

# Association between Alcohol Consumption and Hypertension

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## ABSTRACT

**Background:** Heavy alcohol consumption increases the risk of hypertension, but the effect of light to moderate alcohol consumption on the risk of hypertension remains controversial. In this cross-sectional study we aimed to identify the association between alcohol consumption and hypertension, and verify whether this association is influenced by age. **Methods:** Study participants were 498 men and 610 women, aged 23 to 88 years, who underwent periodic health examinations at one institute in Incheon, Korea. **Results:** Compared with nondrinkers, multivariate-adjusted odds ratio (OR) (95% confidence interval, CI) for hypertension according to the number of standard drinks consumed weekly was as follows: 1 to 3 drinks, OR = 1.13 (95% CI, 0.56–2.29); 4 to 10 drinks, OR = 0.51 (95% CI, 0.27–0.97); 11 to 18 drinks, OR = 1.11 (95% CI, 0.55–2.20);  $\geq 19$  drinks per week, OR = 1.97 (95% CI, 1.18–3.29). A positive association between the prevalence of hypertension and alcohol consumption of  $\geq 19$  drinks per week was found for patients aged  $\geq 60$  years (OR = 2.47; 95% CI, 1.21–5.05), but not in patients aged  $< 60$  years (OR = 1.54; 95% CI, 0.72–3.32). Light to moderate alcohol consumption from 4 to 10 drinks per week was significantly associated with a decreased risk of hypertension in subjects aged  $< 60$  years (OR = 0.32; 95% CI, 0.11–0.97), but not in subjects aged  $\geq 60$  years (OR = 0.70; 95% CI, 0.31–1.58). **Conclusions:** Light to moderate alcohol consumption can decrease the risk of hypertension, whereas heavy alcohol intake is associated with an increased risk of hypertension. The association between alcohol consumption and hypertension may be changed by age. (J Korean Soc Hypertens 2011;17(2):65-73)

**Key Words:** Alcohol drinking; Hypertension; Age factors; Coronary disease

## Introduction

Numerous studies have established a close relationship between alcohol consumption and hypertension.<sup>1,2)</sup> Heavy alcohol consumption has been demonstrated to be associated with an increased risk of hypertension.<sup>1,3-7)</sup> A meta-analysis of randomized controlled trials reported that a reduction in alcohol intake among heavy drinkers significantly re-

duces systolic and diastolic blood pressure.<sup>8)</sup> However, the association between light to moderate alcohol consumption and hypertension is unclear. Some studies have shown that light to moderate alcohol intake can decrease the risk of hypertension.<sup>2,9)</sup> Others have indicated that the effect of light to moderate alcohol intake on the risk of hypertension may be harmful or insignificant.<sup>3,4,7,10,11)</sup>

It has been suggested that there are differences in pathophysiology and pattern of hypertension between young and elderly hypertensive patients.<sup>12-15)</sup> Therefore, it is needed to verify whether the relationship between alcohol consumption and hypertension is affected by age. A few

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studies have shown that the association between alcohol intake and hypertension may be different between age groups.<sup>11,16,17)</sup> Other studies, however, have indicated that heavy drinking is positively associated with hypertension irrespective of age.<sup>6)</sup>

The aim of this study is to identify the relationship between alcohol consumption and blood pressure, and to determine whether this relationship is changed by age.

## Subjects and methods

### 1. Study population

Study participants were Korean adults who underwent their periodic health check-up at one institute in Incheon, Korea between April 2010 and December 2010. Among 1,712 participants, subjects who reported a history of hypertension or antihypertensive treatment were excluded. The patients diagnosed with heart disease including coronary heart disease were also excluded. They were excluded to rule out the possible influence of a diagnosis of hypertension and heart disease on the pattern of alcohol consumption. A total of 1,108 subjects remained eligible for analysis. The study group consisted of 498 men and 610 women aged between 23 and 88 years (median 58 years).

### 2. Methods

Alcohol consumption was ascertained by means of self-administered questionnaires. Subjects were asked how often they usually drank alcohol on a weekly basis and how many standard drinks they usually consumed on a daily basis. A standard drink was considered any drink that contains about 10 g of pure alcohol. Patients were categorized according to the number of standard drinks consumed weekly: none, 1 to 3 per week, 4 to 10 per week, 11 to 18 per week, and 19 or more per week. A few studies

have shown that the effect of alcohol consumption on the risk of hypertension starts with consumption of more than threshold amount.<sup>2,7)</sup> A prospective study of young women reported that light drinkers who consumed more than 0.25 drink per day showed a decrease in the risk of hypertension.<sup>2)</sup> In this study, therefore, the consumption in the 1 to 3 drinks per week category was included to see whether there is a threshold level for the association between alcohol consumption and the risk of hypertension. In addition, drinking frequency was categorized as none, 1 to 2 days per week, and 3 or more days per week. Drinking quantity was categorized as none, 1 to 6 drinks per day, and 7 or more drinks per day.

Self-administered questionnaires were also used to examine the status of cigarette smoking and physical activity. Individuals were categorized as nonsmoker, ex-smoker, and current smoker. Weekly frequency of moderate- or vigorous-intensity physical activity was asked. Regular exercise was defined as getting at least 20 minutes of vigorous-intensity physical activity or at least 30 minutes of moderate-intensity physical activity three or more days per week.

Blood pressure was measured after the subject had been seated for 5 minutes. Trained nurses measured sitting blood pressure by use of a standard mercury sphygmomanometer. Systolic and diastolic blood pressures were defined as the first and fifth-phase Korotkoff sounds. Subjects were categorized as having hypertension if they had systolic blood pressure  $\geq 140$  mm Hg or diastolic blood pressure  $\geq 90$  mm Hg.

Body weight with light clothing and height without shoes were measured. Body mass index (BMI) was calculated as the weight in kilograms divided by the square of height in meters.

Laboratory tests included fasting blood sugar (FBS), high density lipoprotein-cholesterol (HDL-C), and low density lipoprotein-cholesterol (LDL-C). Blood specimens were

sampled after an overnight fasting. Laboratory analysis was performed with an automated chemistry analyzer (Imola, Randox).

### 3. Statistical analysis

Clinical characteristics were compared between the subjects with and without hypertension using Student's *t*-test or Pearson's chi-square test. The association between alcohol consumption and the risk of hypertension was analyzed by logistic regression analysis. For all analyses, nondrinkers were considered the referent category. Multivariate-adjusted odds ratio (OR) and 95% confidence interval (CI) for hypertension was calculated. This study examined age and sex-adjusted models, then adjusted for BMI, FBS, HDL-C, LDL-C, smoking status, and physical activity.

Age-specific logistic regression analysis was used to determine whether there is a difference in the effect of alcohol consumption on the risk of hypertension between young and old subjects. Old subjects were defined as those aged 60 or over. All analyses were performed with SPSS statistical software. A *p*-values <0.05 were considered statistically significant.

### Results

Of the 1,108 subjects, 236 cases (21.3%) of hypertension were identified (148, aged  $\geq 60$  years; 88, aged < 60 years). Mean ( $\pm$  standard deviation) blood pressure was 120.4 ( $\pm 9.6$ )/74.4 ( $\pm 5.9$ ) mm Hg in normotensive subjects and 142.7 ( $\pm 10.4$ )/90.7 ( $\pm 48.1$ ) mm Hg in hypertensive subjects. The number of hypertensive subjects in categories accord-

**Table 1.** Comparison of clinical characteristics between the subjects with and without hypertension

Variables	Hypertension (n = 236)	Normotension (n = 872)	p-value
Men/women	128/108 (54.2/45.8)	370/502 (42.4/57.6)	0.001*
Age (yr)	62.6 $\pm$ 11.2	56.2 $\pm$ 11.6	<0.001 <sup>†</sup>
FBS (mg/dL)	105.3 $\pm$ 27.2	99.8 $\pm$ 24.4	0.003 <sup>†</sup>
HDL-C (mg/dL)	48.5 $\pm$ 12.2	51.4 $\pm$ 12.8	0.002 <sup>†</sup>
LDL-C (mg/dL)	118.7 $\pm$ 31.3	116.4 $\pm$ 32.2	0.326 <sup>†</sup>
BMI (kg/m <sup>2</sup> )	24.3 $\pm$ 3.1	23.6 $\pm$ 3.0	<0.001 <sup>†</sup>
Alcohol intake (drink/wk)			0.007*
0	161 (68.2)	602 (69.0)	
1–3	12 (5.1)	47 (5.4)	
4–10	13 (5.5)	95 (10.9)	
11–18	13 (5.5)	51 (5.8)	
$\geq 19$	37 (15.7)	77 (8.8)	
Drinking frequency (day/wk)			0.038*
0	161 (68.2)	602 (69.0)	
1–2	33 (14.0)	163 (18.7)	
$\geq 3$	42 (17.8)	107 (12.3)	
Drinking quantity (drink/day)			0.944*
0	161 (68.2)	602 (69.0)	
1–6	38 (16.1)	141 (16.2)	
$\geq 7$	37 (15.7)	129 (14.8)	
Smoking			0.056*
Nonsmoker	143 (60.6)	593 (68.0)	
Ex-smoker	45 (19.1)	118 (13.5)	
Current smoker	48 (20.3)	161 (18.5)	
Regular exerciser	46 (19.5)	172 (19.7)	0.936*

Values were presented by mean  $\pm$  standard deviation or number (%).

FBS, fasting blood sugar; HDL-C, high density lipoprotein-cholesterol; LDL-C, low density lipoprotein cholesterol; BMI, body mass index. p-values were obtained by \*Pearson's chi-square test or <sup>†</sup>Student t test.

**Table 2.** Association between alcohol consumption and risk of hypertension by logistic regression analysis

Alcohol intake (drink/wk)	Unadjusted		Model 1*		Model 2 <sup>††</sup>	
	OR (95% CI)	p-value <sup>‡</sup>	OR (95% CI)	p-value <sup>‡</sup>	OR (95% CI)	p-value <sup>‡</sup>
0 <sup>§</sup> (n=763)	1,00		1,00		1,00	
1–3 (n=59)	0,96 (0,50–1,84)	0,890	1,06 (0,54–2,11)	0,865	1,13 (0,56–2,29)	0,726
4–10 (n=108)	0,51 (0,28–0,94)	0,030	0,49 (0,26–0,93)	0,028	0,51 (0,27–0,97)	0,040
11–18 (n=64)	0,95 (0,51–1,80)	0,882	0,98 (0,50–1,90)	0,943	1,11 (0,55–2,20)	0,777
≥19 (n=114)	1,80 (1,17–2,76)	0,007	1,79 (1,11–2,90)	0,018	1,97 (1,18–3,29)	0,010

OR, odds ratio; CI, confidence interval.

\*Adjusted for age and sex.

<sup>†</sup>Adjusted for age, sex, BMI, FBS, HDL-C, LDL-C, smoking status, and physical activity.

<sup>‡</sup>P values were obtained by logistic regression analysis.

<sup>§</sup>Reference category.

ing to blood pressure was as follows: a systolic of 140-159 and/or a diastolic of 90–99 mm Hg, n = 206; a systolic of 160–179 and/or a diastolic of 100–109 mm Hg, n = 29; a systolic greater than or equal to 180 and/or a diastolic greater than or equal to 110 mm Hg, n = 1. The characteristics according to blood pressure are presented in Table 1. Men and old patients were more likely to be hypertensive. HDL-C was lower and FBS was higher among hypertensive subjects than normotensive subjects. Hypertensive patients showed higher BMI. The proportion of individuals who were hypertensive varied significantly by level of drinking frequency. On the other hand, the percentage of hypertensive subjects did not appear to differ by drinking quantity in univariate analysis.

Logistic regression analysis of the relationship between alcohol consumption and hypertension is presented in Table 2. In unadjusted model, light to moderate alcohol consumption from 4 to 10 drinks per week was associated with significant reductions in the risk of hypertension (OR = 0.51; 95% CI, 0.28–0.94; p = 0.030). Alcohol consumption in the 1 to 3 drinks per week category did not have a significant effect on the risk of hypertension (OR = 0.96; 95% CI, 0.50–1.84; p = 0.890). The risk of hypertension was significantly increased when consuming ≥ 19 drinks per week (OR = 1.80; 95% CI, 1.17–2.76; p = 0.007). This pattern of association persisted after adjustment for sex, age,

BMI, FBS, HDL-C, LDL-C, smoking status, and physical activity. Compared with nondrinkers, OR of hypertension was lowest among subjects drinking 4 to 10 drinks per week (OR = 0.51; 95% CI, 0.27–0.97; p = 0.040) and highest among subjects drinking 19 or more drinks per week (OR = 1.97; 95% CI, 1.18–3.29; p = 0.010). To evaluate interaction between covariates described previously, interaction terms between these covariates were included in this model, but none reached statistical significance except that between FBS and LDL-C (p-value for interaction = 0.03). Addition of this interaction term to the multivariate model did not change the results substantially (data not shown). Additionally, the association between alcohol consumption and blood pressure when the exposure to alcohol was stratified according to drinking frequency and quantity was analyzed by means of multivariate logistic regression analysis. Compared with nondrinkers, OR (95% CI) of hypertension was as follows: 1 to 2 days per week and 1 to 6 drinks per day, 0.87 (0.50–1.50); 1 to 2 days per week and 7 or more drinks per day, 0.81 (0.41–1.59); 3 or more days per week and 1 to 6 drinks per day, 1.39 (0.73–2.64); 3 or more days per week and 7 or more drinks per day, 1.56 (0.87–2.78). Interestingly, alcohol consumption of 1 to 2 days per week did not appear to increase the risk of hypertension even when the subjects drank 7 or more drinks per day. This finding can strengthen the interpretation that

**Table 3.** Association between alcohol consumption and risk of hypertension by age-specific logistic regression analysis

Alcohol intake (drink/wk)	Unadjusted		Model 1*		Model 2**	
	OR (95% CI)	p-value†	OR (95% CI)	p-value†	OR (95% CI)	p-value†
Age ≥60 yr						
0 <sup>§</sup> (n=357)	1.00		1.00		1.00	
1–3 (n=17)	1.70 (0.63–4.59)	0.293	1.68 (0.62–4.56)	0.313	1.77 (0.63–4.95)	0.280
4–10 (n=40)	0.71 (0.33–1.54)	0.380	0.69 (0.31–1.54)	0.362	0.70 (0.31–1.58)	0.387
11–18 (n=29)	0.77 (0.32–1.87)	0.569	0.76 (0.31–1.86)	0.544	0.82 (0.32–2.09)	0.679
≥19 (n=45)	2.13 (1.14–3.99)	0.018	2.07 (1.06–4.05)	0.034	2.47 (1.21–5.05)	0.013
Age <60 yr						
0 <sup>§</sup> (n=406)	1.00		1.00		1.00	
1–3 (n=42)	0.83 (0.31–2.19)	0.703	0.77 (0.29–2.05)	0.600	0.88 (0.33–2.39)	0.807
4–10 (n=68)	0.38 (0.13–1.09)	0.072	0.30 (0.10–0.89)	0.029	0.32 (0.11–0.97)	0.043
11–18 (n=35)	1.27 (0.50–3.19)	0.615	1.00 (0.38–2.60)	1.000	1.20 (0.44–3.26)	0.728
≥19 (n=69)	1.85 (0.99–3.45)	0.054	1.40 (0.70–2.78)	0.340	1.54 (0.72–3.32)	0.268

OR, odds ratio; CI, confidence interval.

\*Adjusted for sex.

†Adjusted for sex, BMI, FBS, HDL-C, LDL-C, smoking status, and physical activity.

‡p-values were obtained by logistic regression analysis.

§Reference category.

frequent drinking is a stronger risk factor for hypertension than binge drinking.

Age-specific logistic regression analysis is presented in Table 3. By age-specific analysis, the effect of alcohol consumption in the range of 4 to 10 drinks per week on hypertension became more protective in young patients (OR = 0.32; 95% CI, 0.11–0.97;  $p = 0.043$  in the model including all the confounders). On the other hand, consumption of  $\geq 19$  drinks per week was not significantly associated with an increased risk of hypertension in young patients (OR = 1.54; 95% CI, 0.72–3.32;  $p = 0.268$  in the model including all the confounders). In old patients, high alcohol intake ( $\geq 19$  drinks per week) was more strongly associated with an increased risk of hypertension by age-specific analysis (OR = 2.47; 95% CI, 1.21–5.05;  $p = 0.013$  in the model including all the confounders), with no evidence of significant benefit in the light to moderate drinking from 4 to 10 drinks per week (OR = 0.70; 95% CI, 0.31–1.58;  $p = 0.387$  in the model including all the confounders).

## Discussion

This cross-sectional study confirmed that heavy alcohol

intake increases hypertension risk, whereas light to moderate alcohol intake can decrease hypertension risk. In accordance with previous studies,<sup>2,7)</sup> there was a threshold level for this association. Light to moderate alcohol consumption had a protective effect on the prevalence of hypertension when consuming  $\geq 4$  drinks per week in this study. Heavy alcohol intake was significantly associated with an increased risk of hypertension for subjects who consumed  $\geq 19$  drinks per week. However, several studies have reported different thresholds.<sup>18)</sup> In old subjects, alcohol consumption from 1 to 3 drinks per week seemed to increase the risk of hypertension though not statistically significant. It is difficult to conclude that light alcohol intake can increase the risk of hypertension in old subjects from this result. The cause of this result is uncertain, but it may have been due to the small number of participants in this category. Activation of the sympathetic nervous system and alteration of vascular tone have been hypothesized as the probable mechanisms explaining the relationship between heavy alcohol intake and an increased risk of hypertension.<sup>1,19,20)</sup> Some studies have suggested that alcohol has a direct effect on blood pressure, but others have

indicated that repeated withdrawal from alcohol is at least as likely an explanation for elevated blood pressure.<sup>9,18)</sup> It has been proposed that the effect of heavy alcohol intake on blood pressure may be mediated by the actions of hormones such as norepinephrine and cortisol.<sup>1,18,21)</sup> The mechanism by which light to moderate alcohol consumption decreases the risk of hypertension is uncertain. A few studies have suggested that depressor effects of alcohol on blood pressure may predominate over withdrawal effects at low levels of intake, especially if the frequency of intake is low.<sup>9,22)</sup> In addition, it has been suggested that light to moderate alcohol consumption may reduce anxiety that is considered to be associated with hypertension.<sup>9,23)</sup> This study founded that the association between alcohol consumption and the risk of hypertension differed in young and old patients. Although the mechanism underlying this difference remains largely unknown, the pathophysiologic changes of aging such as increased peripheral vascular resistance, decreases in plasma renin activity, and reduced beta-adrenergic function<sup>14,15)</sup> may be the key to clarifying the mechanism. It has been suggested that the difference in the pattern of alcohol use and hormonal status may be one of the likely mechanisms.<sup>16)</sup>

Light to moderate drinking has been shown to be associated with a reduced risk of ischemic stroke, coronary heart disease, and mortality.<sup>24-29)</sup> It has been suggested that the beneficial influences of alcohol intake on lipids and haemostatic factors may explain this association.<sup>30-33)</sup> Some authors have indicated that red wine may enhance endothelial nitric oxide synthase function and antagonize the development of endothelial dysfunction and atherosclerosis.<sup>34,35)</sup> A few studies have speculated that the protective effect of light to moderate alcohol consumption on the risk of hypertension may reflect an additional pathway by which light to moderate alcohol intake reduces the risk of coronary heart disease and death.<sup>9)</sup> However, there is counter evidence to this hypothesis. Some studies have shown that

older people at high risk of coronary heart disease and ischemic stroke are more likely to have survival benefit from light to moderate alcohol consumption.<sup>36-38)</sup> But, the present study has shown that the protective effect of light to moderate alcohol intake on hypertension appears confined to the patients aged < 60 years. A few studies have suggested that light drinking significantly increased blood pressure only in the older groups.<sup>11,17)</sup> In addition, it has been suggested that the protection against coronary heart disease afforded by moderate alcohol consumption may be mediated by an increase in HDL-C and a decrease in LDL-C, but counterbalanced by an increase in risk due to increased systolic blood pressure.<sup>31)</sup> It is speculated that the mechanisms underlying the association between light to moderate alcohol consumption and hypertension may differ from those for coronary heart disease and ischemic stroke. Although this study has indicated that light to moderate alcohol consumption can decrease the risk of hypertension in young patients as previous studies have reported,<sup>9)</sup> some studies have shown that light to moderate alcohol consumption may have unassociated or deleterious effects on the risk of coronary heart disease, ischemic stroke, and mortality in young patients.<sup>36-38)</sup> Therefore, a comprehensive analysis of the risk of hypertension and other diseases such as coronary heart disease and ischemic stroke is needed to assess the effect of light to moderate alcohol consumption.

Heavy alcohol intake has been shown to be associated with an increased risk of hypertension, coronary heart disease, stroke, and death.<sup>2,4,39,40)</sup> In the current study, however, heavy alcohol intake appeared to be unassociated with an increased risk of hypertension in young patients. A few studies have reported that the elevating effect of alcohol drinking on blood pressure was more prominent in the elderly than in the young,<sup>11,16)</sup> in accordance with the result of the current study. Although the mechanism underlying this result needs to be clarified, alcohol intake seems to be more harmful to old patients than young patients in

terms of increasing the risk of hypertension.

This study lacked details on beverage-specific intake and drinking patterns. This limitation of the present study deserves mention since some studies have reported the relationship between pattern of alcohol use and hypertension risk.<sup>41)</sup> However, several studies have shown that the effect of alcohol consumption on hypertension risk can be independent of the type of alcoholic beverage and drinking patterns.<sup>5,24)</sup> An additional limitation of the study is that data on potential factors explaining the difference in the effect of alcohol on blood pressure between young and elderly patients such as postmenopausal status and postmenopausal hormone use were unavailable. It has been speculated that estrogen use may affect the relationship between alcohol consumption and blood pressure.<sup>16)</sup> Further studies including these factors will be useful for confirming the mechanism underlying the effect of age on the relationship between alcohol intake and blood pressure. Third, analyses of the current study were restricted to the subjects from one institute. Therefore, selection bias could be introduced, and caution is warranted in generalizing these findings beyond the population of the current study. Fourth, this study cannot establish cause-effect relationship between exposure to alcohol and hypertension because of the cross-sectional nature of the study. Finally, single blood pressure measurement could introduce bias into this study. Several studies have indicated that the combination of the second and third blood pressure reading seems to be favorable over single blood pressure reading.<sup>42)</sup> On the other hand, it was suggested that one measurement of blood pressure may be reliable data in the cross-sectional study.<sup>43)</sup>

In conclusion, this study has indicated that light to moderate alcohol consumption can be associated with a decreased risk of hypertension, whereas heavy alcohol intake can increase the risk of hypertension. It is suggested that the effect of alcohol consumption on the risk of hyper-

tension may be influenced by age. There should be a consideration of age when assessing the relationship between alcohol consumption and blood pressure. However, further studies are needed to verify these results since the present study is limited to cross-sectional design.

## Summary

**연구배경:** 과다음주가 혈압을 증가시킨다는 것은 잘 알려져 있는 반면에, 소량음주가 혈압에 미치는 영향에 대해서는 아직 논란의 여지가 있다. 본 연구는 음주와 고혈압의 관계를 밝히고, 그것이 음주자의 연령에 영향을 받는지를 밝히고자 하였다.

**방법:** 인천의 한 건강검진기관에서 검사를 받은 한국인들을 대상으로 하였다. 498명의 남자, 610명의 여자가 연구대상이었으며, 나이는 23세에서 88세까지로 분포되었다.

**결과:** 다변량 로지스틱 회귀분석에서 비음주자에 비해, 주당 19잔 이상의 과다음주자는 고혈압의 유병률이 더 높았고, 주당 4잔에서 10잔의 음주자는 고혈압의 유병률이 더 낮았다. 60세 이상의 고령자에서는 비음주에 비해, 과다음주가 높은 고혈압의 유병률과 관계있는 것으로 나타났지만, 60세 미만의 연령군에서는 그렇지 않았다. 주당 4잔에서 10잔의 음주는 60세 미만의 대상자에서는 낮은 고혈압의 유병률을 보였지만, 고령군에서는 그렇지 않았다.

**결론:** 과다음주자는 비음주자에 비해 고혈압의 유병률이 높았지만, 소량음주자는 고혈압의 유병률이 더 낮았다. 음주와 혈압의 관계는 음주자의 연령에 따라 달라질 수 있었다.

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