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Association Between Alcohol Consumption and Metabolic Syndrome in a Community-Based Cohort of Korean Adults

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Background: The relationship between alcohol consumption and metabolic syndrome (MetS) remains controversial. This study investigated the relationship between alcohol consumption and MetS components and prevalence.

Material/Methods: We analyzed 10 037 subjects (3076 MetS and 6961 non-MetS) in a community-based cohort. MetS was defined according to the ATP III Guidelines. Subjects were divided according to amount of alcohol consumption; non-drinker, very light (0.1–5.0 g/day), light (5.1–15.0 g/day), moderate (15.1–30.0 g/day), and heavy drinker (>30 g/day). Multiple logistic regression models were performed to estimate odds ratios (ORs) and confidence intervals (CIs). The analyses were performed in men and women separately. SPSS statistical software was used for analyses.





Results: The prevalence of MetS in both males and females was associated with alcohol drinking status ($p < 0.0001$). Amount of alcohol consumption (0.1–5.0 g/day) was significantly associated with lower prevalence of MetS in both genders compared to non-drinkers. Amount of alcohol consumption (>30.0 g/day) did not show a significant association with prevalence of MetS. However, alcohol consumption (>30.0 g/day) showed an association with glucose and HDL cholesterol among the components of MetS.

Conclusions: Our results indicate that alcohol drinking (0.1–5.0 g/day) contributed to decrease prevalence of MetS and components, including triglyceride and HDL cholesterol.

MeSH Keywords: **Alcohol Drinking • Association • Cohort Studies • Metabolic Syndrome X**

Abbreviations: **MetS** – metabolic syndrome; **BMI** – body mass index; **HDL** – high density lipoprotein; **OR** – odds ratio; **CI** – confidence interval

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Background

In recent years, metabolic syndrome (MetS) has become a major global public health problem around the world [1]. MetS is a complex clustering of metabolic disorders with a combination of components, such as abdominal fat, high blood pressure, elevated triglyceride level, low high-density lipoprotein (HDL) cholesterol levels, and glucose intolerance [2]. Each MetS component is a known risk factor for increased blood vessel occlusion, incidence and mortality of cardiovascular disease, type 2 diabetes mellitus, and stroke [3–7].

The global prevalence of MetS is estimated at about 20–25% of adult worldwide [8]. According to the annual Korea National Health and Nutrition Examination Surveys (KNHANES), prevalence of MetS in Korea has increased markedly, from 24.9% in 1998 to 31.3% in 2007 [9].

Environmental factors such as low physical activity and unhealthy lifestyle are risk factors for MetS. Alcohol consumption, part of an unhealthy lifestyle, contributes to many health problems. A large population-based study in the United States showed that mild-to-moderate alcohol consumption contributed to increased lipids concentrations, waist circumference, and fasting insulin levels compared to non-drinkers [10]. Increased alcohol consumption has also been reported to contribute to development of hypertension [11]. Furthermore, alcohol consumption was associated with insulin resistance, which is the key pathophysiology of MetS [12].

In the present study, we evaluated the relationship between alcohol consumption and prevalence of MetS in males and females and the effect on each component of MetS from a community-based cohort study (Ansan and Ansung City, Republic of Korea).

Material and Methods

Subjects

This study analyzed data from the Korean Genome and Epidemiology Study (KoGES), a community-based cohort conducted in 2001–2002 consisting of 10 037 adults. KoGES is the principal cohort study to provide valuable evidence for prevention of chronic diseases such as hypertension, cardiovascular diseases, MetS, chronic obstructive pulmonary disease, osteoporosis, arthritis, and diabetes among Korean adults. Information on KoGES and the methods used were described in a previous study [13]. General information (age and sex); medical information (body mass index [BMI, kg/m²], systolic and diastolic blood pressures [mmHg], and levels of fasting glucose [mg/dL], total cholesterol [mg/dL], triglyceride [mg/dL],

and HDL cholesterol [mg/dL]); family history of disease (hypertension and diabetes mellitus); history of alcohol consumption (never, past, or current); and amount of alcohol consumption (non-, very light, light, moderate, or heavy drinker) were extracted for analysis. BMI was calculated using weight divided by height squared. The Ethics Committee of Shinhan University approved this study.

Assessment of drinking

We extracted data regarding individual alcohol consumption from the community-based cohort database. Individuals were classified according to alcohol consumption as non-drinkers, very light drinkers (0.1–5.0 g/day), light drinkers (5.1–15.0 g/day), moderate drinkers (15.1–30.0 g/day), or heavy drinkers (>30 g/day). To calculate individual alcohol consumption, total alcohol consumption per day (g/day) was used according to survey questions. There were various alcohol types (4.5% for beer, 13% for wine, 40% for hard liquor, 22% for soju, 15% for chungju, and 6% for makgeolli). Total alcohol consumption was calculated on the basis of the alcohol type, frequency of drinking, and the amount consumed [14].

MetS criteria

MetS was defined according to the ATP III Guidelines of the National Cholesterol Education Program: abdominal obesity (waist circumference: men >90 cm, women >80 cm), high blood pressure (\geq 130/85 mmHg), high fasting glucose level (\geq 110 mg/dL), hypertriglyceridemia (\geq 150 mg/dL), and low HDL cholesterol level (men <40 mg/dL, women <50 mg/dL). MetS was diagnosed for subjects with at least 3 of these 5 factors [15].

Statistical analysis

Statistical analysis was performed using a statistical software program (SPSS, Chicago, IL). The *t* test was used to compare characteristics between the MetS and non-MetS groups. MetS prevalence differences between these groups were analyzed using the chi-square test. Multiple logistic regression analysis was used to examine the association between alcohol consumption and MetS prevalence and its components. Age, sex, hypertension, BMI, and diabetes were adjusted in the analysis. The odds ratios (ORs), 95% confidence intervals (CIs), and *P* values were calculated. *P* values <0.05 were considered statistically significant associations.

Results

As shown Table 1, data were analyzed from a total of 10 037 subjects. In this study population, 6961 subjects were non-MetS (3683 men and 3278 women) and 3076 were MetS (1079

Table 1. Basic characteristics of the non-metabolic syndrome (MetS) group and the MetS group.

	Non-MetS	MetS	P value	Non-MetS	MetS	P value	Non-MetS	MetS	P value
	(n=6,961)	(n=3,076)		(n=3,683)	(n=1,079)		(n=3,278)	(n=1,997)	
	Total	Total		Male	Male		Female	Female	
Age (years)	51.1±8.8	55.1±8.7	p<0.0001	51.7±8.9	52.7±8.5	p=0.001	50.4±8.7	56.5±8.5	p<0.0001
Height (cm)	160.8±8.5	158.2±9	p<0.0001	166.6±5.9	167.8±5.7	p<0.0001	154.3±5.6	153±5.4	p<0.0001
Weight (kg)	61.5±9.6	66.6±10.5	p<0.0001	65.5±9	74.7±9	p<0.0001	57±8.1	62.3±8.5	p<0.0001
Waist circumference (cm)	79.9±8	89.2±7.2	p<0.0001	81.6±6.9	90.7±6.2	p<0.0001	77.9±8.7	88.4±7.6	p<0.0001
Body mass index (kg/m ²)	23.8±2.9	26.6±2.9	p<0.0001	23.6±2.7	26.5±2.6	p<0.0001	24±3.1	26.6±3.1	p<0.0001
Systolic blood pressure (mmHg)	116.2±17.1	132.5±18.6	p<0.0001	118.7±17	131.5±17.3	p<0.0001	113.4±16.8	133±19.2	p<0.0001
Diastolic blood pressure (mmHg)	77.2±11.3	86.6±11.5	p<0.0001	79.5±11.3	88.2±10.9	p<0.0001	74.5±10.8	85.8±11.7	p<0.0001
Fasting glucose (mg/dL)	84.4±14.7	94.3±31	p<0.0001	87±17.2	100±35.5	p<0.0001	81.5±10.7	91.2±27.7	p<0.0001
Total cholesterol (mg/dL)	188.4±35.4	197.6±36	p<0.0001	189.9±36.1	195.7±36.4	p<0.0001	186.8±34.6	198.6±35.8	p<0.0001
Triglyceride (mg/dL)	135.1±79.8	224.5±126.5	p<0.0001	152.7±96.2	262.9±147.8	p<0.0001	115.3±48.9	203.8±107.7	p<0.0001
HDL cholesterol (mg/dL)	47.2±10.2	39±7.1	p<0.0001	45.6±10	36.9±6.7	p<0.0001	49±10.2	40.2±7.1	p<0.0001
Family history of hypertension									
Yes	1256	667	p<0.0001	621	230	p=0.001	635	437	p=0.029
No	5705	2409		3062	849		2643	1560	
Family history of diabetes mellitus									
Yes	799	381	0.202	379	136	p=0.034	420	245	p=0.578
No	6162	2695		3304	943		2858	1752	
Alcohol drinking									
Never	2890	1708	p<0.0001	683	195	p=0.018	2207	1513	p<0.0001
Past	443	210		356	136		87	74	
Current	3580	1115		2627	739		953	376	
Alcohol consumption									
Non-drinker	3548	2012		1165	370		2383	1642	
Very light drinker	1219	377		553	114		666	263	
Light drinker	805	240		648	187		157	53	
Moderate drinker	671	207		626	182		45	25	
Heavy drinker	718	240		691	226		27	14	

men and 1997 women). The prevalence of MetS in the present study was 30.65% in adult subjects. Waist circumference, BMI, systolic blood pressure, diastolic blood pressure, fasting glucose, total cholesterol, and triglyceride levels in the MetS group were higher than those in the non-MetS group. HDL cholesterol levels in the MetS groups were lower than those

in the non-MetS group (Table 1). These differences were statistically significant (p<0.0001). There were also significant associations between the non-MetS and MetS groups regarding alcohol consumption status (p<0.0001).

Table 2. Odds ratios of metabolic syndrome (MetS) according to alcohol drinking status in male and female.

Variables	Adjusted OR (95% CI)	p	Variables	Adjusted OR (95% CI)	p
Male			Female		
Alcohol drinking			Alcohol drinking		
Never	1		Never	1	
Past	1.19 (0.89–1.60)	0.24	Past	1.20 (0.83–1.75)	0.34
Current	0.96 (0.78–1.17)	0.67	Current	0.75 (0.64–0.88)	p<0.0001
Amount of alcohol drinking (g/day)			Amount of alcohol drinking (g/day)		
Non-drinker	1		Non-drinker	1	
Very light drinker	0.65 (0.50–0.85)	0.001	Very light drinker	0.72 (0.60–0.86)	p<0.0001
Light drinker	0.93 (0.74–1.17)	0.52	Light drinker	0.72 (0.50–1.03)	0.07
Moderate drinker	0.90 (0.72–1.14)	0.38	Moderate drinker	0.95 (0.53–1.68)	0.85
Heavy drinker	1.07 (0.86–1.34)	0.54	Heavy drinker	0.94 (0.45–1.97)	0.87

OR – odds ratio; CI – confidence interval. The logistic regression was applied. Age, hypertension, BMI, and diabetes were adjusted in logistic regression analysis. Bold numbers indicate significant association.

Table 3. Odds ratios of metabolic syndrome (MetS) according to type of alcohol in male and female.

Alcohol type	Alcohol consumption	OR (95% CI)	p	Alcohol consumption	OR (95% CI)	p
Male			Female			
Makgeolli	Non-drinker	1		Non-drinker	1	
	Very light drinker	0.545 (0.355–0.837)	0.006	Very light drinker	0.810 (0.516–1.272)	0.361
	Light drinker	0.471 (0.211–1.055)	0.067	Light drinker	1.459 (0.364–5.841)	0.594
	Moderate drinker	0.369 (0.085–1.597)	0.182	Moderate drinker		
	Heavy drinker	2.102 (0.754–5.855)	0.155	Heavy drinker		
Beer	Non-drinker			Non-drinker		
	Very light drinker	1		Very light drinker	1	
	Light drinker	1.374 (0.989–1.910)	0.058	Light drinker	0.580 (0.254–1.323)	0.196
	Moderate drinker	1.609 (0.967–2.677)	0.067	Moderate drinker	1.187 (0.316–4.458)	0.799
	Heavy drinker	1.528 (0.777–3.004)	0.219	Heavy drinker	1.187 (0.236–5.961)	0.835
Wine	Non-drinker			Non-drinker		
	Very light drinker	1		Very light drinker	1	
	Light drinker	1.000 (0.256–3.902)	1.000	Light drinker	2.577 (0.427–15.563)	0.302
	Moderate drinker			Moderate drinker		
	Heavy drinker			Heavy drinker		
Soju	Non-drinker			Non-drinker		
	Very light drinker	1		Very light drinker	1	
	Light drinker	1.150 (0.889–1.488)	0.288	Light drinker	0.993 (0.633–1.557)	0.976
	Moderate drinker	1.434 (1.117–1.841)	0.005	Moderate drinker	2.586 (1.280–5.223)	0.008
	Heavy drinker	1.513 (1.170–1.955)	0.002	Heavy drinker	1.748 (0.668–4.577)	0.255

OR – odds ratio; CI – confidence interval. Bold numbers indicate significant association.

Table 4. Odds ratios of components of metabolic syndrome (MetS) according to alcohol drinking status in male and female.

Variables	Adjusted OR (95% CI)				
	Abdominal obesity	High blood pressure	High fasting glucose	Hypertriglyceridemia	Low HDL cholesterol
Male					
Alcohol drinking					
Never	1	1	1	1	1
Past	1.42 (0.97–2.06)	1.13 (0.89–1.44)	0.80 (0.51–1.25)	1.10 (0.87–1.40)	0.94 (0.75–1.18)
Current	1.22 (0.94–1.58)	1.47 (0.25–1.73)	1.12 (0.84–1.49)	1.48 (1.26–1.73)	0.40 (0.34–0.47)
Amount of alcohol drinking (g/day)					
Non-drinker	1	1	1	1	1
Very light drinker	0.83 (0.60–1.14)	0.86 (0.71–1.05)	0.76 (0.50–1.14)	1.00 (0.83–1.22)	0.69 (0.57–0.84)
Light drinker	0.94 (0.70–1.26)	1.34 (1.12–1.61)	1.28 (0.92–1.77)	1.32 (1.10–1.58)	0.51 (0.43–0.62)
Moderate drinker	1.18 (0.88–1.57)	1.61 (1.34–1.93)	1.09 (0.78–1.53)	1.33 (1.11–1.59)	0.39 (0.32–0.47)
Heavy drinker	1.16 (0.88–1.53)	1.63 (1.36–1.94)	1.88 (1.40–2.51)	1.71 (1.44–2.04)	0.30 (0.25–0.36)
Female					
Alcohol drinking					
Never	1	1	1	1	1
Past	1.75 (1.10–2.8)	1.13 (0.80–1.62)	1.08 (0.55–2.11)	1.19 (0.85–1.67)	0.95 (0.66–1.37)
Current	0.97 (0.82–1.15)	0.99 (0.85–1.14)	0.90 (0.66–1.24)	0.80 (0.69–0.92)	0.65 (0.56–0.74)
Amount of alcohol drinking (g/day)					
Non-drinker	1	1	1	1	1
Very light drinker	0.84 (0.69–1.02)	0.95 (0.80–1.12)	0.80 (0.55–1.16)	0.75 (0.64–0.89)	0.71 (0.60–0.82)
Light drinker	1.00 (0.69–1.44)	0.91 (0.66–1.28)	0.62 (0.27–1.44)	0.81 (0.59–1.12)	0.48 (0.36–0.64)
Moderate drinker	0.71 (0.36–1.39)	1.13 (0.66–1.92)	1.64 (0.68–3.94)	1.05 (0.63–1.77)	0.53 (0.32–0.87)
Heavy drinker	1.24 (0.54–2.86)	1.84 (0.94–3.57)	3.50 (1.41–8.71)	1.40 (0.73–2.68)	0.41 (0.22–0.77)

OR – odds ratio; CI – confidence interval. The logistic regression was applied. Age, hypertension, BMI, and diabetes were adjusted in logistic regression analysis. Bold numbers indicate significant association.

Because alcohol consumption differed according to sex, we divided the subjects into males and females in order to separately analyze the association between MetS and alcohol consumption. The prevalence of MetS according to amount of alcohol consumption (non-, very light, light, moderate, and heavy drinker) was 24.10%, 17.09%, 22.40%, 22.52%, and 24.65%, respectively, in male subjects, and 40.80%, 28.31%, 25.24%, 35.71%, and 34.15%, respectively, in female subjects. Table 2 displays the ORs and P values of MetS according to alcohol drinking status. In women, alcohol consumption showed a significant association between the MetS and non-MetS groups (OR=0.75, 95% CI=0.64–0.88, p<0.0001). However, there was no association with prevalence of MetS in men. Very light drinking in both men and women was associated with reduced prevalence of MetS (men, OR=0.65, 95% CI=0.50–0.85, p=0.001; women, OR=0.72, 95% CI=0.60–0.86, p<0.0001, Table 2).

Next, we analyzed the relationship between prevalence of MetS and type of alcohol in males and females. In males, very light drinking of makegeolli alcohol was associated with prevalence of MetS (OR=0.545, 95% CI=0.355–0.837, p=0.006). Also, moderate and heavy drinking of soju alcohol in males and moderate drinking in females showed high prevalence of MetS (p<0.05) (Table 3).

Finally, we analyzed the relationship between alcohol consumption and components of MetS (abdominal obesity, high blood pressure, high fasting glucose, hypertriglyceridemia, and low HDL cholesterol levels) (Table 4). Current alcohol drinking was associated with low HDL cholesterol levels in both men and women (men, OR=0.40, 95% CI=0.34–0.47; women, OR=0.65, 95% CI=0.56–0.74). Current alcohol drinking in men was significantly associated with increased triglyceridemia (OR=1.48, 95% CI=1.26–1.73). However, current alcohol drinking in women was associated with decreased triglyceridemia (OR=0.80,

95% CI=0.64–0.89). Light, moderate, and heavy drinking were associated with high blood pressure, hypertriglyceridemia, high fasting glucose, and low HDL cholesterol levels in men (Table 4). These results indicate that alcohol consumption >5 g/day in men may contribute to components of MetS. In women, very light, light, moderate, and heavy drinking were associated with low HDL cholesterol levels, and heavy drinkers showed increased high fasting glucose levels. However, very light drinkers had decreased triglyceridemia. These results indicate that alcohol consumption <5 g/day might contribute to prevention of MetS in women.

Discussion

Alcohol can be beneficial or harmful in the human body according to level of alcohol consumption. Alcohol is one of the risk factors influencing the development of MetS. It is suggested that alcohol may influence lipoprotein synthesis, mainly through the decrease of the HDL level and hepatic apolipoproteins class A production. Also, alcohol may induce disturbances of hepatic gluconeogenesis, preventing lactate oxidation to pyruvate in carbohydrate metabolism. These effects of alcohol drinking can lead to development of MetS [16].

Although several studies reported a relationship alcohol consumption and prevalence of MetS, the association between alcohol consumption and prevalence of MetS remains unclear and controversial [17,18]. Daily light to moderate alcohol consumption showed an association with lower prevalence of MetS in several studies [10,19,20]; but other studies only showed the association with MetS in women [21,22] or no significant association between MetS and alcohol consumption [23,24].

In the present study, we investigated the relationship between alcohol consumption and MetS and its components in a large population. The overall prevalence of MetS was 30.65% and was lower in men (22.66%) than in women (37.86%). Compared to non-drinkers, the prevalence was decreased in both sexes according to the level of alcohol consumption (light, moderate, and heavy drinkers), except for males who were heavy drinkers. The prevalence among very light drinkers (<5 g/day) was significantly lower than that of the non-drinkers in both males and females. These results indicate that alcohol consumption <5 g/day may be associated with decreased prevalence of MetS.

A cross-sectional study in a Japanese population found that alcohol consumption of more than 40.0 g per day was associated with increased MetS prevalence [17]. They also reported the lowest prevalence in both male and female light drinkers (<22 g/day) and increased prevalence among male very heavy drinkers (>43 g/day) compared to non-drinkers. Light

drinkers (<22 g/day) showed significantly decreased triglyceride levels. These results are consistent with the findings of the present study.

Although our findings are in agreement with a previous study, they are also discordant with those of other studies on the relationship between alcohol consumption and MetS. Gignoux et al. reported that moderate alcohol consumption was associated with a more favorable metabolic profile than mild alcohol consumption [25]. Alcohol consumption >40.0 g/day has also been associated with increased prevalence of MetS [17]. However, a study in an elderly Italian population observed no relationship between alcohol consumption and MetS prevalence and incidence [18].

The present study also evaluated the association between alcohol consumption and the components of MetS. Our results show that alcohol consumption is risk factor for high blood pressure, high fasting glucose levels, hypertriglyceridemia, and low HDL cholesterol levels in men. Current alcohol drinking was associated with increased triglyceride and low HDL cholesterol in men compared to never alcohol drinking, and current alcohol drinking was associated with decreased triglyceride and increased HDL cholesterol in women. The percentage of non-drinkers, very light drinkers, light drinkers, moderate drinkers, and heavy drinkers was 34.29%, 10.57%, 17.33%, 16.87%, 20.95% in men and 82.22%, 13.17%, 2.65%, 1.25%, 0.70%, in women, respectively.

In women, alcohol consumption >30 g/day was associated with increased glucose levels and decreased HDL cholesterol. However, alcohol consumption <5 g/day was associated with decreased triglyceride and increased HDL cholesterol compared to non-alcohol consumption. In men, alcohol consumption <5 g/day was also associated with increased HDL cholesterol compared to non-alcohol consumption.

A recent Mendelian randomization study reported that moderate alcohol consumption is associated with lower triglyceride levels [26]. The consumption of 20 g or less of alcohol per day can have a positive effect on triglyceride concentration [27].

Alcohol consumption has been shown to play a role in plasma lipoprotein metabolism [28]. Moderate alcohol consumption increases serum HDL cholesterol and may decrease the concentration of lipoprotein.

Conclusions

The results of this study suggest that daily consumption of alcohol is both positively and negatively associated with MetS and its components. In both men and women, alcohol consumption

0.1–5.0 g/day was associated with low prevalence of MetS and its component of MetS, including HDL cholesterol. However, alcohol consumption >5 g/day may contribute to abnormalities of MetS, including high glucose and blood pressure, hypertriglyceridemia, and low HDL cholesterol.

Our study has several limitations. First, this analysis utilized data from a cross-sectional study; therefore, the associations between MetS and alcohol consumption require validation in future large-scale longitudinal and other cohort studies. Second, many different confounders of alcohol consumption exist. The pattern of alcohol consumption also differs between males and females and among populations. Third, individual lifestyle and physical activity can also effect the prevalence of MetS. However, the present results may be helpful for prevention of MetS.

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Conflict of interest

The authors declare that they have no conflicts of interest.