supported by a significant alcohol grouping by sex interaction. While prior research has demonstrated that older females who drink moderate amounts of alcohol display increased HRV relative to abstainers (Masters et al., 2004), we did not observe this phenomenon in young adult females, possibly due to increased HRV in younger than in older adults (Agelink et al., 2001). While estrogen may have a protective effect on the cardiovascular system (Epstein, Mendelsohn, & Karas, 1999), estrogen levels reduce to similar levels as men of the same age after menopause (Yen & Jaffe, 1991). Interestingly, postmenopausal estrogen therapy has been found to reduce cardiovascular disease mortality (Stampfer et al., 1991). Thus, moderate alcohol intake in younger adult populations may only confer a protective effect on males due to their lower HRV (supported here by a main effect of sex).

Increased HRV has a number of implications for health and well-being (Kemp & Quintana, 2013). Increased HRV is associated with several indices of psychological well-being such as cheerfulness and calmness (Geisler, Vennewald, Kubiak, & Weber, 2010), motivation for social engagement (Kemp et al., 2012; Porges, 2011), and psychological flexibility (Kashdan & Rottenberg, 2010); and although more research is required in this area, HRV also appears to be essential for long-term health, resilience, and well-being (Kashdan & Rottenberg, 2010; Kemp & Quintana, 2013). These observations are also congruous with research findings on the association between positive psychological well-being and cardiovascular health; traits such as mindfulness, optimism, and gratitude reduce the risk of cardiovascular disease (Boehm & Kubzansky, 2012; DuBois et al., 2012), possibly via increases in HRV. Importantly, HRV may actually be a more sensitive indicator of differences between groups, which may explain our finding of no differences on mood or anxiety between those who abstain versus those who consume moderate amounts of alcohol. We note, however, that we did not collect any measures of positive well-being in our study. Prior research has indicated that moderate consumers of alcohol show increases in measures of positive well-being such as stress reduction and improved mental health in comparison to abstainers (Peele & Brodsky, 2000; Skogen et al., 2009). To the best of our knowledge, this is the first study to demonstrate that healthy, relatively young adult males who drink alcohol in moderation display increased HRV.

Although past research indicates that moderate alcohol intake increases HRV in an older cohort (Masters et al., 2004), a biological mechanism for this phenomenon and the implications for improved health and well-being have not been offered. Ethanol has no direct impact on the sinoatrial node, the heart's pacemaker (James & Bear, 1967); however, it does impact on central structures including prefrontal cortex, amygdala, and brainstem (Kong, Zheng, Lian, & Zhang, 2012; Kunos, Varga, & Zakhari, 1992; Sripada, Angstadt, McNamara, King, & Phan, 2011), key structures involved in cognitive, affective, and autonomic regulation (Thayer, Hansen, Saus-Rose, & Johnsen, 2009). Therefore, rather than alcohol having a direct impact on the cardiovascular system, changes in HRV may occur as a downstream consequence of the effects of moderate alcohol intake on central structures. Evidence also indicates that moderate beer, red wine, and white wine consumption all reduce inflammation, indexed by C-reactive protein (Sacanella et al., 2007; Sierksma et al., 2002). Thus, HRV may be further increased through reductions in inflammatory processes. While over the short term increases in HRV will have beneficial effects on psychological well-being, over the longer term, these increases will contribute to improvements in physical health including longevity (Kemp & Quintana, 2013). Considering the steady reductions of HRV with aging, especially between the 2nd and 5th decades of life, the preservation of autonomic cardiac control may play an important role in longevity. Indeed, prior research has indicated that preservation of parasympathetic function as indicated by HRV is key to longevity (Zulfiqar, Jurivich, Gao, & Singer, 2010).

While a limitation of the current study is that we did not obtain specific information on the type of alcoholic beverage consumed by our participants, it is not clear that any particular type of beverage offers greater cardioprotective effects than others. In France, the low rate of CHD compared to other developed nations has been attributed to high wine intake (Criqui & Ringel, 1994). Reviews have also concluded that wine drinking is associated with a decreased risk of death due to cardiovascular diseases compared to nonwine drinkers (Grønbæk, 2002). However a meta-analysis of nine studies, which included 294,452 participants, concluded that wine was no more beneficial than beer or spirits (Cleophas, 1999). Thus, the type of drink consumed may not be a factor for reduced risk of heart disease (Klatsky, 2010). Additional limitations of the current study include a relatively small sample size (in relation to large epidemiological cohorts), and no clinical evaluation for alcohol use disorders or cardiovascular disease. However, our sample size ($N = 47$) is similar to that of a related study in an older cohort ($N = 52$; Masters et al., 2004); none of the participants' AUDIT-C scores were high enough to indicate heavy drinking (Aalto et al., 2009), and focusing on a young cohort largely avoids any chance that cardiovascular disease would have been found (Yusuf et al., 2001).

Our findings suggest that autonomic cardiac regulation may underpin previously reported epidemiological findings of decreased risk of CHD in younger adults who consume moderate amounts of alcohol (Hvidtfeldt et al., 2010). By contrast, it should be noted that the cardioprotective benefits of moderate alcohol may be offset by an increased risk of cancer (Corrao et al., 2004), particularly for women (Allen et al., 2009). To this end, Winstanley and colleagues (2011) recommended abstaining from drinking alcohol altogether to reduce the risk of cancer. The American Heart Association Science Advisory Committee has also recommended against using moderate alcohol intake as a cardioprotective strategy (Pearson, 1996). This advice is particularly relevant to young adults given frequent reports on alcohol abuse in these populations (Teesson et al., 2010; White, Kraus, & Swartzwelder, 2006). The risks of developing alcohol use disorders likely outweigh any potential cardioprotective benefits conferred by moderate alcohol consumption given the difficulty in forecasting who may develop problems with alcohol use (Goldberg, Mosca, Piano, & Fisher, 2001).

In summary, the present study indicates that habitual moderate consumption of alcohol is related to increased HRV in comparison to abstinence, highlighting HRV as a candidate mechanism for the J-shaped hypothesis discussed in the epidemiological literature (Corrao et al., 2004; Lipton, 1994). Our findings further understanding on the impact of moderate alcohol intake on autonomic cardiac control and highlight the potential benefits to health and well-being associated with the responsible drinking of alcohol.

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