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Food and Nutrient Intake, Anthropometric Measurements and Smoking according to Alcohol Consumption in the EPIC Heidelberg Study

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Key Words
EPIC Heidelberg · Alcohol consumption · Dietary intake · Body mass index · Smoking

Abstract
Aims: The study was carried out to determine associations of reported alcohol intake with dietary habits, body mass index, waist-to-hip ratio (WHR) and smoking. ***Subjects and Methods:*** 24,894 subjects who participated in the baseline examination of the German part of the European Prospective Investigation into Cancer and Nutrition (EPIC) in Heidelberg and were between 35 and 65 years of age at baseline were included in the present cross-sectional analysis (11,617 men, 13,277 women). Diet and alcohol consumption were assessed with a semiquantitative food frequency questionnaire. Analysis of covariance with age as a covariate was used to analyse the association between alcohol intake and dietary consumption patterns, BMI, WHR and smoking. ***Results:*** Alcohol did not replace other food items, but was an addition to the diet. Among alcohol consumers, fat and protein intake as a percentage of energy was slightly higher and carbohydrate intake was slightly lower than among abstainers. Alcohol consumers had a lower intake of fruits, dairy products, cereal products, and added vegetable fat and a higher intake of animal products such as meat, fish, eggs and added animal fat than abstainers. The prevalence of current smoking showed a U-shaped relation to alcohol intake in men and women. In men, a U-shaped association was also seen between the prevalence of former smoking and alcohol intake, while the prevalence of former smoking increased linearly with alcohol intake in women. ***Conclusion:*** The results show that alcohol consumption is associated with dietary consumption patterns and smoking. Therefore, it will be important to consider dietary patterns and other lifestyle parameters when investigating the health effects of alcohol intake in the future.

Introduction

Alcohol consumption in Germany is high compared to other countries (Germany: 9.9 litres of ethanol per capita, USA: 6.8 litres per capita) [1]. Nearly 23% of all deaths are attributable to alcohol consumption. The median age at death of all deaths exclusively due to alcohol is 15 years below the median age at death in the male and 24 years below the age at death in the female population, respectively [2].

The consequences of alcohol consumption on health have been extensively studied. On the one hand, high amounts of alcohol consumption increase the risk for chronic diseases such as hypertension, stroke, osteoporo-

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sis and various cancers such as cancers of the upper gastrointestinal tract, breast and colorectal cancer [3], and on the other hand, a moderate alcohol intake is associated with lower cardiovascular morbidity and mortality [4]. Bagnardi et al. [5] reported that alcoholic beverages increased strongly the risk of cancers of the oral cavity, pharynx, oesophagus and larynx. Less strong direct relations were observed for cancers of the stomach, colon, rectum, liver, breast and ovary. These risks were essentially due to total ethanol intake and tended to increase with the amount of alcohol consumed. Alcohol intake combined with smoking also increased the risk of laryngeal, lung and bladder cancers [5]. These cancer sites occurred more often in men than in women presumably because of the higher tobacco and alcohol intake of men [6].

Many studies investigated alcohol as a risk factor but did not regard the nutritional behaviour and the changes in dietary patterns caused by alcohol consumption [5, 2, 7, 8]. Factors which are associated with alcohol intake, e.g. food intake, could influence the relationship between alcohol and diseases.

To further elucidate the effects of alcohol consumption on cancer risk it is important to understand the association between alcohol intake and other risk factors. Therefore, it was the aim of the present study to analyse the association between alcohol intake, dietary habits, anthropometric measurements and smoking habits.

Subjects and Methods

Subjects for the Heidelberg component of the German EPIC (European Prospective Investigation into cancer and nutrition) cohort were recruited from a random sample of the general population through population registries. Recruitment procedures have been reported in detail [9]. In short, potential participants between 40 and 65 years of age for men and between 35 and 65 years for women were invited by mail to the study centre in Heidelberg. The resulting participation rate was about 38%. Baseline assessment was carried out from June 1994 to October 1998. In total, 25,543 study participants were registered. Dietary habits and consumption of alcoholic beverages during the previous 12 months were assessed by a self-administered validated food frequency questionnaire [10]. Socio-demographic data, smoking habits, physical activity and medical history were assessed through a self-administered lifestyle questionnaire and an interview. Anthropometric measures were obtained according to standard procedures [11].

For the present analysis, all men aged 40–65 years of age and all women aged 35–65 years were selected, resulting in 25,536 subjects (11,924 men, 13,612 women). Seven subjects of the total 25,543 participants were excluded, because they did not fall into the appropriate age range. Subjects with extreme reported energy intake values (men <4.12 or >20.16 MJ/day, women <3.28 or >15.85 MJ/day) (241 men, 273 women) and subjects with missing BMI, waist-to-hip ratio (WHR = waist circumference in cm/hip circumference in cm) and smoking status (66 men, 62 women) were excluded. The final study sample comprised 24,894 subjects (11,617 men, 13,277 women). Besides food consumption and alcohol intake the analysis included BMI (BMI = body weight in kg/height in m^2) and smoking habits (current, ex or never). The number of cigarettes smoked per day was not taken into account.

The intake of energy, macronutrients and fibre was calculated with the aid of the German Food Code (BLS II.3) [12]. Alcohol intake (g/day) was estimated from the consumed alcoholic beverages (ml/day of wine, beer, spirits) using a weighted average of the alcohol content of alcoholic beverages of the German Food Code. For example for the calculations one glass of beer (0.33 l) was defined to contain 11.65 g, one glass of wine (0.25 l) 25 g and one glass of spirits (0.02 l) 7 g ethanol, respectively.

Subjects were categorized according to their estimated daily alcohol intake. Cut-off points of the six groups were 0, 5, 10, 20, 40 and >40 g ethanol/day. The group classifications were <0.01, 0.01–4.99, and 5.00–9.99 g ethanol/day, etc.

The general linear model ANCOVA (analysis of covariance) with age categorized in 5-year age groups as a covariate was used to calculate age-adjusted means of energy intake, nutrient intake, food consumption, smoking status and physical activity level according to each of the six alcohol categories. Statistical significance was tested using a test for linear trend. p values <0.05 were considered to be statistically significant.

The analysis was performed using SAS® statistical software package version 8.0 (SAS Institute, Cary, N.C., USA).

Results

Alcohol Consumption

In this German population of middle-aged men and women the mean daily alcohol intake was 25.6 g/day (standard error = 0.25 g) in men and 10.6 g/day (standard error = 0.12 g) in women. 5.1% of all men and 5.9% of all women were abstainers. The largest number of men (n = 2,868; 24.7%) was found in the fifth alcohol group (20–39.99 g ethanol/day), whereas the largest number of women (n = 5,655; 42.6%) was found in the second alcohol group (0.01–4.99 g ethanol/day). A daily consumption of 40 g of ethanol or more was reported by 22.4% of the male and 5.1% of the female participants.

Alcohol Consumption, Age, Anthropometric Measurements and Smoking Status

In men, a positive linear trend was observed between age and the amount of alcohol consumed ($p < 0.0001$) but overall there were only slight differences in age of approximately 1–3 years, between the alcohol groups in men and in women.

Table 1. Age-adjusted geometric mean of body composition and smoking status of the study population according to alcohol consumption

	Alcohol consumption g/day						Test for trend p value
	0	0.01–4.99	5.00–9.99	10.00–19.99	20.00–39.99	≥40.00	
Men	592	1,718	1,490	2,353	2,868	2,596	
Age at baseline, years[1]	51.8	51.7	51.6	52	51.9	53.0	<0.0001
BMI, kg/m^2	26.6	26.8	26.8	26.5	26.6	26.9	0.2812
WHR	0.94	0.94	0.94	0.93	0.94	0.95	<0.0001
Smoking status							
Current smoker, %	33.6	25.8	24.4	24.3	29.3	34.3	
Ex-smoker, %	43.4	36.6	38.3	41.4	43.0	44.3	
Never-smoker, %	23.0	37.6	37.3	34.3	27.7	21.4	
Women	783	5,655	2,335	2,248	1,584	672	
Age at baseline, years[1]	51.1	48.9	48.4	48.7	49.0	50.4	0.4589
BMI, kg/m^2	25.8	25.5	24.9	24.5	24.2	24.6	<0.0001
WHR	0.82	0.80	0.80	0.79	0.80	0.81	0.0028
Smoking status							
Current smoker, %	24.3	20.8	21.0	23.3	27.1	35.0	
Ex-smoker, %	19.9	24.7	31.0	33.3	33.8	36.7	
Never-smoker, %	55.8	54.5	48.0	43.4	39.1	28.3	

[1] Mean not adjusted for age.

BMI was similar in all alcohol groups in men (n.s.), but decreased with alcohol intake in women ($p < 0.0001$). In women, the mean BMI of heavy alcohol consumers was 1.2 kg/m^2 lower than the mean BMI of abstainers (24.6 vs. 25.8 kg/m^2). Differences in WHR between the alcohol consumption groups were in the magnitude of 0.01–0.03 in men and women and therefore do not seem to have any major biological importance (table 1).

In men, the prevalence of current smokers as well as the prevalence of ex-smokers showed a U-shaped relation to alcohol intake (table 1). The prevalence of current smokers was lowest in men consuming between 10.00 and 19.99 g ethanol/day (24.3%) whereas the prevalence of ex-smokers was lowest in men consuming between 0.01 and 4.99 g ethanol/day (36.6%). Abstainers and heavy drinkers showed very similar prevalence of current and ex-smokers, respectively (33.6 vs. 34.3% and 43.4 vs. 44.3%).

In women, the prevalence of current smoking also showed a U-shaped relation to alcohol intake with the lowest smoking prevalence among women consuming between 0.01 and 4.99 g ethanol/day (20.8%). In contrast to men, however, the percentage of current smokers was higher in subjects with a high alcohol intake compared to abstainers (35.0 vs. 24.3%). The prevalence of ex-smokers increased while the percentage of never-smokers decreased constantly with higher alcohol intake. The respective percentages in abstainers and in women with the highest alcohol intake were 19.9 vs. 36.7 and 55.8 vs. 28.3%, respectively (table 1).

Alcohol Consumption and Nutrient Intake

Men had a higher intake of total energy, carbohydrate, protein, fat and fibre than women. Total energy intake was significantly associated with alcohol intake in men and in women ($p < 0.0001$) and showed large differences of 1.8 MJ/day (430 kcal/day) for men and 1.4 MJ/day (335 kcal/day) for women between subjects consuming low amounts of alcohol (0.01–4.99 g/day) and those consuming >40.00 g/day. Energy intake from food was only marginally lower in subjects with high alcohol intake compared to those with no or low alcohol intake in both genders (table 2).

With high alcohol intake the consumption of total carbohydrate, fat and fibre intake was lower in men and protein intake showed a U-shaped relation. In women, carbohydrate and fibre consumption was also lower and protein intake was higher with increasing alcohol intake whereas fat intake was highest in subjects in the mid-range of alcohol intake. All these differences were gener-

Table 2. Age-adjusted geometric mean of total energy, macronutrient and fibre intake according to alcohol consumption in men (n = 11,617) and women (n = 13,277)

	Alcohol consumption, g/day						Test for trend p value	Differences[1] g/d
	0	0.01–4.99	5.00–9.99	10.00–19.99	20.00–39.99	≥40.00		
Men	592	1,718	1,490	2,353	2,868	2,596		
Total energy, MJ/day	8.96	8.22	8.31	8.42	8.82	10.02	<0.0001	+1.06
Energy from food, MJ/day	8.96	8.15	8.08	7.98	7.96	8.14	0.0668	–0.82
Carbohydrate, g/day	249.6	226.5	222.6	218.6	216.3	223.2	0.0001	–26.4
Protein, g/day	79.3	72.8	72.9	72.8	73.9	77.2	<0.0001	–2.1
Fat, g/day	84.9	77.7	77.8	77.4	77.4	76.8	0.0867	–8.1
Fibre, g/day	22.2	20.7	20.6	20.2	19.5	18.3	<0.0001	–3.9
Alcohol from beverages, g/day	0	1.59	7.42	14.50	27.77	59.79	<0.0001	+59.79
Total alcohol, g/day	0.18	1.97	7.71	14.77	28.03	60.09	<0.0001	+59.91
Energy from protein, %[2]	15.3	15.4	15.6	15.7	16.0	16.3	<0.0001	+1.0
Energy from carbohydrates, %[2]	47.9	47.7	47.2	46.9	46.5	47.0	<0.0001	–0.9
Energy from fat, %[2]	35.7	35.8	36.1	36.3	36.4	35.4	<0.0001	–0.3
Women	783	5,655	2,335	2,248	1,584	672	<0.0001	
Total energy, MJ/day	6.67	6.75	6.95	7.09	7.37	8.15	0.0028	+1.48
Energy from food, MJ/day	6.67	6.69	6.73	6.65	6.56	6.49	<0.0001	–0.18
Carbohydrate, g/day	187.8	186.5	183.8	181.1	177.2	171.8	0.0006	–16.0
Protein, g/day	57.9	58.6	59.9	60.0	60.2	61.0	0.4650	+3.1
Fat, g/day	62.8	64.2	66.0	65.1	64.3	63.7	<0.0001	+0.9
Fibre, g/day	18.8	18.8	18.5	18.1	17.4	16.0	<0.0001	–2.8
Alcohol from beverages, g/day	0	1.31	7.38	14.19	26.28	53.64	<0.0001	+53.64
Total alcohol, g/day	0.11	1.62	7.61	14.43	26.52	53.92	<0.0001	+53.81
Energy from protein, %[2]	15.1	15.1	15.3	15.5	15.7	16.2	<0.0001	+1.1
Energy from carbohydrates, %[2]	48.4	47.7	48.7	46.6	46.2	45.4	<0.0001	–3.0
Energy from fat, %[2]	35.3	36.0	36.7	36.6	36.7	36.7	<0.0001	+1.4

[1] Mean % based on total energy intake from food.
[2] Difference between the intake of abstainers and the subjects of the highest alcohol category.

ally small. They varied between 5 g/day for fat and protein, 3 g/day for fibre and 20 g/day for carbohydrates (table 2).

Differences between the alcohol consumption categories in the non-alcoholic energy percentages derived from fat, protein and carbohydrate were also relatively small especially in men. In men, a maximum difference of about 1% was observed. In women, differences were slightly higher with a maximum difference of about 3% for energy from carbohydrates (table 2).

Alcohol Consumption and Food Intake

Dietary patterns were different between men and women. Compared with women, men had a higher intake of legumes, dairy products, cereal products, meat and meat products, fish, eggs and vegetable fats. Women consumed more vegetables and fruits. These differences did not change from abstainers to alcohol drinkers except for dairy products. Women with moderate or high alcohol intake consumed more dairy products than men of the respective alcohol consumption categories.

Differences in intake observed between alcohol consumption categories were generally larger for food groups than for nutrients. Men and women who consumed high amounts of alcohol had a lower intake of fruits, dairy products, cereal products, vegetable fat and non-alcoholic beverages compared to abstainers (e.g. fruits: men 96.7 vs. 130.7 g/day ($p < 0.0001$); women 112.3 vs. 141.4 g/day ($p < 0.0001$) (table 3)).

Higher intakes were observed for animal products such as meat, fish, eggs and animal fat in men and women with a high alcohol intake (table 3).

Table 3. Age-adjusted geometric mean of food intake according to alcohol consumption in men and women

	Alcohol consumption, g/day						Test for trend p value	Differences[1] g/d
	0	0.01–4.99	5.00–9.99	10.00–19.99	20.00–39.99	≥40.00		
Men	592	1,718	1,490	2,353	2,868	2,596		
Potatoes, g/day	11.94.7	11.92.4	11.94.7	11.92.8	11.94.6	11.97.2	0.0048	+2.5
Vegetables, g/day	1.118.4	1.112.6	1.110.3	1.112.8	1.113.1	1.114.0	0.1814	+4.4
Legumes, g/day	11.19.0	111.7.5	111.7.5	111.7.7	111.7.9	11.18.5	0.0012	–0.5
Fruits, g/day	1.130.7	1.122.4	1.118.3	1.116.1	1.109.5	96.7	<0.0001	–34.0
Dairy products, g/day	1.303.3	1.281.8	1.265.7	1.229.1	1.214.1	188.8	<0.0001	–114.5
Cereals, cereal products, g/day	1.228.7	1.217.1	1.216.3	1.215.3	1.211.1	200.9	<0.0001	–27.8
Meat, meat products, g/day	1.123.7	1.107.2	1.109.0	1.113.4	1.119.0	132.2	<0.0001	+8.5
Fish and seafood, g/day	11.20.3	11.19.8	11.21.9	11.22.3	11.23.2	24.8	<0.0001	+4.5
Eggs, g/day	11.16.5	11.13.5	11.14.0	11.14.4	11.15.6	17.2	<0.0001	+0.7
Non-alcoholic beverages, g/day	1,895.1	1,600.9	1,516.8	1,465.1	1,409.6	1369.8	<0.0001	–525.3
Fats and oils, g/day	11.24.2	11.22.9	11.23.6	11.23.2	11.23.4	23.0	0.9674	–1.2
Animal fat	111.8.4	111.9.2	111.9.3	111.9.7	11.10.2	9.6	0.0391	+1.2
Vegetable fat	11.14.6	11.12.6	11.13.0	11.12.2	11.11.9	12.0	0.0044	–2.6
Women	783	5,655	2,335	2,248	1,584	672		
Potatoes, g/day	11.80.3	11.77.3	11.74.7	11.73.1	11.73.5	70.2	<0.0001	–10.1
Vegetables, g/day	1.126.4	1.121.9	1.122.5	1.122.7	1.126.3	129.3	0.0085	+2.9
Legumes, g/day	111.4.6	111.4.5	11.14.6	111.4.7	111.4.9	5.3	0.0008	+0.7
Fruits, g/day	1.141.4	1.142.6	1.134.4	1.131.3	1.128.1	112.3	<0.0001	–29.1
Dairy products, g/day	1.289.9	1.259.9	1.253.4	1.244.7	1.233.6	202.3	<0.0001	–87.6
Cereals, cereal products, g/day	1.173.7	1.177.9	1.179.7	1.176.4	1.171.9	162.0	0.0029	–11.7
Meat, meat products, g/day	11.67.9	11.71.3	11.72.7	11.73.5	11.76.8	84.7	<0.0001	+16.8
Fish and seafood, g/day	11.14.1	11.15.7	11.17.1	11.17.7	11.19.2	20.5	<0.0001	+6.4
Eggs, g/day	11.10.9	11.11.6	11.13.1	11.13.7	11.14.9	16.6	<0.0001	+5.7
Non alcoholic beverages, g/day	1,700.9	1,635.5	1,580.5	1,579.0	1,539.8	1567.6	<0.0001	–133.3
Fats and oils, g/day	11.20.8	11.20.9	11.21.6	11.21.1	11.21.8	21.8	0.0007	+1.0
Animal fat	111.8.8	111.9.4	11.10.1	11.10.0	11.10.4	9.9	<0.0001	+1.1
Vegetable fat	11.11.2	11.10.8	11.10.7	11.10.4	11.10.5	11.1	0.3091	–0.1

[1] Difference between the intake of abstainers and the subjects of the highest alcohol category.

Alcohol Intake, BMI and Diet Stratified by Smoking Status

Among men, 28.5% (n = 3,307) of all participants were current smokers, 41.5% (n = 4,817) were ex-smokers and 30.0% (n = 3,493) were never-smokers. Among women the percentages were 22.9% (n = 3,044), 28.7% (n = 3,808) and 48.4% (n = 6,425), respectively.

In all smoking groups, the largest number of women was found in the lowest alcohol consumption category of 0.01–4.99 g/day (between 36.7 and 47.9% depending on smoking status). In men, however, the largest number of subjects was found in the highest alcohol consumption group for current smokers (26.9%, n = 890), in the second highest alcohol consumption group for ex-smokers (25.6%, n = 1,235) and in the third highest alcohol consumption group for never-smokers (23.1%, n = 807).

Figure 1 shows the association between BMI and alcohol intake for males and females stratified by smoking status. Alcohol intake was negatively associated with BMI in all women independent of smoking status ($p < 0.0001$) and in male current smokers ($p < 0.0001$). A tendency for a U-shaped relation was observed between alcohol intake and BMI in male ex- and never-smokers.

In all smoking groups, total energy intake increased with alcohol intake ($p < 0.0001$) (fig. 2). Abstainers, however, had a higher total energy intake than subjects consuming moderate amounts of alcohol except for female ex- and never-smokers. In spite of the relatively large differences in BMI between the smoking groups of up to 2 units for men and 1.5 units for women (fig. 1), total energy intake was very similar in current smokers, ex-smokers and never-smokers within each alcohol consumption

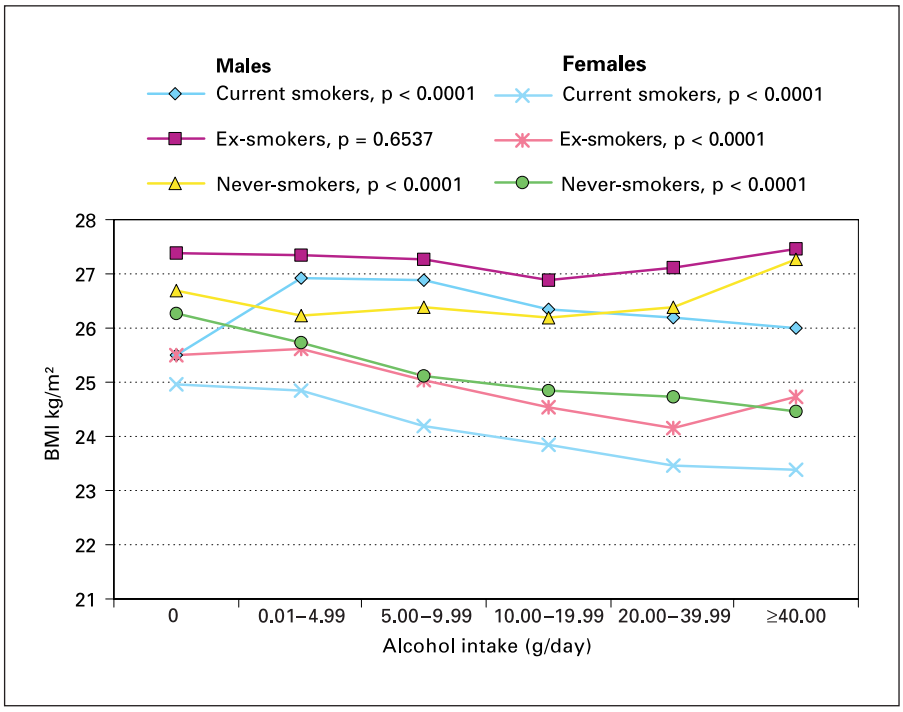

Fig. 1. Body mass index (BMI) by alcohol consumption.

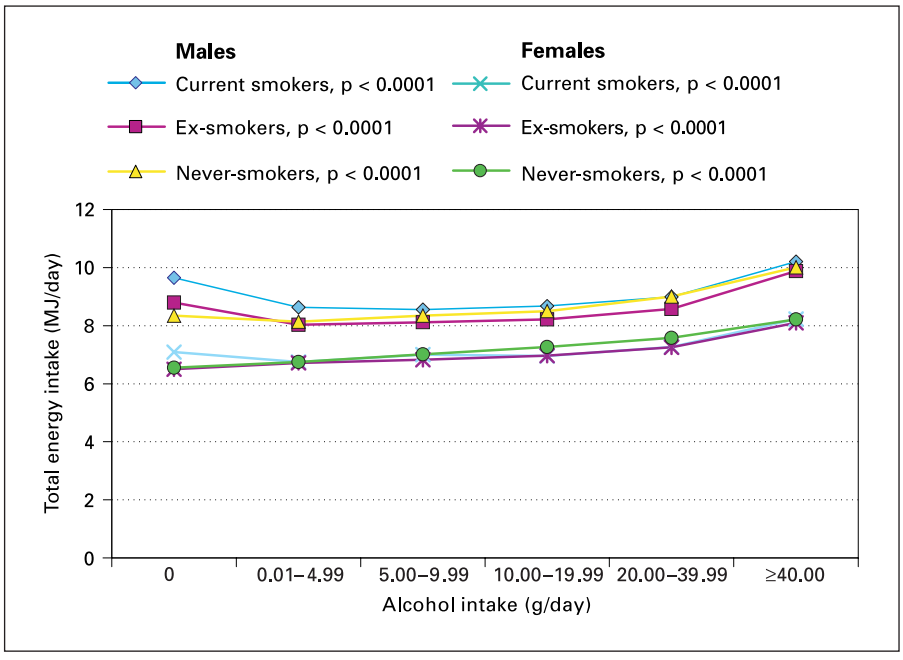

Fig. 2. Total energy intake (MJ/day) by alcohol consumption.

category. The maximum difference between the smoking groups was about 0.5 MJ/day within all alcohol consumption categories except for male abstainers. In this group, larger differences of up to 1.3 MJ/day were observed.

With higher alcohol intake, carbohydrate intake was about 10 to 36 g/day lower in both genders independent of smoking status ($p < 0.05$ in all groups with the exception of male ex-smokers where the p value was not significant) (data not shown).

Protein intake differed by 1.5–8 g/day for men and by about 4.5 g/day for women. Statistical significance could only seen for the U-shaped relation in male ex-smokers

Table 4. Age-adjusted geometric mean of energy from protein (%), carbohydrates (%) and fat (%) based on total energy intake from food ($p < 0.0001$)

	Alcohol consumption, g/day						Differences[1]
	0	0.01–4.99	5.00–9.99	10.00–19.99	20.00–39.99	≥40.00	%
Male current smokers	199	443	363	572	840	890	
Energy from protein, %	15.5	15.5	15.7	15.8	16.1	16.3	+0.8
Energy from carbohydrates, %	46.8	47.0	46.4	46.8	46.3	47.1	+0.3
Energy from fat, %	36.6	36.3	36.8	36.3	36.6	35.4	–1.2
Male ex-smokers	257	629	571	974	1235	1151	
Energy from protein, %	15.3	15.6	15.6	15.9	16.0	16.4	+1.1
Energy from carbohydrates, %	48.2	47.6	47.0	46.8	46.6	46.9	–1.3
Energy from fat, %	35.4	35.7	36.3	36.3	36.3	35.5	+0.1
Male never-smokers	136	646	556	807	793	555	
Energy from protein, %	15.1	15.1	15.4	15.4	15.8	16.3	+1.2
Energy from carbohydrates, %	48.8	48.3	48.0	47.2	46.7	47.2	–1.6
Energy from fat, %	35.0	35.5	35.5	36.3	36.4	35.3	+0.3
Female current smokers	190	1,177	490	523	429	235	
Energy from protein, %	14.9	15.1	15.4	15.7	15.7	16.5	+1.6
Energy from carbohydrates, %	46.9	47.2	46.2	45.7	46.0	45.1	–1.8
Energy from fat, %	36.9	36.5	37.2	37.3	37.0	36.7	–0.2
Female ex-smokers	156	1,398	723	749	535	247	
Energy from protein, %	15.0	15.1	15.3	15.6	15.8	16.0	+1.0
Energy from carbohydrates, %	49.0	47.6	46.8	46.3	46.2	46.0	–3.0
Energy from fat, %	34.8	36.1	36.6	36.8	36.6	36.4	+1.6
Female never-smokers	437	3,080	1122	976	620	190	
Energy from protein, %	15.2	15.1	15.3	15.4	15.8	16.2	+1.0
Energy from carbohydrates, %	48.8	48.0	46.9	47.2	46.4	44.9	–3.9
Energy from fat, %	34.8	35.7	36.6	36.1	36.5	37.2	+2.4

[1] Difference between the intake of abstainers and the subjects of the highest alcohol category.

($p = 0.0008$) and for the higher protein intake with higher alcohol consumption for male and female never-smokers ($p < 0.0001$).

Fat intake decreased with increasing alcohol intake in male current smokers (–16 g/day, $p = 0.0025$), male ex-smokers (–7 g/day) and female current smokers (–6 g/day). In male never-smokers the difference in fat consumption according to alcohol intake was small (± 2 g/day). In female ex- (+3 g/day) and never-smokers (+5 g/day) ($p = 0.0004$) fat consumption was marginally higher in subjects with the highest alcohol intake compared to abstainers.

All three main nutrients expressed as energy percent from food differed only marginally about a few percent between alcohol consumption categories although all associations were statistically significant (table 4). The largest differences between abstainers and subjects consuming high amounts of alcohol were observed for percent energy from carbohydrates in female ex- and never-smokers (–3 and –4% respectively).

In men, independent of smoking status, the greatest differences in food intake depending on alcohol intake were found for fruits, meat and meat products. The consumption of fruits decreased from abstainers to heavy alcohol consumers in all smoking categories. The absolute differences between abstainers and subjects in the highest alcohol consumption category varied for fruits between 30.1 g/day (120.0 vs. 89.9 g/day, $p = 0.0003$) for current smokers, 27.9 g/day (130.1 vs. 102.2 g/day, $p < 0.0001$) for ex-smokers and 50.8 g/day (147.4 vs. 96.6 g/day, $p < 0.0001$) for never-smokers. Meat and meat product consumption decreased in male current smokers (150.0 to 131.1 g/day, $p = 0.0008$) and increased in male ex- (119.4 to 130.6 g/day, $p < 0.0001$) and never-

smokers (93.8 to 137.0 g/day, $p < 0.0001$) with higher alcohol intake.

In women, intake of fruits was lower and the consumption of meat was higher in subjects consuming high amounts of alcohol compared to abstainers. The absolute differences for fruits between abstainers and subjects in the highest alcohol category varied between 8.9 g/day (122.5 vs. 113.6 g/day, $p = 0.0036$) for current smokers, 32.6 g/day (145.8 vs. 113.2 g/day, $p < 0.0001$) for ex-smokers and 41.3 g/day (149.0 vs. 107.7 g/day, $p < 0.0001$) for never-smokers. With higher alcohol intake meat and meat products consumption increased from 76.8 to 86.9 g/day for current smokers (n.s.), from 58.5 to 77.2 g/day for ex-smokers ($p = 0.002$) and from 67.4 to 91.6 g/day for never-smokers ($p < 0.0001$).

Discussion

In our study, dietary habits were associated with alcohol intake in men and women. Dietary patterns were generally different between men and women. Men compared with women had a higher overall intake of legumes, dairy products, cereal products, meat and meat products, fish, eggs and animal fat. Women consumed more vegetables and fruits. In our population the mean consumption of all food items were slightly higher than in the VERA Study [13].

Consistent with other studies [14, 15] alcohol was added to the diet and did not seem to substitute for other food items. Energy intake from food was only marginally lower in men and in women with high alcohol intake compared to those with low or no alcohol intake. Thus with higher alcohol intake, total daily energy intake increased considerably.

Varied results have been reported in the literature concerning nutrient intake between abstainers and alcohol consumers. Generally only small differences in nutrient intake were found although the consumption of many food items varied [14, 15].

In the present study, macronutrient intake differed only marginally between subjects with no alcohol intake and those with greater alcohol intake. Fat and protein intake expressed as energy percent from food showed slight increases with increasing alcohol intake whereas the percentage of energy from carbohydrates decreased with increasing alcohol intake. Our results are consistent with a study of Kesse et al. [16] who found that increasing alcohol consumption was associated with a higher total energy intake, a higher percentage of energy intake as protein and lipids and a lower percentage of energy from carbohydrates in a group of French women [16]. Similar observations were reported in a study of Männistö et al. [8] for protein, fat and carbohydrates in men and for fat and carbohydrates in women. Gruchow et al. [17] described a substantially lower carbohydrate intake of alcohol consumers compared to non-drinkers and an inverse dose-response relationship between carbohydrate and alcohol intakes.

Despite a higher percentage of energy from fat and protein the daily consumption of total fat decreased in men just like total carbohydrate and fibre intake, protein intake showed a U-shaped relation. In women, carbohydrate and fibre consumption were lower and protein intake was higher with greater alcohol intake, fat intake was higher in those with low consumption of alcohol compared with high alcohol consumers. Although the absolute differences were relatively small, they may affect the health of the subjects. Especially the low intake of fibre observed among subjects consuming high amounts of alcohol could have negative consequences for health if the observed dietary habits are pertained over a longer period of time. Männistö et al. [14] found no relation between the consumption of alcohol and the intake of protein and fat, but a 10% lower fibre intake with higher alcohol consumption. This is consistent with our results of an 18% (–3.9 g/day) lower intake of fibre in men and a 12% (–2.2 g/day) lower intake in women with a high alcohol intake compared to abstainers.

The dietary profile of participants with a high alcohol intake was characterized by high intake of animal products such as meat, meat products, fish and eggs, and low intake of fruits, dairy products, cereals and cereal products which may result in low vitamin and mineral intake, respectively. This is consistent with another German study [13] which found that a high alcohol intake was associated with lower consumption of dairy products and cereals in both genders and of citrus fruits in men compared to moderate alcohol consumption. Männistö et al. [14] reported that the intake of vegetables, beef, poultry and fish increased with alcohol consumption by over 20% between the lowest and the highest categories, whereas the consumption of cereals, milk and cream decreased by over 20%. Gruchow et al. [17] found that alcohol consumers had higher nutrient densities of niacin, riboflavin, vitamin C, iron, phosphorus and potassium and a lower density of calcium and thiamine than abstainers [17]. In a French sample a higher intake of retinol, iron and vitamin E was observed with higher alcohol consumption and only ß-carotene intake was lower [16]. In a Finish popula-

tion, Männistö et al. [8] reported a higher intake of niacin, iron intake was lower and there was no relation to the vitamin E intake with high alcohol intake [8].

Despite the higher total energy intake of alcohol consumers, because alcohol was added to the diet, body weight increased less than expected. BMI was only marginally higher in men and it was significantly lower in women with high alcohol intake. A different physical activity level could be relevant for this as has been suggested by Barefoot et al. [18], where abstainers had a lower regular exercise level compared to alcohol consumers. However, in the study of the French MONICA Centres, physical activity decreases with the increase of alcohol consumption [19]. Similar results were found in other studies [20, 22]. In the Nurses' Health Study the average BMI of women who were moderate alcohol consumers was 15% lower than that of non-consumers [20]. In men, no clear association between daily alcohol energy intake and BMI was observed [8, 14, 21, 22]. In one study, Männistö et al. [14] reported a positive association between alcohol consumption and BMI whereas in another study [8] they observed that male abstainers had the highest BMI. Dallongeville et al. [22] found in a French sample no association between alcohol intake and BMI and body weight in men, whereas in women alcohol consumption was inversely correlated with BMI and body weight. In both men and women, alcohol intake was associated with greater WHR and waist girth independently of BMI and body weight [22].

In conclusion, energy from alcohol affected body weight less than expected. One reason could be that energy from alcohol is utilized less efficiently and has a lower biological value than non-alcohol energy, or that alcohol may interfere with the efficient utilization of other calories [14]. However, metabolic investigations on the effect of alcohol intake clearly showed that ethanol energy was used with an efficiency of the body comparable with that of a carbohydrate and protein meal and that it reduced fat oxidation [23]. Different from macronutrients, ethanol is not stored in the body, but it is oxidized in preference over other fuels. There is no reason to claim that ethanol energy does not play a role in energy balance regulation. Further studies are needed to resolve the above-mentioned paradox [23].

In our study population the largest number of women was found in the lowest alcohol consumption group (0.01–4.99 g/day) independent of smoking status. In men, differences were seen depending on smoking status. In current smokers most men were found in the highest alcohol group (n = 890). This affirms the association between alcohol intake and smoking which has been reported in many other studies. Smoking of at least one cigarette per day was positively related to high amounts of alcohol intake in men and women [8, 15, 22].

Despite the highest energy intake, female current smokers had the lowest BMI independent from alcohol intake. A higher physical activity could be an explanation for this. Overall the highest BMI was found in male exsmokers and in female never-smokers. Männistö et al. [8] found in their study population the highest BMI in male abstainers, who also smoked less than alcohol consumers and in the FINRISK studies [24] male and female exsmokers had the highest BMI.

It seems that smoking is associated with less health consciousness, so that people who were smoking had the highest alcohol intake and the unhealthiest diet. Beside this, the socio-economic status had a relevant effect on smoking behaviour and alcohol intake, and this should be considered.

With the correlation between alcohol intake and smoking a third risk factor was found. John and Hanke [2] observed that of all alcohol-attributable cases of death, 73.8% were also associated with tobacco. Smoking intensity was a possible factor in the increased mortality of heavy alcohol consumers and smoking and drinking are synergistic in the production of certain cancers [25].

A high alcohol intake is a known risk factor for the following cancers: cancer of the mouth, pharynx, larynx, oesophagus and liver [26]. Colon-rectum and breast cancer are probably associated with high alcohol intake and lung cancer might be associated with high alcohol intake [26]. On the other hand, vegetables and fruit consumption decreased the cancer risk for cancers of the mouth, pharynx, oesophagus, lung and stomach [26]. Furthermore, a higher intake of animal products and fat is a risk factor for various cancers (colon, rectum, breast) [27].

In spite of the known association between dietary factors and cancer risk, many studies which examined alcohol as a risk factor for cancer did not take dietary patterns into account [5].

In the present study we have shown that alcohol drinkers were characterised by less healthy dietary patterns which could also have an impact on cancer risk.

In interpreting the results of this study, several potential limitations should be considered. In the recruitment process the participation rate compared to the invited number of subjects was 38.3% for the EPIC Heidelberg Study. Data from the National Health Survey 1991/1992 revealed that cohort populations were of higher socio-economic status and were healthier than the source popula-

tion [9]. Therefore, we probably tended to recruit more health-conscious persons. Other studies have shown that alcohol intake is generally under-reported by the participants [28]. In our analysis, measurement errors could not be ruled out. However, the food frequency questionnaire is a qualified method to investigate alcohol consumption [28] and our instrument has been validated against biomarkers of recent alcohol intake [10].

In conclusion it should be stressed that due to the large sample size of this study, many differences turned out to be statistically significant although they are probably without any deeper biological relevance. Furthermore, due to the large number of tests which have been performed, some statistically significant results could be caused by change. Nonetheless, overall our results show that a high alcohol intake is associated with less healthy dietary patterns and with smoking. All this could contribute to the association observed between alcohol intake and various cancers. Therefore, it will be necessary for future studies to consider also dietary patterns when investigation the effects of alcohol intake.

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