# Association between Alcohol Consumption and Carotid Intima-Media Thickness in a Healthy Population - Data of the STRATEGY Study (Stress, Atherosclerosis, and ECG Study) -

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Birgit-Christiane Zyriax[a], Katharina Lau[b], Tilman Klähn[a], Heiner Boeing[c], Henry Völzke[b] and Eberhard Windler[a]

[a]Endocrinology and Metabolism of Ageing, University Medical Center Hamburg-Eppendorf
[b]Institute for Community Medicine, SHIP/Clinical-Epidemiological Research Unit, Ernst-Moritz-Arndt-University Greifswald, Greifswald
[c]Department of Epidemiology, German Institute of Human Nutrition Potsdam-Rehbrücke

**Corresponding author:**
Dr. Birgit-Christiane Zyriax, Endokrinologie und Stoffwechsel des Alterns, Universitätsklinikum Hamburg-Eppendorf, Martinistrasse 52, N 36, D-20246 Hamburg, Germany; Telefax: : +49 – 40 – 74105-5059, Phone: +49 – 163 – 6009 738
E-mail: bzyriax@uke.de

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The authors declare no conflict of interest.

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**ABSTRACT**

**Objectives:** Epidemiologic evidence suggests a protective effect of moderate alcohol consumption on cardiovascular events. However, studies assessing the association between alcohol intake and intima-media thickness (IMT) as a marker of subclinical atherosclerosis have provided inconsistent results. Aim of this analysis of the STRATEGY study was to investigate the relation of alcohol intake and intima-media thickness in a selectively healthy population.

**Design:** In a cross-sectional study laboratory values, anthropometric data, nutrition habits and physical activity were assessed in 106 men and 107 women evenly distributed between 30 and 70 years. Carotid intima-media thickness was determined by B-mode ultrasonography according to the standardized protocol of the Study of Health in Pomerania (SHIP).

**Results:** In men, a significant positive correlation between daily alcohol consumption and intima-media thickness was observed ($p < 0.0001$), whereas in women the positive correlation was not significant. The type of beverage consumed did not affect this finding. Mean intima-media thickness was significantly higher in men with an alcohol intake above the upper limit of 20 g/d compared to men with an alcohol intake <20 g/d ($p<0.001$). According to a stepwise linear regression model adjusted for age, conventional risk factors, nutrition, and physical activity, the intima-media thickness increases by 0.0253 mm per 21,4 g/d intake of alcohol per day in men ($p<0.05$).

**Conclusion:** The STRATEGY study revealed a positive association between alcohol consumption and carotid intima-media thickness in healthy men aged 30-70 years. This relationship remained significant after adjustment for nutrition, physical activity, anthropometry, and conventional cardiovascular risk factors.

## INTRODUCTION

Epidemiologic evidence indicates a J-shaped or U-shaped association between alcohol consumption and cardiovascular morbidity and mortality (Di Castelnuovo *et al.*, 2006; Fagrell *et al*., 1999; Thun *et al.;* 1997; Corrao *et al.,* 2000). Light to moderate drinking seems to reduce the risk of cardiovascular events compared to abstention or heavier consumption of alcohol (Di Castelnuovo *et al*., 2006; O'Keefe *et al*., 2007; Roerecke *et al.*, 2010). Also among individuals with previous cardiovascular disease, a protective effect of alcohol has been reported (Kaski *et al.,* 2008).

As yet, the mechanisms of cardiovascular protection of alcohol are not fully elucidated. It has been suggested that cardiovascular benefits of moderate alcohol consumption are causal and may be explained in part by its influence on serum lipids and insulin sensitivity (Rimm *et al.,* 2000; Djoussé *et al.*, 2009). However, clinical advice to abstainers to initiate daily alcohol consumption for cardiovascular prevention has been given with caution, because of competing risks such as that of cancer (O'Keefe *et al.,* 2007).

Previous studies focused on the association between alcohol intake and clinical endpoints rather than atherosclerosis. Carotid intima-media thickness (IMT) is an established strong predictor of future coronary and cerebrovascular events and presumed to reflect subclinical atherosclerosis, however data in young or healthy individuals are limited and have yielded inconsistent results (Bots *et al.,* 1997; Chambless *et al*., 1997; O'Leary *et al*., 1999; Lorenz *et al.,* 2007). Some investigators found an inverse association in men but not in women, while others failed to show a relationship at all (Lee *et al.*, 2009; Schminke *et al.*, 2005; Zureik *et al*., 2004; *Kauhanen et al.*, 1999). Previous studies have mainly been performed in middle-aged or elderly subjects with established risk factors for cardiovascular disease (CVD). Recently, a positive relationship has been shown in young adults (Juonala *et al*., 2009). Thus, more studies are needed to provide a larger database on alcohol and IMT in different

subpopulations, particularly in young or healthy subjects using IMT-measurements as a predictor of individual cardiovascular risk.

The aim of the present study was to investigate the association between alcohol consumption and IMT in healthy men and women aged 30 to 70 years without evident risk factors taking account of possible confounding dietary habits.

## METHODS

### Design and recruitment

The Stress Atherosclerosis and ECG Study (STRATEGY Study) is a cross-sectional study in a healthy population. Men and women aged 30 to 70 years were recruited in Hamburg through a health insurance via a flyer randomly included in regular mailings between September 2006 and March 2007. On telephone contact, participants were invited for a visit fasting in the morning and one week later in the afternoon, if the following exclusion criteria were not met: acute or chronic diseases or any medication except for hormone replacement therapy or oral contraceptives and thyroxin for stably substituted hypothyroidism. Up to at least 25 participants per age decade and gender were consecutively included. Of 215 eligible subjects, two were excluded from this analysis because of missing data with regard to alcohol consumption or IMT, respectively. The final study population comprised 106 men and 107 women (men/women: 30 to 39 years, n= 26/26; 40 to 49 years, n= 26/29; 50 to 59 years, n= 27/27; 60 to 70 years, n=27/25). The study protocol was approved by the ethical committee of Hamburg and conducted according to the principles of the 'Declaration of Helsinki'.

## Data collection

### Assessment of lifestyle and alcohol consumption

All interviews and physical examinations were performed by the same trained investigator. Data on lifestyle, nutrition, sociodemographic characteristics and family history of cardiovascular disease were obtained using validated questionnaires developed for the EPIC study (European Prospective Investigation into Cancer and Nutrition) (Bohlscheid *et al.,* 1997a; Bohlscheid *et al.*, 1997b). A self-administered food questionnaire recorded the frequency and portion size of 146 food items eaten during the preceding year. Daily alcohol intake was calculated from the individual portion size and frequency of the consumption of various alcoholic beverages (beer, wine, champagne, spirits, liqueur and mixed alcohol beverages). One portion size was defined as 0.5 l beer or 0.25 l wine or 0.1 l of sparkling wine, 8 cl of liquor, 2 cl of spirits or 0.2 l of mixed alcohol beverages. Non-beverage sources of alcohol such as filled chocolates, cake, fruit juice or milk products (yoghurt, kefir) were also taken into account.

Physical activity in hours per week was estimated from the kind, time and frequency of sports in summer and winter by a validated lifestyle questionnaire. With regard to smoking status, participants were categorized as current smokers, former smokers and never smokers. Education level characterized by years of schooling comprised the following categories: less than 10 years (low level), 10 years (intermediate level) and more than ten years (higher level).

### Anthropometric and laboratory data

Height and weight were measured to the nearest 0,5 cm or 0,1 kg, respectively and body mass index (BMI) was calculated as BMI = (weight, kg)/(height, m)$^2$. Waist circumference was measured in the middle between the lower rib margin and the iliac crest. Central obesity

was defined by a waist circumference ≥ 80 cm in women and ≥ 94 cm in men. A fasting morning blood sample was taken, immediately centrifuged at 4°C, and stored at 4°C in tubes containing 1 mg fluoride per ml blood. Fasting plasma glucose, plasma glucose two hours after 75 g glucose (OGTT), high-density lipoprotein (HDL) cholesterol, triglycerides, lipoprotein(a) and serum enzyme levels of ASAT, ALAT, GGT, GLDH were determined by standard technique. Low-density lipoprotein (LDL) cholesterol was calculated using the Friedewald formula. Blood pressure was taken in a sitting position in the morning three times in 1 min intervals after at least 5 min rest. The results of the second and third measurement were averaged and used for the present analysis.

**Carotid intima-media thickness**

The common carotid artery was recorded on both sides between the carotid bulb origin and a point 10 mm proximal using high-resolution B-mode ultrasound (General Electric Vivid 3 Expert with a 7,5- MHz linear-array transducer). The intima-media thickness (IMT) was assessed off-line as the average of at least 5 consecutive measurements in 1-mm steps on both sides of the distance from the media-adventitia interface to the intima-lumen interface on the far wall in a region free of plaques (only one plaque in one participant was detected) by a trained investigator according to the standardized protocol of the Study of Health in Pomerania (SHIP) (Lüdemann *et al.,* 2000; Völzke *et al*., 2010).

**Statistical analyses**

Baseline clinical and lifestyle characteristics are expressed as means ± 1 standard deviation or as categories (percentage, number). Comparisons between groups were performed two-tailed using ANOVA for continuous variables, and $\chi^2$-test for categorical variables. The association between IMT and daily alcohol consumption was determined by multiple linear regression analyses adjusted for potential confounders and in participants with lower and higher alcohol consumption as determined by univariate tests. *P*-values below 0.05 were

considered statistically significant. All statistical analyses were performed using STATA version 10 (StataCorp, College Station, TX).

## RESULTS

### Baseline characteristics

Analyses were performed separately in men and women because of the sex-specific differences in alcohol metabolism and consumption. Baseline characteristics are given in Table 1. Mean age did not differ between men and women. On average, both genders were characterized by a relatively favorable profile of cardiovascular risk factors, particularly regarding lipids, fasting and postprandial glucose and blood pressure. Notably, though in the reference range, in men almost all laboratory values were significantly higher, in the case of HDL-cholesterol lower, as compared to women. Mean serum levels of liver enzymes as markers of possible alcohol abuse did not show major abnormalities. Gamma-GT was above the upper limit of normal in no woman and eight men, in one man above two times the upper limit of normal (> 2SD). In only two cases this was accompanied by slightly elevated ALAT (data not shown).

Mean BMI of women was in the range of normal, while that of men was within the range of overweight. Yet, both sexes surpassed the defined cutoffs for an elevated waist circumference of 94 cm for men and 80 cm for women. In both gender, the prevalence of smokers was low and levels of physical activity high. Men reported a higher intake of energy particularly as meat and meat products and a lower consumption of fruit and vegetables compared to women. This was even more evident if the intake was calculated per 1000 kcal of energy intake (Table 1).

**Alcohol intake and drinking patterns**

The participants reported a light to moderate alcohol intake (Figure 1). The mean alcohol consumption was significantly higher in men compared to women. One woman reported to drink no alcohol at all. In 45% of women and 42% of men, the mean daily alcohol intake was above the sex-specific upper tolerable limits (women: 10 g/day, men 20 g/day) (Table 2) (Deutsche Gesellschaft für Ernährung, 2000; Kushi *et al.,* 2006). The frequency of alcohol consumption was higher in men compared to women (Figure 2). Two-thirds of men (67%), but barely half of the women (47%) consumed at least two or three drinks per week. Among men, 11% reported to consume one or two drinks per day, in women the rate was 7%.

Alcohol intake predominantly comprised alcoholic beverages. The preference differed somewhat between men and women (men/women: wine 55%/68%; beer 34%/15%; spirits including liquor and mixed alcoholic beverages 9%/12%; sparkling wine 2%/5%). However, most participants did not exclusively consume one type of alcoholic beverage. Other sources of alcohol played a minor role (9% in men, 6% in women) (Table 1).

Regarding the variables shown in Table 1, men with a mean alcohol intake of >20 g/d versus ≤ 20 g/d were characterized by a significantly higher energy intake, higher age, higher level of HDL-cholesterol and a lower postprandial glucose (data not shown). Women with a mean alcohol consumption of >10 g/d differed from those with an intake ≤ 10 g/d in a higher energy intake, a lower consumption of fruit and vegetables per 1000 kcal energy, and a higher waist circumference, but not in the remainder of variables shown in Table 1 (data not shown).

**Alcohol intake and IMT**

In men, a significant positive correlation between daily alcohol intake and IMT was observed (Figure 3). The slope of the correlation was even stronger below an alcohol intake of 60g/d (data not shown). In women a positive trend was also notable, which, however, was much

weaker and not significant (Figure 3). The mean IMT was significantly higher in men with an alcohol intake above the recommended upper limit of 20 g/d compared to ≤20 g/d ($p<0.001$), but not in women with an alcohol intake >10 g/d versus ≤10g/d (Table 2). By confounder analysis the association between alcohol intake and IMT was not influenced by the type of beverages consumed (data not shown).

In men, a stepwise linear regression model revealed a significant increase of 0.0253 mm IMT per 21.4 g alcohol per day after adjustment for age, HDL-cholesterol and LDL-cholesterol (Table 3). This association remained significant after further adjustment for systolic blood pressure and smoking status (model 2) and additionally for waist circumference and fasting glucose (model 3). Further adjustment for dietary factors such as intake of total energy, meat and meat products, and fruit and vegetables, and physical activity (model 4), or lipoprotein(a) as a genetic marker for cardiovascular risk (model 5) did not change the result. Yet, in women no significant association was detected in any of the models (data not shown).

## DISCUSSION

The STRATEGY study showed a positive association between alcohol intake and carotid IMT in healthy men aged 30 to 70 years. This relationship was independent of nutrition, physical activity, anthropometry, and conventional cardiovascular risk factors. In women, the trend was positive too, but much weaker and not significant. The more favorable risk profile and dietary pattern in women may have mitigated the possible harmful effects of alcohol consumption on IMT.

In men the positive correlation between alcohol consumption and IMT held for any level of alcohol intake. The correlation was even stronger for an alcohol intake below 60 g/d. Most participants reported a light to moderate alcohol intake regularly on several occasions a

week. The amount was beyond the upper limit of what is assumed to be tolerable in nearly half of the men and women. Liver enzymes did not show any major abnormalities indicating that the observed positive association between alcohol intake and IMT was caused by alcohol abuse or a binge drinking behavior as reported in several epidemiological studies (Kauhanen *et al.,* 1999; Bagnardi *et al.,* 2008; Roerecke *et al.*, 2010 ).

Most participants of the STRATEGY study consumed various types of beverages. However recent evidence suggested that the protective effect of alcohol is attributable primarily to the alcohol content rather than to other component. Also wine drinking is associated with a higher socioeconomic status including a healthier lifestyle (Klatsky *et al.,* 2001, Mortensen *et al.,* 2001).

The findings of the present study appear to be in striking contrast to several studies that reported an inverse association between alcohol intake and cardiovascular disease (Arriola *et al*., 2010; Di Castelnuovo *et al*., 2006; Fagrell *et al*., 1999; Thun *et al*., 1997; Corrao *et al.*, 2000). A moderate alcohol consumption correlated with a decreasing risk of cardiovascular events and stroke, whereas a harmful effect became evident only at excessive levels (Corrao *et al.,* 2000; Fragell *et al.*, 1999; Roerecke *et al.,* 2010). However, several studies suggest that the benefit of alcohol drinking is largely confined to individuals at increased risk for cardiovascular disease, to older subjects or those with a poor nutrition status (Fuchs *et al.,* 1995; Merchant *et a*l., 2008; Bos *et al*., 2010; Zyriax *et al*., 2005). In contrast, studies including younger adults suggested that increasing alcohol intake is associated with coronary calcification and vascular damage (Pletcher *et al.*, 2005; van Trijp *et al.*, 2005).

The few studies evaluating the effect of alcohol consumption on IMT have provided conflicting results. Data of the Atherosclerosis Risk in Communities Study (ARIC) and the Three-City-Study found no relationship between alcohol consumption and IMT (Demirovic *et*

*al.*, 1993; Zureik *et al*., 2004). Data from SHIP showed an inverse correlation of alcohol consumption with IMT in men, whereas in women no correlation was seen (Schminke *et al*., 2005). In the Cardiovascular Health Study (CHS) of adults aged ≥65 years and older only a moderate alcohol intake was inversely related to IMT, whereas a higher amount showed a positive correlation (Mukamal *et al*., 2003). Similarly, in the Bruneck Study, including men and women aged 40-79 years a J-shaped association between alcohol intake and progression of IMT was detected (Kiechl *et al.*, 1998).

The findings of the STRATEGY study are in line with recent data of the Cardiovascular Risk in Young Finns Study which revealed a positive association between alcohol intake and IMT in young adults aged 24-39 years (Juonala *et al*., 2009). The authors suggested a pro-atherogenetic effect of alcohol consumption. Both populations were characterized by comparatively healthy individuals, due to young age in the Finnish study and by selecting subjects aged 30-70 years without known cardiovascular risk factors and medication in the STRATEGY study. They followed a prudent lifestyle pattern. Also, in a sample of healthy middle-aged French men and women a significant and positive association between alcohol consumption and IMT was found (Ferrières *et al.*, 1999).

The protective effect of alcohol may only be detectable in individuals at higher cardiovascular risk, if alcohol alleviates the effect of risk factors. Evidence for this concept is provided by a population-based, cross-sectional study that suggests that moderate alcohol intake may attenuate the relation between saturated fat and increased IMT (Merchant *et al*., 2008). Presumably, selecting a population following a prudent dietary pattern and lifestyle, the beneficial effects of moderate alcohol intake on subclinical atherosclerosis may not be relevant. Unfortunately, only few studies have taken dietary habits into account.

However, there are some more potential explanations for the controversial results. Beneficial effects of alcohol consumption are assumed to be mediated by increased HDL-cholesterol and insulin sensitivity, improvement in endothelial function, myocyte resistance to ischemic injury, reduced platelet aggregation or inflammation (Rimm *et al.*, 1999; Teragawa *et al.,* 2002; Imhof *et al.,* 2001; Zhou *et al.*, 2002). Thus, some effects of alcohol are mediated through mechanisms that are not reflected by IMT and may compete with deleterious effects on the vessel wall. Hence, the protective effect of alcohol on cardiovascular events may differ in older subjects at higher risk from those pathways leading to an increase in IMT in younger or healthy adults. Also, some studies observed that alcohol intake was positively and independently correlated with common carotid arterial diameter, indicating that in early stage of atherosclerosis alcohol may compensate for arterial wall thickening and plaque formation and reducing shear stress (Crouse *et al.*, 1994; Bonithon-Kopp *et al.*, 1996). In the end, the increase in IMT through alcohol may not reflect atherogenesis, but stabilization, thus may be beneficial as well. This, however, would impact on the interpretation of IMT as a surrogate of atherosclerosis and vascular risk.

**Study limitations**

The STRATEGY study has several limitations. First, persons who reported morbidities or medication for cardiovascular risk factors were excluded. Accordingly, the findings are confined to explicitly healthy volunteers, characterized by a favorable lifestyle and a low risk profile. Second, our data are based on self-reported food-frequency including portion size for alcohol intake. Underreporting might have occurred particularly in heavier drinking groups, though not very likely, and thereby the ability to evaluate excessive drinking was limited. Third, because of the sample size, the study may have been underpowered to detect an association between mean daily alcohol intake and IMT in women.

**Conclusion**

The STRATEGY study shows that alcohol consumption is associated with an increase in IMT in healthy men. In the light of evidence from several studies reporting a protective effect of alcohol on cardiovascular events, higher IMT values may not necessarily reflect early atherosclerosis and vascular risk, at least in healthy subjects with light to moderate alcohol consumption, following a protective nutrition and lifestyle. This, however, raises the fundamental question about the prognostic value of IMT measurements in healthy individuals.

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## Author Disclosure Statement

Competing financial interests of all authors have been appropriately disclosed according to the policy of the Journal. No competing financial interests exist.

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**Table 1**
Clinical and lifestyle characteristics of the study population as mean ± 1 standard deviation

| Variables | Men<br>n = 107 | Women<br>n = 107 | Significance<br>p-value |
|---|---|---|---|
| **Clinical characteristics** | | | |
| Age (years) | 49.6 ± 11.3 | 49.3 ± 10.6 | n.s. |
| BMI (kg/m$^2$) | 26.2 ± 3.2 | 23.9 ± 3.3 | <0.001 |
| Waist circumference (cm) | 95.9 ± 10.5 | 81.6 ± 9.4 | <0.001 |
| Fasting glucose (mg/dl) | 92.3 ± 9.5 | 87.5 ± 7.8 | < 0.01 |
| 2h glucose (75 g OGTT) (mg/dl) | 83.6 ± 22.9 | 83.9 ± 17.6 | n.s. |
| HDL-cholesterol (mg/dl) | 63.2 ± 15.8 | 80.4 ± 17.6 | <0.001 |
| LDL-cholesterol (mg/dl) | 124.1 ± 31.0 | 110.4 ± 32.2 | < 0.01 |
| Triglycerides (mg/dl) | 116.6 ± 66.6 | 85.0 ± 36.6 | <0.001 |
| Lipoprotein(a) (mg/dl) | 25.7 ± 34.5 | 32.5 ± 37.9 | n.s. |
| ALAT (IU/l) | 28.8 ± 12.0 | 20.0 ± 9.1 | <0.001 |
| ASAT (IU/l) | 26.7 ± 5.9 | 24.1 ± 6.1 | < 0.01 |
| GGT (IU/l) | 31.7 ± 23.5 | 16.7 ± 9.6 | <0.001 |
| GLDH (IU/l) | 3.6 ± 3.5 | 2.5 ± 1.8 | <0.001 |
| Systolic blood pressure (mm Hg) | 126.6 ± 15.1 | 119.9 ± 18.8 | < 0.01 |
| Diastolic blood pressure (mm Hg) | 78.8 ± 11.7 | 73.1 ± 9.3 | < 0.01 |

**To be continued next page**

**Table 1 continued**

| Variables | Men<br>n = 107 | Women<br>n = 107 | Significance<br>p-value |
|---|---|---|---|
| **Dietary characteristics** | | | |
| Total Alcohol intake (g/day) | 21.1 ± 21.4 | 14.1 ± 17.2 | <0.05 |
| Alcohol intake from alcoholic beverages (g/day) | 19.9 ± 21.3 | 13.3 ± 17.2 | <0.05 |
| Alcohol intake from other sources (g/day) | 1.0 ± 1.2 | 0.7 ± 0.4 | <0.05 |
| Total energy intake (kJ/day) | 11310 ± 3115 | 8302 ± 1962 | <0.001 |
| Total energy intake (kcal/day) | 2701 ± 745 | 1983 ± 469 | <0.001 |
| Intake of meat and sausage (g/day) | 155.3 ± 76.2 | 72.8 ± 35.9 | <0.001 |
| Intake of meat and sausage (g/day per 1.000 kcal) | 58.7 ± 24.9 | 36.9 ± 15.6 | <0.001 |
| Intake of fruit and vegetables (g/day) | 394.6 ± 171.0 | 442.3 ± 169.3 | <0.05 |
| Intake of fruit and vegetables (g/day per 1.000 kcal) | 149.0 ± 63.2 | 230.4 ± 94.7 | <0.001 |
| **Lifestyle characteristics and education** | | | |
| Physical activity (h/week) | 4.3 ± 3.2 | 3.6 ± 2.9 | n.s. |
| Smoking status (%) | | | n.s. |
| never smokers | 57.6 ± 61 | 61.7 ± 66 | |
| former smokers | 34.0 ± 36 | 27.1 ± 29 | |
| current smokers | 8.4 ± 9 | 11.2 ± 12 | |
| School education (%) | | | <0.05 |
| < 10 years | 9.4 ± 10 | 23.2 ± 25 | |
| = 10 years | 47.2 ± 50 | 33.3 ± 36 | |
| > 10 years | 43.4 ± 46 | 43.5 ± 46 | |

**Table 2**
Categories of alcohol consumption (g/day) and mean IMT (mm ±1standard deviation) in men and women.

| **Men** | | | | |
|---|---|---|---|---|
| Total alcohol intake ≤ 20 g/d | | Total alcohol intake > 20 g/d | | |
| n (%) | IMT (mm) | n (%) | IMT (mm) | p |
| 62 (58%) | 0.669 ± 0.096 | 44 (42%) | 0.745 ± 0.073 | < 0.001 |
| **Women** | | | | |
| Total alcohol intake ≤ 10 g/d | | Total alcohol intake > 10 g/d | | |
| n (%) | IMT (mm) | n (%) | IMT (mm) | p |
| 59 (55%) | 0.678 ± 0.083 | 48 (45%) | 0.683 ± 0.088 | n.s. |

**Table 3**
Multiple linear regression analysis of daily alcohol intake and IMT in men (n = 106)

| Explanatory variables | **Model 1** | | **Model 2** | | **Model 3** | | **Model 4** | | **Model 5** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | β-estimate | p | β-estimate | p | β-estimate | p | β-estimate | p | β-estimate | p |
| Age (years) | 0.0038 | **< 0.001** | 0.0036 | **< 0.001** | 0.0033 | **< 0.001** | 0.0034 | **< 0.001** | 0.0040 | **< 0.001** |
| HDL-cholesterol (mg/dl) | -0.0037 | 0.65 | -0.0012 | 0.89 | 0.0007 | 0.94 | -0.0012 | 0.92 | -0.0017 | 0.88 |
| LDL-cholesterol (mg/dl) | -0.0015 | 0.84 | -0.0000 | 0.99 | 0.0004 | 0.96 | 0.0024 | 0.82 | -0.0022 | 0.83 |
| Systolic blood pressure (mm Hg) | | | 0.0112 | 0.18 | 0.0100 | 0.26 | 0.0066 | 0.54 | 0.0003 | 0.98 |
| Smoking status | | | 0.0083 | 0.77 | 0.0113 | 0.69 | 0.0094 | 0.81 | 0.0136 | 0.72 |
| Fasting glucose (mg/dl) | | | | | 0.0009 | 0.36 | 0.0003 | 0.79 | -0.0002 | 0.89 |
| Waist circumference (cm) | | | | | -0.0001 | 0.88 | 0.0012 | 0.40 | 0.0010 | 0.48 |
| Energy intake (kcal/day) | | | | | | | -0.0021 | 0.87 | -0.0095 | 0.47 |
| Meat and meat products (g/day) | | | | | | | 0.0052 | 0.67 | -0.0043 | 0.74 |
| Fruit and vegetables (g/day) | | | | | | | 0.0032 | 0.78 | 0.0051 | 0.65 |
| Physical activity (h/week) | | | | | | | 0.0075 | 0.48 | 0.0021 | 0.85 |
| Lipoprotein(a) (mg/dl) | | | | | | | | | -0.0011 | 0.92 |
| Alcohol consumption (g/day] | 0.0253 | **<0.05** | 0.0247 | **<0.05** | 0.0242 | **<0.05** | 0.0251 | **<0.05** | 0.0274 | **<0.05** |

Model 1 adjusted for age, HDL-cholesterol, and LDL-cholesterol
Model 2 adjusted for model 1 + systolic blood pressure and smoking status
Model 3 adjusted for model 2 + fasting glucose and waist circumference
Model 4 adjusted for model 3 + daily intake of energy, meat and meat products, fruit and vegetables, and physical activity
Model 5 adjusted for model 4 + lipoprotein(a)

Figure 1: Daily alcohol intake in men and women according to categories of alcohol consumption.

Figure 2: Frequency of alcohol consumption in men and women.

Figure 3: Relation between alcohol intake (g/Day) and IMT (mm) in men and women.

Figure 1

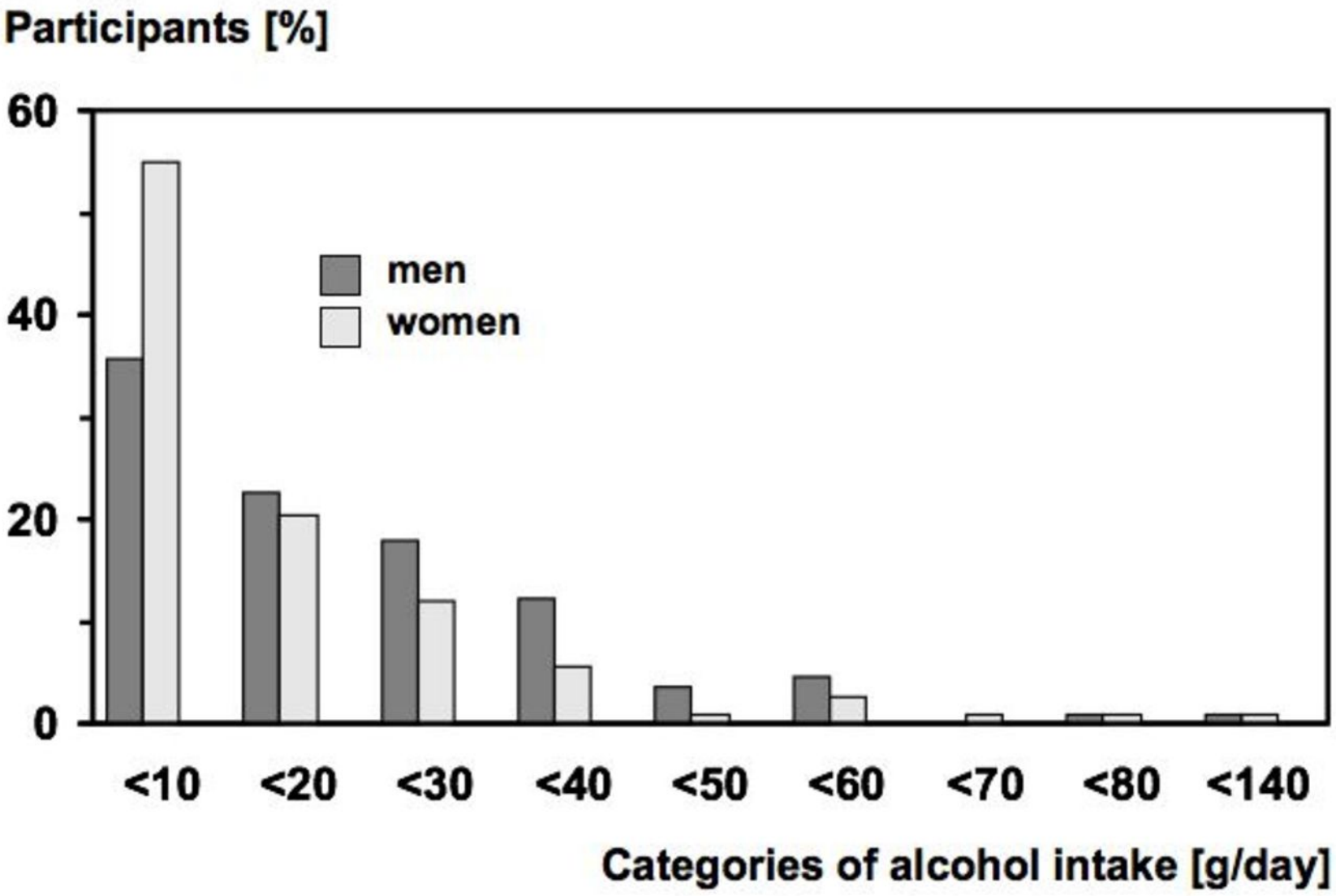

Participants [%]
60
40
20
0
men
women
<10
<20
<30
<40
<50
<60
<70
<80
<140
Categories of alcohol intake [g/day]

**Figure 2**

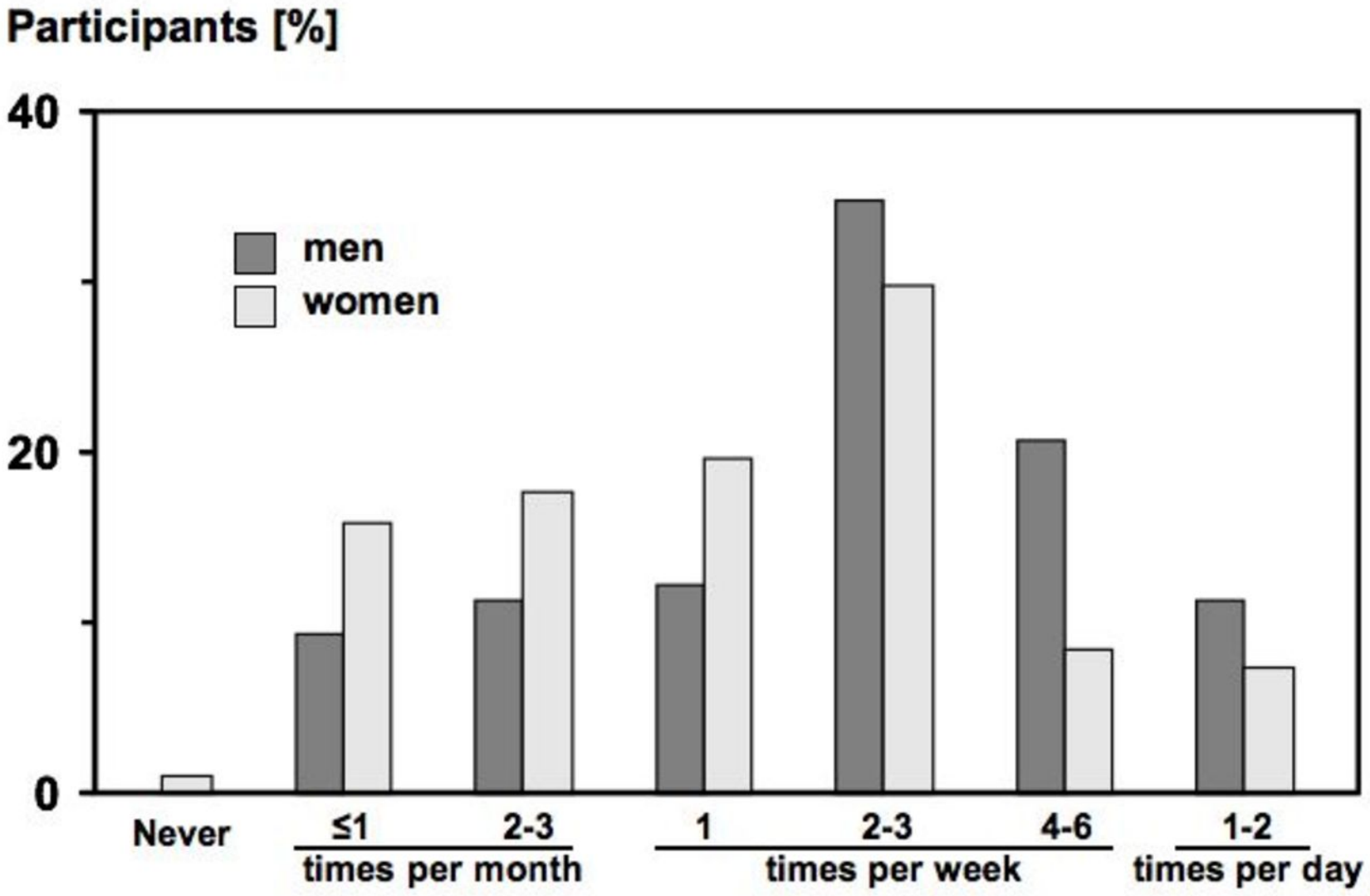
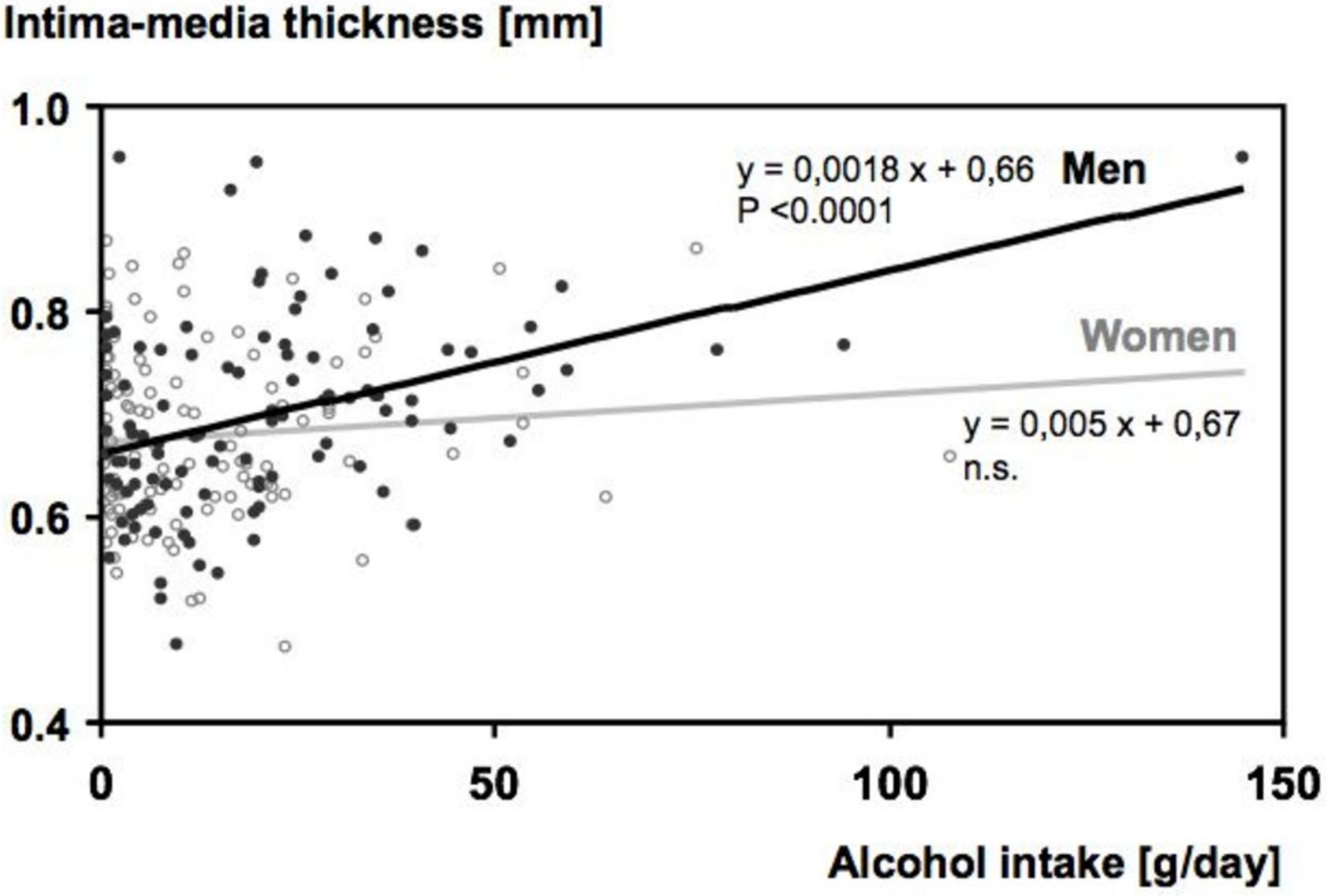

Participants [%]
40
20
0
men
women
Never
≤1
2-3
times per month
1
2-3
4-6
times per week
1-2
times per day

**Figure 3**


Intima-media thickness [mm]
1.0
0.8
0.6
0.4
0
50
100
150
Alcohol intake [g/day]
y = 0,0018 x + 0,66
P <0.0001
Men
Women
y = 0,005 x + 0,67
n.s.