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Alcohol and blood pressure and its interaction with smoking and other behavioural variables: results from the MONICA Augsburg Survey 1984–1985

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Data from the Augsburg Survey 1984–1985 of the WHO-project Monitoring Trends and Determinants in Cardiovascular Disease (MONICA), a cross-sectional study on a two-stage cluster sample ($n = 5312$) of the 25–64-year-old population of the Augsburg study area, were analyzed with regard to alcohol consumption and blood pressure. Putative confounders such as age, body mass index, smoking, sporting activity and educational attainment were controlled for by multiple regression analyses. The main effect models showed that men aged 25–64 years consuming ≥ 80 g alcohol per day had, on average, 3–11 mmHg higher systolic blood pressure (SBP) values and 2–6 mmHg higher diastolic blood pressure (DBP) values compared with non-drinkers. Women consuming ≥ 40 g alcohol per day showed consistently higher SBP (2–6 mmHg) and DBP (1–5 mmHg) values compared with non-drinkers. In the group aged 55–64 years, no clear relationship was seen for SBP or DBP in men or women. Multiple regression models, allowing for interactions between alcohol consumption and the four behavioural variables: smoking; sporting activity; coffee consumption; and type A/B behaviour, showed a consistent interaction between alcohol consumption and smoking in men and women. Smoking modified the effect of alcohol on SBP and DBP in men by 2–8 mmHg and in women by 1–14 mmHg. These findings confirm those obtained for women in previous studies in Munich and Lübeck. Interactions between alcohol and sporting activity, coffee consumption and type A/B behaviour are less consistent.

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Introduction

A positive association between alcohol consumption and blood pressure has been reported in numerous clinical and epidemiological studies [1–11]. The relationship between alcohol use and blood pressure has been described as linear [5,6] or curvilinear [12]. A threshold effect has also been reported [3]. Occasionally, a J-shaped relationship between alcohol consumption and blood pressure has been found [9], indicating a protective effect of low-levels of alcohol consumption. With regard to high-alcohol consump-

tion, the studies are fairly uniform in reporting elevated blood pressure levels.

Obviously it is difficult to accurately assess alcohol consumption in epidemiological studies [13]. Furthermore, it is difficult to distinguish between the effects of alcohol and those of various accompanying life style factors such as obesity, smoking, coffee consumption, physical activity, educational attainment and Type A/B behaviour.

Data on the alcohol–blood pressure relationship in the Federal Republic of Germany are available from

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two cross-sectional studies: the Lübeck Blood Pressure Study (LBS) [9] and the Munich Blood Pressure Study (MBS) [10]. In both studies, putative confounders such as obesity, smoking, sporting activity and educational attainment were controlled for by multiple linear regression analyses. A J-shaped relationship between alcohol consumption and systolic blood pressure (SBP) was seen in Lübeck men. In women, strong interactions between age and alcohol consumption were found. For this reason, those aged 30–44 years and those aged 45–69 years were analyzed as separate groups. In the older age group, a strong interaction between alcohol consumption and smoking was found. Steep increases in the adjusted mean diastolic blood pressure (DBP) and SBP values were seen in women who smoked in the alcohol consumption category ≥ 20 g alcohol/day. A flat curve was seen for non-smoking women with regard to mean DBP and SBP values. These findings were replicated in the MBS data set [9].

Data from the MONICA Augsburg survey 1984–1985 [14] provide the opportunity to check whether the J-shaped relationship found in Lübeck men and the alcohol–smoking interaction found in Lübeck and Munich women persists in the MONICA Augsburg survey data. In addition, the Augsburg data set provides two additional broad behavioural variables, coffee consumption and Type A/B behaviour, which may also be important in consideration of the alcohol–blood pressure relationship. If alcohol consumption varies, for example with behaviour type, it may be the latter variable which produces the ‘alcohol effect’ [15].

Methods

Design of the first MONICA Augsburg Survey 1984–1985

The designs of the multinational World Health Organization MONICA project and the MONICA Augsburg project have been described in detail elsewhere [16,17]. The main objective of the first MONICA Augsburg survey 1984–1985 was the investigation of the prevalence and distribution of cardiovascular risk factors in the study area in order to establish baseline data for the 10-year monitoring of risk factors.

The study area was made up of the city of Augsburg and two adjacent counties in the south of the Federal Republic of Germany, with a population of 532 987 inhabitants in 1984. The study was restricted to those aged 25–64 years. The data-gathering phase lasted from October 1984 to May 1985. A two-stage cluster sample of 5312 persons of German nationality was drawn from a population of 282 279 inhabitants, aged 25–64 years.

In the city of Augsburg, an age-stratified random sample was drawn. In the two adjacent counties, 16 communities were randomly selected from a total of 68. In each of the 16 communities, an age-stratified random sample was drawn. Thus, the study population was represented by 5312 people consisting of eight, 10-year age–sex strata of 664 people each. A detailed description of the sampling methods is given elsewhere [17,18].

The data were gathered through interview, physical examination and self-administered questionnaire. A response of 79.3% was achieved, i.e. 4022 of the 5069 ‘available’ (5312 minus those who had died after sampling, minus errors in the population register, etc.) [14].

Blood pressure measurements

The Hawksley Random Zero Sphygmomanometer [19] (Hawksley & Sons Ltd, Lancing, UK) was used for blood pressure determinations. Three blood pressure recordings were taken after completion of the interview so that each person had been at rest in a sitting position for approximately 60 min before the first blood pressure recording was performed. Blood pressure was measured under the standardized conditions of the MONICA Manual [20] and the American Heart Association [21], with 3-min intervals between each measurement. Korotkoff phases I, IV and V and pulse rate were recorded. Three cuff sizes (bladder size 12×23 cm, 12×28 cm and 14×40 cm) were used according to the circumference of the right upper arm of the participant. All results concerning blood pressure values are based on the Korotkoff phases I and V and on the mean of the second and third blood pressure measurements.

Estimation of alcohol consumption

Each subject was asked how much beer, wine and spirits he or she had drunk on the previous workday and over the previous weekend. The questions on alcohol use were as follows: (1) How much beer, wine and spirits did you drink the previous weekend (Saturday and Sunday)? (2) How much beer, wine and spirits did you drink during the previous workday (or on the previous, Thursday, if Friday was the previous workday)?

Total alcohol usage was calculated by multiplying weekday consumption by five and adding this figure to weekend consumption. The following conversions were then made: 1 liter beer = 40 g alcohol; 1 liter wine = 100 g alcohol; 1 shot spirits (0.2 liters) = 6.2 g alcohol.

Finally, an average value for g alcohol/day consumed was derived.

Determination of putative confounding and effect modifying variables

Body mass index (BMI) was calculated as weight/height² (kg/m²) [22]. For determination of

body weight and height, participants were asked to remove shoes and heavy clothing. The following BMI categories were used: BMI <24, BMI 24–27, BMI ≥28.

A smoker was defined as someone who smoked currently or who had given up smoking within the last 6 months and who smoked or had smoked more than five cigarettes per day. When smoking is the main effect, smokers are separated into those who smoked more than 20 cigarettes per day and those who did not.

The degree of sporting activity was estimated by the following questions: 'How often are you sportingly active in the winter?' and 'How often are you sportingly active in the summer?' The following answers could be given: (1) regularly, more than 2 h per week; (2) regularly, 1–2 h per week; (3) less than 1 h per week; or (4) no sporting activities

The winter and summer responses have been combined to define one sport variable, whereby a responder is considered active in sport if he/she is active in summer and winter and, in at least one season, falls into one of the two more active categories.

Coffee consumption was assessed by the following questions: 'How many cups of coffee and how many cups of black tea do you usually drink per day?' The number of cups was given separately for tea and coffee. Since tea consumption was minimal, only the coffee variable is used here, dichotomizing into 0–3 or ≥4 cups per day.

Educational attainment was estimated by recording years of schooling completed, taking the German school system into account [23]. Educational attainment was dichotomized into ≤10 years and >10 years.

With some minor modifications, the Framingham scale has been used for the assessment of Type A behaviour. This scale has 10 items and shows high consistency with the structured interview by Rosenman and Friedman and with the Jenkins Activity Survey as tested by Haynes *et al.* [24]. For the present analyses, the Type A/B variable was dichotomized. To identify people with Type A behaviour, the same cut points were used as have been reported for the Framingham study [24,25]. In contrast to the other behavioural variables, Type A behaviour was measured by a self-administered questionnaire.

Exclusions from the analyses

From the 2023 men and 1999 women of the MONICA Augsburg survey, there were 27 men and 37 women who had missing values for one of the following variables: smoking, alcohol consumption, sporting activity, BMI and educational attainment. These 64 participants were eliminated from the regression analyses

which were, therefore, started with 1996 men and 1962 women.

When Type A/B behaviour was considered in the analysis, a further 127 men and 207 women who had incompletely filled out the self-administered questionnaire on psychosocial variables had to be eliminated. Thus, the regression analyses including Type A/B behaviour were run on 1869 men and 1755 women.

Statistical analysis

Since the sample for the MONICA Augsburg survey was stratified by sex and age and since the older groups were somewhat oversampled, age–sex specific analyses were performed. For the age–sex specific regression analyses, the fact that the sample was a two-stage cluster sample was ignored.

SBP and DBP were analyzed separately. First, as functions of categorical variables for alcohol consumption, BMI, education, smoking, sporting activity and a continuous age variable. In these models, six alcohol categories for men and four for women were used. The first models contained no interactions with the alcohol variable.

Models were then fitted to allow the alcohol effect to vary with either smoking level, sporting activity level, coffee consumption level or with Type A/B behaviour. However, the alcohol effect was allowed to vary in respect of only one of these variables at any time. The interaction terms in the models were simply the products of the alcohol and the behavioural dummy variables.

In these interaction models for men, only four alcohol categories were used to insure at least 20 subjects in each alcohol × 'behavioural' variable cell. The alcohol categories used for men were: 0 g/day; 1–39 g/day; 40–59 g/day; and ≥60 g/day. For women, there were not enough drinkers of ≥40 g/day in any one age decade to consider the various alcohol–behavioural variable interactions. Therefore, the two younger and the two older age groups were combined and models were fitted to age groups 25–44 and 45–64 years. In spite of this, there were still too few women in the 45–64 year age group (43 women) drinking ≥40 g/day to allow us to consider the interactions. Thus, for the 45–64 year age group, the following alcohol categories were used: 0 g/day; 1–19 g/day; and ≥20 g/day. For the 25–44 year age group, the following categories were used: 0 g/day; 1–19 g/day; 20–39 g/day; and ≥40 g/day. The alcohol interactions for women were considered by applying these categories.

The differences in the adjusted mean blood pressure values between various alcohol consumption categories and non-drinkers were tested in the main effect models. Additionally, the linear and quadratic trend of the adjusted mean blood pressure values in the alcohol consumption groups were considered by the method of orthogonal polynomials. Interactions were

assessed for strength and consistency over the alcohol consumption categories and for consistency over the age and sex groups.

The models were re-examined after excluding all participants on antihypertensive medication. This procedure did not substantially change the pattern of associations. Therefore, only the results obtained from the complete data set are presented here.

Results

Descriptive statistics

Hypertension is a major problem in the Augsburg area, with 19% of men and 15% of women in the 25–64-year-old age group either having blood pressure values ≥ 160 mmHg SBP and/or ≥ 95 mmHg DBP, or being on antihypertensive medication [14]. Alcohol consumption also has a high prevalence in Augsburg, with 87% of men and 62% of women aged 25–64 years reportedly drinking alcohol. Forty-one per cent of men and 7% of women consumed ≥ 40 g/day (Table 1). With regard to the 'behavioural' variables, Type A/B behaviour, sporting activity, coffee consumption and cigarette use, for men and women aged 25–64 years, showed the following results: the estimated frequency of Type A behaviour was 41% in men and 37% in women; 45% of men and 37% of women showed sporting activity; 31% of men and 32% of women usually drank ≥ 4 cups of coffee per day; and 40% of men and 22% of women were current cigarette smokers [14].

Figure 1 shows the crude mean SBP and DBP values by alcohol consumption categories, stratified by four,

10-year age and sex groups. In men, a clear increase in mean SBP and DBP values with increasing alcohol consumption can be seen for those aged 25–54 years. No clear relationship between alcohol consumption and SBP or DBP is depicted for those aged 55–64 years. For women, Fig. 1 shows small increases in mean SBP values with increasing alcohol consumption for those aged 25–54 years and small increases in mean DBP values for those aged 25–44 years. (The covariance adjusted mean SBP and DBP values for men and women — from the regression model without alcohol interactions — are practically identical with the crude values and have not been plotted.)

Regression analyses without alcohol interaction

The differences in adjusted mean SBP and DBP between various alcohol consumption categories and non-drinkers for men by age are shown in Table 2. For the three lower age groups, higher blood pressure values can be seen at nearly all consumption levels, with a fairly clear dose-response effect. The linear trends of the adjusted means were statistically significant ($P < 0.05$) in the three younger age groups, the trends increasing with increasing age. For the 55–64-year-old men, no clear relationship was seen.

Table 3 shows the differences in adjusted mean SBP and DBP between three alcohol consumption categories and non-drinkers for women by age. Fewer alcohol categories were considered because fewer women were considered as heavy drinkers. For the three lower age groups, increased SBP and DBP for alcohol consumption ≥ 40 g/day can be seen. The linear trend reached statistical significance ($P < 0.05$) only in those aged 35–44 years. As for men, in those aged 55–64 years, no clear association was seen.

Table 1. Per cent distribution of alcohol consumption categories and average daily alcohol consumption by age and sex. MONICA Augsburg Survey 1984–1985.

	Age group (years)	Alcohol consumption categories (g/day)							Mean alcohol consumption (g/day)
		n	0	1–19	20–39	40–59	60–79	≥ 80	
Men:	25–64	2017	13.0	23.0	23.2	19.3	11.1	10.4	36.4
	25–34	461	11.8	27.7	23.5	20.0	9.6	7.4	33.6
	35–44	485	13.9	21.5	22.1	17.6	11.9	13.1	38.8
	45–54	537	12.3	17.7	24.0	23.0	11.7	11.4	38.9
	55–64	534	14.4	25.3	23.2	16.0	11.5	9.6	33.9
Women:	25–64	1999	38.0	38.8	16.6	4.8	1.1	0.7	10.8
	25–34	463	35.0	42.2	15.2	5.7	1.1	0.8	10.9
	35–44	523	30.2	40.5	19.5	7.0	2.3	0.5	13.3
	45–54	515	42.7	38.0	15.0	2.8	0.8	0.8	9.5
	55–64	498	44.8	34.1	16.9	3.6	0.2	0.5	9.2

Weighted to allow for the two-stage cluster sampling scheme.

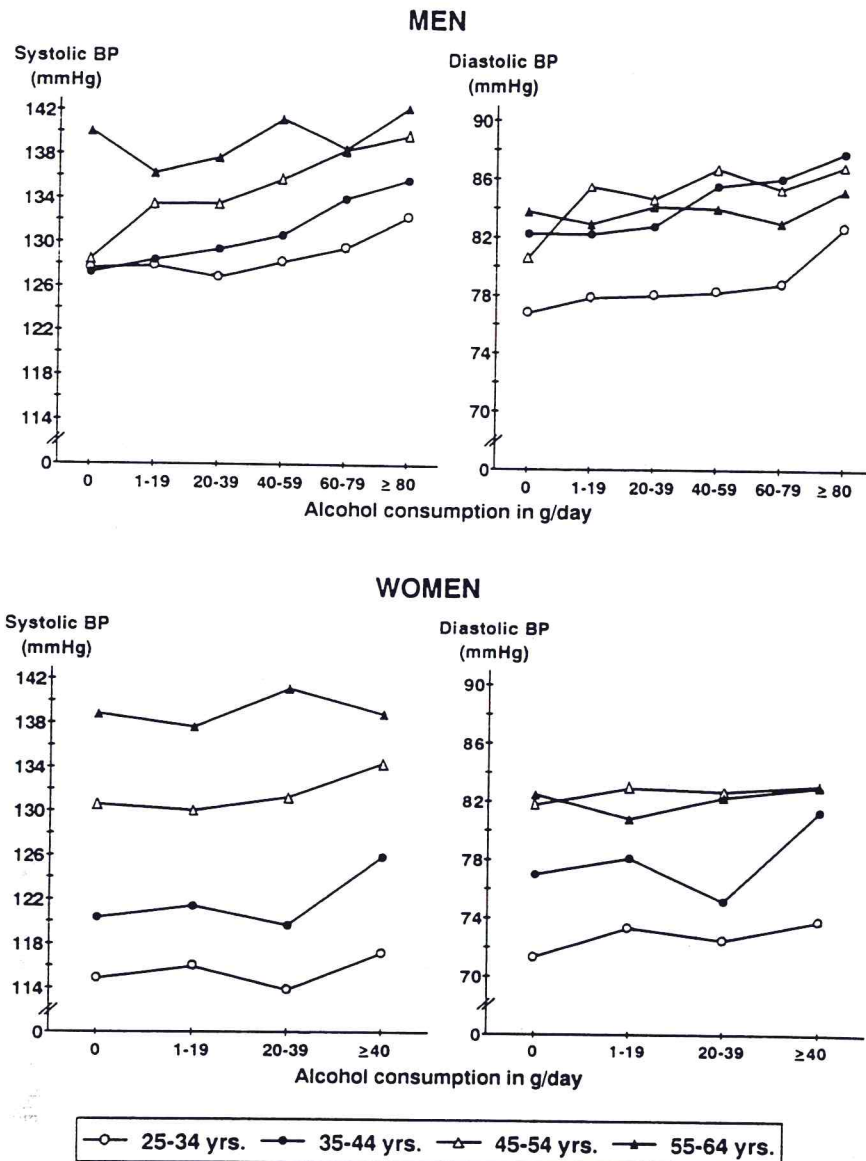


Fig. 1. Unadjusted mean systolic and diastolic blood pressure (BP) values by alcohol consumption categories stratified by 10-year age and sex groups. MONICA Augsburg Survey 1984–1985.

Regression analyses with interactions between alcohol and 'behavioural' variables

Smoking

Tables 4 and 5 show that the heavy alcohol consumption effect on blood pressure is consistently larger for smokers than for non-smokers for men in the four age groups and for women especially in those aged 45–64 years. The differences between smokers and non-smokers are: SBP, 2–14 mmHg; DBP, 1–8 mmHg. The blood pressure differences due to the heavy drinking effect were statistically significant between smokers and non-smokers for DBP in men aged 35–44 years ($P = 0.02$) and in women aged 45–64 years with respect to both SBP ($P < 0.01$) and DBP ($P = 0.01$).

Coffee consumption

There is no statistically significant interaction ($P > 0.05$) between alcohol and coffee consumption. Both positive and negative trends were seen (Tables 4 and 5).

Sporting activity

The alcohol–sporting activity interaction models could not discern a consistent picture over all the categories. Only the 'heavy' alcohol consumption–blood pressure relationship is consistently modified by sporting activity in that a decrease of the positive 'heavy' alcohol consumption effect on blood pressure is seen among

Table 2. Difference in adjusted† mean blood pressure between various alcohol consumption categories and non-drinkers. Men by age (n = 1996). MONICA Augsburg Survey 1984–1985.

Age group (years)	n	Blood pressure (mmHg)	Alcohol consumption category (g/day)				
			1-19	20-39	40-59	60-79	≥ 80
Men:							
25-34	455	SBP	1	0	1	2	5
		DBP	2	2	2	4	5*
		(n)	(126)	(110)	(90)	(43)	(35)
35-44	482	SBP	1	3	3	7**	8**
		DBP	0	1	3	3	5**
		(n)	(104)	(104)	(85)	(57)	(63)
45-54	531	SBP	4	4	7**	10**	11**
		DBP	4*	3*	5**	5**	6**
		(n)	(92)	(130)	(125)	(60)	(59)
55-64	528	SBP	-5	-2	1	-2	3
		DBP	-1	0	0	-1	2
		(n)	(136)	(123)	(84)	(59)	(50)

* $P < 0.05$, ** $P < 0.01$, drinkers versus non-drinkers. †Adjusted for age (continuous), body mass index (three categories), education (two categories), sporting activity (two categories) and smoking (three categories). SBP, systolic blood pressure; DBP, diastolic blood pressure.

Table 3. Difference in adjusted† mean blood pressure between various alcohol consumption categories and non-drinkers. Women by age (n = 1962). MONICA Augsburg Survey 1984–1985.

Age group (years)	n	Blood pressure (mmHg)	Alcohol consumption category (g/day)		
			1–19	20–39	≥ 40
Women:					
25–34	438	SBP	1	0	3
		DBP	1	2	3
		(n)	(182)	(70)	(36)
35–44	517	SBP	1	1	6**
		DBP	1	–1	5**
		(n)	(206)	(103)	(50)
45–54	511	SBP	0	1	6
		DBP	2	1	3
		(n)	(193)	(76)	(22)
55–64	496	SBP	–1	2	2
		DBP	–2	0	1
		(n)	(170)	(81)	(20)

** $P < 0.01$, drinkers versus non-drinkers. †Adjusted for age (continuous), body mass index (three categories), education (two categories), sporting activity (two categories) and smoking (three categories). SBP, systolic blood pressure; DBP, diastolic blood pressure.

the sportingly active subjects with the exception of women aged 45–64 years (Tables 4 and 5).

Type A/B behaviour

The analyses show inconsistent patterns of alcohol-behaviour type interactions, sometimes positive, sometimes negative and, for 25–34-year-old men, even in opposite directions for SBP and DBP (data not shown).

Table 4. Differences in adjusted† mean blood pressure between heavy drinkers (≥ 60 g/day) and non-drinkers by various variables. Men by age. MONICA Augsburg Survey 1984–1985.

Age group (years)	Blood pressure (mmHg)	Main effect model†	Smoker		Sporting activity		Coffee consumption ≥ 4 cups/day	
			No	Yes	No	Yes	No	Yes
Men:								
25–34	SBP	3	0	6	3	3	4	2
	DBP	4	3	6	5	4	5	3
	(n) +	(78)	(36)	(42)	(38)	(40)	(47)	(31)
35–44	SBP	7	6	10	9	4	8	5
	DBP	4	1	9*	5	4	4	4
	(n) +	(120)	(61)	(59)	(72)	(48)	(89)	(31)
45–54	SBP	11	10	12	12	8	7	16
	DBP	6	5	7	6	5	4	10
	(n) +	(119)	(67)	(52)	(85)	(34)	(95)	(24)
55–64	SBP	0	0	2	2	–5	–1	3
	DBP	1	0	3	1	–1	–1	4
	(n) +	(109)	(65)	(44)	(82)	(27)	(83)	(26)

* $P = 0.02$, versus respective 'no' cell. †Adjusted for the variables in the main effect model and for coffee consumption when interaction with this variable was analysed. ‡Includes four alcohol categories (0, 1–19, 40–59, ≥ 60 g/day), age (continuous), three body mass index categories, two education categories, two sporting activity categories and three smoking categories. †Number of heavy drinkers (≥ 60 g/day) in the respective cells. SBP, systolic blood pressure; DBP, diastolic blood pressure.

Table 5. Differences in adjusted† mean blood pressure between heavy drinkers§ and non-drinkers by various variables. Women by age. MONICA Augsburg Survey 1984–1985.

Age group (years)	Blood pressure (mmHg)	Main effect model†	Smoker		Sporting activity		Coffee consumption ≥ 4 cups/day	
			No	Yes	No	Yes	No	Yes
Women:								
25–44	SBP	5	4	9	7	3	5	5
	DBP	4	4	5	7	1*	4	3
	(n) +	(86)	(63)	(23)	(41)	(45)	(51)	(53)
45–64	SBP	2	1	15**	0	7	2	0
	DBP	1	0	7*	0	3	1	–2
	(n) +	(199)	(176)	(23)	(143)	(56)	(157)	(42)

* $P = 0.01$, ** $P < 0.01$, versus respective 'no' cell. †Adjusted for the variables in the main effect model and for coffee consumption when interaction with this variable was analysed. ‡Includes four or three alcohol categories (0, 1–19, 20–39, ≥ 40 g/day), age (continuous), three body mass index categories, two education categories, two sporting categories and three smoking categories. †Number of heavy drinkers in the respective cells. §Heavy drinkers aged 25–44, ≥ 40 g/day; aged 45–64, ≥ 20 g/day. SBP, systolic blood pressure; DBP, diastolic blood pressure.

Discussion

The main-effect linear regression models of the alcohol–blood pressure relationship controlled for age, BMI, smoking, education and sporting activity

clearly showed higher SBP and DBP values at nearly all alcohol consumption levels for men in the three lower age groups compared with non-drinkers, with a fairly clear dose-response relationship. The differential is highest in the highest consumption pattern group. In men, aged 55–64 years, no consistent pattern emerged.

In women, fewer alcohol categories were considered because of the lesser number of heavy drinkers among women. For the three lower age groups, small increases in SBP and DBP values for alcohol consumption ≥ 40 g/day were found. For those in the 55–64 year age group, no consistent pattern emerged as for the men.

Obviously, the results obtained from the MONICA Augsburg data set confirm the alcohol-blood pressure relationship found in the LBS and MBS data sets [9,10]. However, the clear J-shaped curve found for LBS men could not be confirmed in the present study [9].

The regression models that allowed for interactions revealed that the alcohol-blood pressure relationship persisted in the MONICA Augsburg data set after consideration, one at a time, of each of the four variables: smoking; sporting activity; coffee consumption; and Type A/B behaviour. Only smoking showed a consistent interaction with the alcohol-blood pressure relationship, with smokers showing a 2–14 mmHg (SBP) and 1–8 mmHg (DBP) increase in 'high' alcohol consumption effect compared with non-smokers. The tests of the differences between smokers and non-smokers were mostly non-significant because of small numbers in the cells. However, the consistency of this interaction with smoking across age and sex groups is impressive and should be noted despite the lack of statistical significance. In the LBS and MBS data sets, this interaction was only found in older women [9], whereas in the MONICA Augsburg data set it is found in all age groups for men and in women aged 25–44 and 45–64 years. As this alcohol-smoking interaction has now consistently been found in three Federal Republic of Germany data sets, it can hardly be discarded as a chance finding. However, one must keep in mind that the three surveys are cross-sectional studies.

Given the high prevalence of hypertension in the population studied, an important possible source of bias is that hypertensives might reduce their alcohol consumption on 'physicians orders'. This would tend to weaken the alcohol-blood pressure relationship if there was a long-term relationship since some of those with high blood pressure may have been heavier drinkers and are now misclassified in a 'long-term' sense as not being heavy drinkers. Furthermore, many of these former heavy drinkers would have been prescribed antihypertensive medication, further complicating the relationship under study. To account for this problem, several studies have included a medication independent variable in the model or, more of-

ten, excluded all those who reported use of antihypertensive medication. We adopted the latter procedure and re-ran our final blood pressure models omitting all those who reported use of such medication. As the alcohol-blood pressure relationships were not essentially changed by this procedure, we prefer to report our models based on the complete data set.

A physiological interpretation of the modifying role of smoking on the alcohol-blood pressure relationship is difficult. However, it is conceivable that an increased sympathetic tone associated with smoking interacts with the alcohol effect on blood pressure.

Sporting activity also had a fairly consistent modifying effect, albeit weak, on the alcohol-blood pressure relationship in the Augsburg data set. High alcohol consumption had a somewhat stronger effect on blood pressure among the non-active, thus confirming findings from the LBS data set [9]. However, in women aged 45–64 years, high alcohol consumption had a stronger effect on blood pressure among the sportingly active. Only after replicating such a finding in other studies should this be interpreted.

The alcohol-behaviour type interactions show an inconsistent pattern and, thus, one may conclude that behaviour type is not an effect modifier of the alcohol-blood pressure relationship. Further analyses showed that neither is it a confounder.

A tendency for a J-shaped alcohol-blood pressure relationship was seen only in those men and women aged 55–64 years. Higher blood pressure values in non-drinkers may be explained by the hypothesis that this group, in addition to lifelong abstainers, also comprises previous heavy drinkers, those who lied about their alcohol intake and those who were too ill to drink.

The physiological mechanisms underlying the alcohol-blood pressure relationship are not yet clear [11,26–28]. 'The most attractive theory on present evidence to explain the mechanism of alcohol induced hypertension is that of a direct effect of alcohol on vascular smooth muscle, perhaps mediated by calcium influx' [26].

If the effect of smoking on the alcohol-blood pressure relationship, suggested by this and a previous report [9], is confirmed by future prospective cohort studies, the findings will have important implications concerning the advice to hypertensives regarding life style changes, i.e. to stop smoking and reduce alcohol consumption.

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