Comparison of the Relationships of Alcohol Intake with Atherosclerotic Risk Factors in Men with and without Diabetes Mellitus

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Abstract — Aims: The purpose of this study was to determine whether diabetes affects relationships between alcohol intake and atherosclerotic risk factors. Methods: Age- and alcohol intake-matched groups of Japanese men with and without diabetes (each group: n = 1440) were prepared. Relationships of alcohol intake with atherosclerotic risk factors were compared among four subgroups divided by alcohol intake (non-, light (<22 g/day), moderate (22 and <44 g/day) and heavy (≥44 g/day) drinkers). Results: Both in diabetic and non-diabetic groups, blood pressure was significantly higher in moderate and heavy drinkers than in non-drinkers, triglycerides were significantly higher in heavy drinkers than in non-drinkers, and high-density lipoprotein (HDL) cholesterol was significantly higher in all drinker groups than in non-drinkers. In the diabetic group, body mass index (BMI) was significantly lower (P < 0.01) in moderate and heavy drinkers than in non-drinkers [26.11 ± 0.17 kg/m² (non-drinkers) vs. 24.83 ± 0.19 kg/m² (moderate drinkers) vs. 24.97 ± 0.23 kg/m² (heavy drinkers)], while these differences were not found in the non-diabetic group [23.33 ± 0.13 kg/m² (non-drinkers) vs. 23.30 ± 0.15 kg/m² (moderate drinkers) vs. 23.46 ± 0.18 kg/m² (heavy drinkers)]. Both in the diabetic and non-diabetic groups, low-density lipoprotein (LDL) cholesterol was significantly lower in moderate and heavy drinkers than in non-drinkers. In the non-diabetic group, LDL cholesterol was also significantly lower in light drinkers than in non-drinkers [124.7 ± 1.3 mg/dl (non-drinkers) vs. 114.5 ± 2.4 mg/dl (light drinkers), P < 0.01], while this difference was not found in the diabetic group [123.6 ± 1.4 mg/dl (non-drinkers) vs. 123.1 ± 2.6 mg/dl (light drinkers)]. Conclusion: The positive associations of alcohol intake with blood pressure, triglycerides and HDL cholesterol are similar in men with and without diabetes, while the negative associations of alcohol intake with BMI and LDL cholesterol are stronger and weaker, respectively, in men with diabetes than in men without diabetes.

INTRODUCTION

Atherosclerotic disease is a major complication of diabetes that determines its prognosis (Ho et al., 2003; Huxley et al., 2006; McCarron et al., 2001). In addition to obesity and physical inactivity, which are well-known risk factors for type 2 diabetes, alcohol consumption is a modifiable risk factor for atherosclerotic disease. Alcohol is known to have diverse effects on progression of atherosclerosis. The beneficial effect of alcohol is mainly explained by its actions through lipid metabolism such as increasing and decreasing actions of alcohol on blood high-density lipoprotein (HDL) cholesterol and low-density lipoprotein (LDL) cholesterol, respectively (Castelli et al., 1977; Langer et al., 1992), while the blood pressure elevating action is a major mechanism for the harmful effect of alcohol on atherosclerosis through induction of hypertension (Estruch et al., 2005; Klatsky, 2003; Xin et al., 2001). Consequently, light-to-moderate alcohol drinking is associated with a lower risk of coronary heart disease (Corrao et al., 2000), and excessive alcohol drinking causes an increased risk of hemorrhagic type of stroke (Reynolds et al., 2003).

Although still under debate, recent systemic reviews have concluded that moderate alcohol consumption is associated with a decreased incidence of diabetes (Baliunas et al., 2009; Howard et al., 2004). There has been only limited information on the effects of alcohol on glucose metabolism in patients with diabetes. Moderate alcohol intake has been reported to reduce plasma glucose and insulin levels in diabetes (Bantle et al., 2008; Burge et al., 1999; Walsh and O’Sullivan, 1974). Light-to-moderate drinkers with diabetes have also been reported to show a decreased risk for coronary heart disease (Ajani et al., 2000; Solomon et al., 2000; Tanasescu et al., 2001; Valmadrid et al., 1999). However, it remains to be determined whether alcohol drinking is beneficial or harmful from the viewpoint of prevention of atherosclerotic disease in patients with diabetes. Although correction of risk factors for atherosclerosis is the primary strategy for prevention of atherosclerotic disease, it is not known whether the relationships between alcohol drinking and atherosclerotic risk factors are affected by diabetes. The purpose of this study was, therefore, to clarify whether associations between alcohol drinking and atherosclerotic risk factors, such as obesity, blood pressure, blood lipids and blood glucose, are different in persons with diabetes and persons without diabetes. For this purpose, age- and alcohol intake-matched groups of subjects with and without diabetes were prepared, and the relationships between alcohol consumption and each atherosclerotic risk factor were compared between the groups with and without diabetes.

METHODS

Subjects

The subjects were male workers aged from 35 to 70 years who had received periodic health examinations at workplaces in Yamagata Prefecture in Japan. A cross-sectional study was performed using a local population-based database for the following subjects. First, subjects with diabetes (n = 1440) were extracted from the database of the health checkup according to the definition of diabetes mentioned below, and then age- and alcohol intake-matched control subjects without diabetes (n = 1440) were randomly selected from the overall subjects of the database (n = 26,317). Subjects with diabetes were defined as those showing high hemoglobin A1C levels.
(≥6.5%), according to the recent criteria for diagnosis of diabetes by the American Diabetes Association (Anonymous, 2010), and/or having a current history of drug therapy for diabetes. Subjects without diabetes were defined as those showing a hemoglobin A1C level of 5.8% or lower. Thus, subjects showing hemoglobin A1C levels of 5.8–8.6% and not receiving therapy for diabetes were gray-zone subjects for diabetes and were excluded from being subjects of this study. In Japan, a hemoglobin A1C level of 5.8% measured by using methods standardized by the Japan Diabetes Society is generally used as a cutoff value for impaired glucose tolerance as well as impaired fasting glucose. In a previous study, the receiver-operated characteristic curve of hemoglobin A1C in subjects with fasting plasma glucose levels of ≥100 mg/dl showed that a hemoglobin A1C level of 5.8% was the most suitable cutoff value (sensitivity of 80.4% and specificity of 79.3%) for diagnosis of impaired glucose tolerance (plasma glucose level of ≥200 mg/dl at 2 h after oral ingestion of 75 g glucose; Ishida et al., 1998). All of the subjects were of Japanese origin. Subjects who were receiving treatment for any illness were requested to state the names of diseases in a questionnaire at the health checkup. This study was approved by the Ethics Committee of Yamagata University School of Medicine (No. 112 from April 2005 to March 2006, approved on 13 March 2006).

Classification of drinker groups

Average alcohol consumption of each subject per week was reported on questionnaires during health examinations at each workplace. Since it is difficult to know the correct average alcohol consumption of occasional drinkers, only regular drinkers who drink almost every day were used as drinkers for analysis in this study. Usual daily alcohol consumption was calculated in terms of the equivalent number of ‘go’, a traditional Japanese unit of amount of sake (rice wine). The amounts of other alcoholic beverages, including beer, wine, whiskey and shochu (traditional Japanese distilled spirit), were converted and expressed as units of ‘go’. One go approximately corresponds to 180 ml of sake, 500 ml of beer, 240 ml of wine, 60 ml of whiskey and 80 ml of shochu. The amount of daily alcohol drinking was categorized as ‘null’, ‘<1 go per day’, ‘1 go or more and <2 go per day’, ‘2 go or more and <3 go per day’ and ‘3 go or more per day’. One ‘go’ contains ~22 g of ethanol, and this amount was used to separate moderate drinkers from light drinkers since it is generally accepted that alcohol intake should be reduced to <30 ml or 20–30 g per day from the viewpoint of prevention of hypertension (Chobanian et al., 2003; Mancia et al., 2007). Average daily alcohol intake (grams of ethanol per day) was then calculated. The subjects were divided into four groups according to ethanol consumption per day (non-drinkers; light drinkers: <22 g of ethanol per day; moderate drinkers: ≥22 and <44 g of ethanol per day; heavy drinkers: ≥44 g of ethanol per day). Histories of cigarette smoking and illness were also surveyed by questionnaire. Major illnesses for which subjects were receiving therapy are as follows: hypertension [16.1% (non-diabetes) vs. 32.2% (diabetes), P < 0.01], dyslipidemia [5.0% (non-diabetes) vs. 14.7% (diabetes), P < 0.01], hyperuricemia [2.4% (non-diabetes) vs. 2.4% (diabetes)], arrhythmia [1.4% (non-diabetes) vs. 2.1% (diabetes)], ischemic heart disease [1.0% (non-diabetes) vs. 2.3% (diabetes), P < 0.05], stroke [0.5% (non-diabetes) vs. 1.2% (diabetes)], liver disease [0.9% (non-diabetes) vs. 1.9% (diabetes), P < 0.05], lumbago [2.4% (non-diabetes) vs. 2.0% (diabetes)] and ocular diseases [1.7% (non-diabetes) vs. 3.3% (diabetes), P < 0.05]. The percentages of subjects receiving therapy for hypertension, dyslipidemia, ischemic heart disease, liver disease and ocular diseases were significantly higher in the diabetes group than in the non-diabetes group.

Measurements

Height and body weight were measured with light clothes at the health checkup. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters. Waist circumference was measured at the navel level according to the recommendation of the definition of the Japanese Committee for the Diagnostic Criteria of Metabolic Syndrome (Anonymous, 2005). Blood pressure was measured by trained nurses, who were part of the local health-checkup company, with a mercury sphygmomanometer once on the day of the health checkup after each subject had rested quietly in a sitting position. Korotkoff phase V was used to define diastolic pressure. Fasted blood was sampled from each subject, and serum HDL and LDL cholesterol and triglycerides were measured by enzymatic methods using commercial kits. Hemoglobin A1C was determined by the latex cohesion method using a commercial kit. Subjects receiving treatment for hypertension, dyslipidemia and diabetes were also included in the above definitions of risk factors.

Statistical analysis

Statistical analyses were performed using a computer software program (SPSS version 16.0 J for Windows, Chicago IL, USA). Mean values of each variable in the groups with and without diabetes were compared using Student’s t-test. The percentages between the groups with and without diabetes were compared using the χ² test for independence or Fisher’s exact probability test. In multivariate analysis, mean values of each variable, calculated after adjustment for additional variables such as age, history of smoking and history of therapy for hypertension, dyslipidemia or diabetes, were compared among the four alcohol groups using analysis of covariance and then Student’s t-test after Bonferroni correction. Means of BMI and waist circumference were calculated after adjustment for age and history of smoking. Serum triglycerides levels were used for analysis after log-conversion. In logistic regression analysis, odds ratios of each drinker group vs. the non-drinker group for high BMI and large waist circumference were calculated after adjustment for age and history of smoking. Odds ratios for high LDL cholesterol were calculated after adjustment for age, history of smoking and history of therapy for dyslipidemia. Odds ratios of the interaction term (multiplication of alcohol drinking by history of diabetes) were also calculated by logistic regression analysis using age, history of smoking, history of diabetes and alcohol drinking as other variables. The criteria for high BMI, large waist circumference and high LDL cholesterol were defined as follows: high BMI, BMI ≥25 kg/m²; large waist circumference, waist circumference ≥85 cm; high LDL cholesterol, LDL cholesterol ≥140.
mg/dl. Probability \((P)\) values of <0.05 were defined as significant.

**RESULTS**

Comparison of each variable in the diabetes and non-diabetes groups

Table 1 shows profiles of the diabetes and non-diabetes groups. Age and alcohol intake were matched in the two groups. The percentage of smokers was not significantly different between the groups. BMI was significantly higher and waist circumference was significantly larger in the diabetes group than in the non-diabetes group. Hemoglobin A1C, systolic and diastolic blood pressure, log-converted triglycerides and LDL cholesterol were significantly higher in the diabetes group than in the non-diabetes group. HDL cholesterol was significantly lower in the diabetes group than in the non-diabetes group. The percentages of subjects receiving therapy for hypertension and dyslipidemia were significantly higher in the diabetes group than in the non-diabetes group.

Comparison of each atherosclerotic risk factor among the four alcohol groups in subjects with and without diabetes

Mean levels of each atherosclerotic risk factor after adjustment for other variables such as age, history of smoking and history of therapy for hypertension, dyslipidemia or diabetes were compared among the alcohol groups (Figs 1–3). In subjects with diabetes, BMI was significantly lower \((P < 0.01)\) in moderate and heavy drinker groups than in the non-drinkers group \(26.11 \pm 0.17 \text{ kg/m}^2\) (non-drinkers) vs. \(24.83 \pm 0.19 \text{ kg/m}^2\) (moderate drinkers) vs. \(24.97 \pm 0.23 \text{ kg/m}^2\) (heavy drinkers), while there was no significant difference in the BMI levels among the four alcohol groups of subjects without diabetes (Fig. 1A). In the diabetes group, considerable differences of \(1.0 \text{ kg/m}^2\) or more were observed in mean BMI levels of non-drinkers and moderate or heavy drinkers (Fig. 1A). In subjects without diabetes, waist circumference was significantly larger in the heavy drinker group than in the non-drinker group \(82.6 \pm 0.4 \text{ cm}\) (non-drinkers) vs. \(84.4 \pm 0.5 \text{ cm}\) (heavy drinkers), \(P < 0.05\), and there were no significant differences in waist circumference among the non-, light and moderate drinker groups. In subjects with diabetes, waist circumference was significantly smaller in the moderate drinker group than in the non-drinker group \(89.6 \pm 0.4 \text{ cm}\) (non-drinkers) vs. \(87.2 \pm 0.5 \text{ cm}\) (moderate drinkers), \(P < 0.01\), while no significant differences were found in waist circumference among the non-, light and moderate drinker groups. In subjects with diabetes, systolic and diastolic blood pressure was significantly higher in the moderate and heavy drinker groups than in the non-drinker group (Fig. 2). Both in subjects with and without diabetes, systolic and diastolic blood pressure was significantly higher in the moderate and heavy drinker groups than in the non-drinker group (Fig. 2). Both in subjects with and without diabetes, log-converted triglycerides were significantly higher in the moderate and heavy drinker groups than in the non-drinker group.

Means with standard deviations or percentages of variables were compared between the non-diabetic and diabetic groups. Asterisks denote significant differences from the non-diabetic group \((**P < 0.01)\).

![Fig. 1. Multivariate analysis of the relationships of alcohol intake with BMI, waist circumference and hemoglobin A1C in the subject groups with and without diabetes. Means with standard errors of BMI and waist circumference were calculated after adjustment for age and history of smoking. History of therapy for diabetes in addition to age and smoking history was adjusted for calculating means of hemoglobin A1C. Means of each variable were compared among non-, light (<22 g/day), moderate (≥22 and <44 g/day) and heavy (≥44 g/day) drinker subgroups in each group with or without diabetes. Asterisks denote significant differences from non-drinkers \((*P < 0.05; **P < 0.01)\).](image-url)
groups compared with the non-drinker group (Fig. 3A). Both
in subjects with and without diabetes, HDL cholesterol was
significantly higher in the light, moderate and heavy drinker
groups than in the non-drinker group (Fig. 3B). Both in sub-
jects with and without diabetes, LDL cholesterol was signifi-
cantly lower in the moderate and heavy drinker groups than
in the non-drinker group (Fig. 3C). LDL cholesterol was sig-
nificantly lower in the light drinker group than in the non-
drinker group \[124.7 \pm 1.3 \text{ mg/dl (non-drinkers) vs. 114.5 \pm 2.4 \text{ mg/dl (light drinkers)}, P < 0.01}\] in subjects without dia-
betes but was not significantly different in the light and non-
drinker groups \[123.6 \pm 1.4 \text{ mg/dl (non-drinkers) vs. 123.1 \pm 2.6 \text{ mg/dl (light drinkers)}\] in subjects with diabetes
(Fig. 3C). In the non-diabetes group, a considerable differ-
ence of ~10 mg/dl was observed in mean LDL cholesterol
levels between non- and light drinkers (Fig. 3C).

Odds ratios of each drinker group vs. the non-drinker
group for high BMI, large waist circumference and
high LDL cholesterol

Since differences between the subject groups with and
without diabetes were found in the relationships of alcohol
intake with BMI, waist circumference and LDL cholesterol
as shown in the afore-mentioned multivariate analysis of
mean levels of the variables, odds ratios of each drinker
group vs. the non-drinker group for high BMI, large waist
circumference and high LDL cholesterol were also compared
in subjects with and without diabetes (Table 2). In subjects
with diabetes, significantly low odds ratios of the moderate
and heavy drinker groups vs. the non-drinker group were
found for high BMI, while these odds ratios were not signifi-
cant in subjects without diabetes. Both in subjects with and
without diabetes, no significant odds ratios of each drinker
group vs. the non-drinker group were found for large waist
circumference. Both in subjects with and without diabetes,
significantly low odds ratios of the moderate and heavy
drinker groups vs. the non-drinker group were found for high
LDL cholesterol. The odds ratio of the light drinker group
vs. the non-drinker group for high LDL cholesterol was sig-
nificantly low in subjects without diabetes but was not signi-
ficant in subjects with diabetes.

Odds ratios of the interaction term of alcohol intake with
history of diabetes were significant for high LDL cholesterol
in light and moderate drinkers but were not significant for
high BMI and large waist circumference in any drinker groups (Table 2).

### DISCUSSION

This study using age- and alcohol intake-matched subject groups with and without diabetes is the first study showing differences in the relationships between alcohol consumption and atherosclerotic risk factors in persons with and without diabetes. It has not been determined whether the relationships between alcohol consumption and atherosclerotic risk factors are influenced by diabetes. Since the age of composition and the percentage of drinkers were expected to be different in persons with and without diabetes in a general population, age- and alcohol intake-matched groups were prepared to compare the relationships of alcohol intake with atherosclerotic risk factors in diabetes and non-diabetes.

In subjects with diabetes, LDL cholesterol was significantly lower in moderate and heavy drinkers than in non-drinkers, and this difference was not found between light drinkers and non-drinkers. These results agree with the results of logistic regression analysis showing significantly low odds ratios vs. non-drinkers for high LDL cholesterol in moderate and heavy drinkers but not in light drinkers. In subjects without diabetes, LDL cholesterol was significantly lower in all of the drinker groups than in the non-drinker group and the odds ratios vs. non-drinkers for high LDL cholesterol were significantly low in moderate and heavy drinkers, while these relationships between alcohol intake and BMI were not found in subjects without diabetes. Moreover, in subjects with diabetes, waist circumference was significantly smaller in moderate drinkers than in non-drinkers, while waist circumference was significantly larger in heavy drinkers than in non-drinkers without diabetes. Thus, associations of alcohol intake with lower obesity-related indexes were found to be significant in the diabetes group but not in the non-diabetes group.

The relationships between alcohol and atherosclerotic vascular risk factors have been shown to be linear, J-shaped and U-shaped (Rouillier et al., 2005) and thus differ depending on risk factors. In the present study, whereas the relationships of alcohol consumption with LDL cholesterol and obesity were suggested to be influenced by diabetes, the relationships of alcohol with blood pressure, HDL cholesterol and triglycerides were similar in subjects with and without diabetes. Therefore, the influence of diabetes on the relationships between alcohol consumption and atherosclerotic risk factors also differs depending on risk factors. The reasons for the afore-mentioned differences in the relationships of alcohol intake with obesity-related indexes and LDL cholesterol in diabetes and non-diabetes remain unknown. One possible reason for the associations of alcohol with lower BMI and smaller waist circumference in subjects with diabetes is weight loss due to poor control of diabetic condition in drinkers. However, this is unlikely because hemoglobin A1c levels in subjects with diabetes were not higher in the drinker groups than in the non-drinker group (Fig. 1C). There is a possibility that the effect of alcohol on BMI is not causal, since a variety of factors, including comitant food intake, frequency of drinking and eating, smoking, age and gender, have been reported to confound the relationship between alcohol intake and obesity (Suter, 2005). In the present study, a negative association between BMI and alcohol intake was observed in the diabetes group but not in the non-diabetes group. Several possible
mechanisms, including alteration in energy expenditure, interference with digestion and absorption of nutrients, and increase of sympathetic activity, have been proposed for the negative relationship between alcohol intake and body weight (Lieber, 1991, 2000; Suter, 2005). However, previous epidemiological studies showed a positive, negative or no relationship between alcohol intake and body weight, and thus it is controversial whether habitual alcohol drinking is a risk factor for obesity (Suter 2005; Yeomans, 2010). Plasma LDL cholesterol is known to be negatively associated with moderate alcohol consumption, and this agrees with the results of the present study and is explained by an increase in lipoprotein lipase activity and a decrease in cholesteryl ester transfer protein activity due to alcohol drinking (Hannuksela et al., 2004). Among the atherosclerotic risk factors tested, strong positive associations were found between alcohol intake and blood pressure and between alcohol intake and HDL cholesterol. Although the dose-dependent relationship between alcohol intake and HDL cholesterol was unclear in the heavy drinkers (Fig. 3B), a clear dose-dependent relationship was obtained between alcohol intake and systolic and diastolic blood pressure (Fig. 2A and B). Therefore, the questionnaires on drinking are validated for blood pressure. The finding of no difference in HDL cholesterol between moderate and heavy drinkers was obtained both in the diabetes and non-diabetes groups.

HDL cholesterol is known to become higher with an increase of age (Wakabayashi and Araki, 2010), and the mean age was slightly younger in heavy drinkers than in moderate drinkers (53.8 ± 6.6 vs. 55.3 ± 7.0 years) in this study. Therefore, difference in age might, in part, contribute to no difference in HDL cholesterol between moderate and heavy drinkers of diabetes and non-diabetes groups, although age was adjusted in multivariate analysis. The exact reason for no difference in HDL cholesterol between moderate and heavy drinkers in this study remains unknown.

Needless to say, alcohol drinking should not be recommended for patients with diabetes, because drinking could disturb the control of diabetic condition by diet therapy and alcohol could acutely induce hypoglycemia in patients receiving drug therapy for diabetes. However, it has not been determined whether light-to-moderate alcohol consumption, which is known to reduce incidence of cardiovascular disease in a general population (Corrao et al., 2000), should be allowed in patients with diabetes. The present study suggests that there may be, at least, no greater disadvantage of alcohol drinking in subjects with diabetes than in subjects without diabetes with regard to associations between alcohol consumption and major atherosclerotic risk factors such as obesity, hypertension and dyslipidemia, except for the relationship with LDL cholesterol, which was lower in light drinkers than in non-drinkers in subjects without diabetes but not in those with diabetes. Moderate alcohol consumption has been shown to be associated with similar reductions of risk for coronary heart disease in persons with and without diabetes (Ajani et al., 2000; Solomon et al., 2000; Tanaseascu et al., 2001; Valmadrid et al., 1999). In addition, our previous study demonstrated that in patients with type 2 diabetes, arterial stiffness, a good surrogate marker for progression of atherosclerosis, was lower in light drinkers than in non-drinkers and was comparable in heavy drinkers and non-drinkers (Wakabayashi et al., 2002). Therefore, from the viewpoint of prevention of atherosclerotic disease, adequacy of alcohol drinking may be similar in persons with and without diabetes. Since this study is cross-sectional in design, further prospective studies are needed to clarify causal relationships of alcohol drinking with atherosclerotic risk factors in patients with diabetes.

There are limitations of this study as follows: subjects with diabetes were defined as those stating a current history of therapy for diabetes in the questionnaire and/or showing hemoglobin A1C levels of 6.5% or higher, which has been proposed as a criterion for diagnosis of diabetes (Anonymous, 2010). Thus, there is an informational bias on history of therapy for diabetes. Most of the subjects with diabetes in this study are expected to be classified as type 2 diabetes, since the prevalence of type 2 diabetes among Japanese middle-aged men (mean age of subjects in this study: 54 years) is speculated to be >100 times higher than the prevalence of type 1 diabetes (Anonymous, 2009). Unfortunately, no accurate information on the type of diabetes could be obtained in the questionnaire, and analysis of the relationships between alcohol drinking and atherosclerotic risk factors in subjects with different types of diabetes was not performed in this study. Since the subjects of this study were all Japanese, further studies are needed to determine the relationships between alcohol intake and atherosclerotic risk factors in different races. The percentages of subjects receiving therapy for hypertension or dyslipidemia were significantly higher in the diabetes group than in the non-diabetes group. Therefore, there is a possibility of confounding of the relationships of alcohol intake with blood pressure and blood lipids by histories of therapy for hypertension and dyslipidemia. The negative association between alcohol intake and LDL cholesterol was weaker in the diabetes group than in the non-diabetes group, while the positive associations of alcohol intake with blood pressure and triglycerides and the negative association of alcohol intake with HDL cholesterol were similar in the diabetes and non-diabetes groups. In the multivariate analyses, a history of therapy for hypertension or dyslipidemia was adjusted for calculating means and odds ratios. It is difficult to speculate whether and how lipid-lowering therapy influenced the negative association between alcohol intake and LDL cholesterol in the diabetes and non-diabetes groups.

In conclusion, the positive associations of alcohol intake with blood pressure, triglycerides and HDL cholesterol were similar in persons with and without diabetes. Differences in the relationships of alcohol intake with several risk factors for atherosclerosis were found in men with diabetes and non-diabetes: the negative association of alcohol intake with serum LDL cholesterol was weaker in men with diabetes than in men without diabetes, and a negative association of alcohol intake with obesity was found in men with diabetes but not in men without diabetes.

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