



**HAL**  
open science

## The association of lifetime alcohol use with measures of abdominal and general adiposity in a large-scale European cohort

Manuela M Bergmann, Madlen Schütze, Annika Steffen, Heiner Boeing, Jytte Halkjær, Anne Tjønneland, Noémie Travier, Antonio Agudo, Nadia Slimani, Sabina Rinaldi, et al.

► **To cite this version:**

Manuela M Bergmann, Madlen Schütze, Annika Steffen, Heiner Boeing, Jytte Halkjær, et al.. The association of lifetime alcohol use with measures of abdominal and general adiposity in a large-scale European cohort. *European Journal of Clinical Nutrition*, 2011, 10.1038/ejcn.2011.70 . hal-00640222

**HAL Id: hal-00640222**

**<https://hal.science/hal-00640222>**

Submitted on 11 Nov 2011

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

## **The association of lifetime alcohol use with measures of abdominal and general adiposity in a large-scale European cohort**

Manuela M Bergmann<sup>1</sup>, Madlen Schütze<sup>1</sup>, Annika Steffen<sup>1</sup>, Heiner Boeing<sup>1</sup>, Jytte Halkjaer<sup>2</sup>, Anne Tjønneland<sup>2</sup>, Noémie Travier<sup>3</sup>, Antonio Agudo<sup>3</sup>, Nadia Slimani<sup>4</sup>, Sabina Rinaldi<sup>4</sup>, Teresa Norat<sup>5</sup>, Dora Romaguera<sup>5</sup>, Sabine Rohrmann<sup>6</sup>, Rudolf Kaaks<sup>6</sup>, Marianne Uhre Jakobsen<sup>7</sup>, Kim Overvad<sup>8,7</sup>, Ulf Ekelund<sup>9</sup>, Elizabeth A Spencer<sup>10</sup>, Laudina Rodríguez<sup>11</sup>, Maria J Sánchez<sup>12</sup>, Miren Dorronsoro<sup>13</sup>, Aurelio Barricarte<sup>14</sup>, María-Dolores Chirlaque<sup>15</sup>, Philippos Orfanos<sup>16</sup>, Androniki Naska<sup>16</sup>, Antonia Trichopoulou<sup>16</sup>, Domenico Palli<sup>17</sup>, Sara Grioni<sup>18</sup>, Paolo Vineis<sup>5, 19</sup>, Salvatore Panico<sup>20</sup>, Rosario Tumino<sup>21</sup>, Elio Riboli<sup>5</sup>, Nicholas J Wareham<sup>9</sup>, Bas Bueno-de-Mesquita<sup>22</sup>, Anne May<sup>23,22 \*</sup>, Petra HM Peeters<sup>23, 5\*</sup>

\* Joint last authors

<sup>1</sup> German Institute of Human Nutrition Potsdam-Rehbrücke, Germany

<sup>2</sup> Danish Cancer Society, Institute of Cancer Epidemiology, Copenhagen, Denmark

<sup>3</sup> Unit of Nutrition, Environment and Cancer, Catalan Institute of Oncology, IDIBELL, Barcelona, Spain

<sup>4</sup> International Agency for Research on Cancer (IARC-WHO), Lyon, France

<sup>5</sup> Department of Epidemiology & Public Health, Imperial College London, United Kingdom

<sup>6</sup> Division of Clinical Epidemiology, German Cancer Research Center, Heidelberg, Germany

<sup>7</sup> Department of Clinical Epidemiology, Aarhus University Hospital, Aalborg, Denmark

- 8 Department of Cardiology, Aalborg Hospital, Aarhus University Hospital, Aalborg,  
Denmark
- 9 Medical Research Council, Epidemiology Unit, Cambridge, United Kingdom
- 10 Cancer Epidemiology Unit, University of Oxford, United Kingdom
- 11 Public Health and Participation Directorate, Health and Health Care Services Council,  
Asturias, Spain
- 12 Escuela Andaluza de Salud Publica, Granada, Spain
- 13 Public Health Department of Gipuzkoa, San Sebastian, Spain
- 14 Public Health Institute of Navarra, Pamplona, Spain
- 15 Department of Epidemiology, Murcia Regional Health Authority, Murcia Spain;  
CIBER Epidemiología y Salud Pública (CIBERESP), Spain
- 16 Department of Hygiene and Epidemiology, School of Medicine, University of Athens,  
Greece AND Hellenic Health Foundation, Athens, Greece
- 17 Molecular and Nutritional Epidemiology Unit, CSPO-Scientific Institute of Tuscany,  
Florence, Italy
- 18 Nutritional Epidemiology Unit, National Cancer Institute, Milan, Italy
- 19 University of Torino, Italy
- 20 Dipartimento di Medicina Clinica e Sperimentale, Università di Napoli, Italy
- 21 Cancer Registry, Azienda Ospedaliera "Civile M.P.Arezzo", Ragusa, Italy
- 22 Center for Nutrition and Health, National Institute of Public Health and the  
Environment (RIVM), Bilthoven, The Netherlands
- 23 Julius Center for Health Sciences and Primary Care, University Medical Center  
Utrecht, Utrecht, The Netherlands;

Corresponding author:

MM Bergmann

German Institute of Human Nutrition Potsdam-Rehbrücke

Arthur-Scheunert-Allee 114-116

14558 Nuthetal

Germany

Fone: +49 33200 88 715/711

Fax: +49 33200 88 721

Email: [bergmann@dife.de](mailto:bergmann@dife.de)

Running title: Lifetime alcohol and abdominal adiposity

## Abstract

### Background:

The relation between lifetime use of alcohol and measures of abdominal and general adiposity is unknown.

### Methods:

Among 99,381 men and 158,796 women of the European Prospective Investigation into Cancer and Nutrition (EPIC) study, means of waist circumference (WC), waist-to-hip-ratio (WHR) and body mass index (BMI), and odds ratios (OR) for a larger WC than predicted for a given BMI (WC<sub>lp</sub>=positive residuals of gender specific linear regression of BMI on WC) across categories of average lifetime use of alcohol (total, from wine and from beer) were calculated, all adjusted for socio-demographic, lifestyle and health factors.

### Results:

WC, WHR and BMI in men using lifetime  $\leq 6$ g/d alcohol were 95.1cm, 0.942 and 27.3kg/m<sup>2</sup>, and 96.2cm, 0.961 and 28.3kg/m<sup>2</sup> when using  $> 6$ g/d. WC and WHR in women was 83.2cm and 0.813 for  $\leq 6$ g/d, and 84.6cm and 0.830 for  $> 6$ g/d while BMI deviated only slightly with the lowest BMI (26.7kg/m<sup>2</sup>) observed for  $> 6$ -24g/d. Compared to  $\leq 6$ g/d, OR for a WC<sub>lp</sub> in both genders increased steadily across categories of alcohol use (up to 1.40 (95% confidence interval 1.32, 1.49) in men using  $> 6$ g/d and 1.63 (1.54, 1.73) in women using  $> 24$ g/d); though increase was higher for alcohol from beer than from wine (p for difference between beer and wine  $< 0.001$  (men) and  $= 0.002$  (women)).

**Conclusion:**

Lifetime alcohol use is positively related to abdominal and general adiposity in men, possibly following the male weight gain pattern; in women it is positively related only to abdominal adiposity. In this context, beer may contribute additionally to abdominal adiposity.

Key words: alcohol, waist circumference, waist-to-hip ratio, BMI, multi-centric cohort study

## **Introduction**

Abdominal fat accumulation, independently from general adiposity, increases the risk for adverse health outcomes (Pischon et al., 2008). The association of alcohol use with measures of abdominal and general adiposity in cross-sectional and prospective epidemiological studies was so far inconclusive. Abdominal adiposity was more prominent in men or in women who used alcohol heavily (Dallongeville et al., 1998; Duncan et al., 1995; Halkjaer et al., 2004; Laws et al., 1990; Slattery et al., 1992). However, some studies did not reveal such a relationship (Halkjaer et al., 2006; Koh-Banerjee et al., 2003) or did not show the relationship in both genders (Halkjaer et al., 2004). Also results on types of beverages and anthropometric measures vary depending on gender and country (Dallongeville et al., 1998; Duncan et al., 1995; Halkjaer et al., 2004; Lukasiewicz et al., 2005; Vadstrup et al., 2003).

Alcohol-related body measures may also result from metabolic changes due to a long term exposure to alcohol and therefore, information on a long term exposure to alcohol is important. However, most of the previous studies are based on information on use of alcohol over a short period of time, e.g. in the past year, month, or week, and lifetime abstainers were not distinguished from users of alcohol who had quit at the time of the measurement. In the European Prospective Investigation into Cancer and Nutrition (EPIC) information on alcohol use in the past was collected, offering the opportunity to investigate the role of lifetime alcohol use on measures of abdominal and general adiposity.

## **Methods**

### ***Study Population***

The European Prospective Investigation into Cancer and Nutrition (EPIC) is an ongoing multi-centric cohort study. The study has been described in full elsewhere (Riboli et al., 2002). In brief, the EPIC population consists of 521,448 individuals, ages 25 to 70 years, recruited from the general population in 23 centres in 10 European countries during 1992–2000. Persons who accepted the invitation to participate in the study gave informed consent and completed questionnaires on their diet, lifestyle, and medical history, and visited a study centre where a blood sample and anthropometric measurements were taken.

Because we used a common data set created also for prospective data analyses, subjects with unknown vital status during follow-up (n=1,517) had been excluded. Further, whose ratio of energy intake to estimated energy requirement calculated from body weight, height, and age was in the top or bottom 1% (n=10,273) was excluded because alcohol use may have been reported invalidly too (Bingham et al., 1994). We further excluded participants who had not filled out the dietary or lifestyle questionnaires (n=6,611), were pregnant at recruitment (n=623), had the anthropometric examination more than one year apart from the recruitment data collection (n=22,084), had extreme or implausible values in body mass index (BMI<16), height (<1.30 m) or waist circumference (WC>160) (n=397), had no anthropometric measures (n=1,429), had missing information (n=4,072) or an implausible high average lifetime alcohol use of >250 g/d (n=158). Information on lifetime use of alcoholic beverages was not available for the study centres Naples (Italy), Bilthoven (The Netherlands), Sweden and Norway (n=116,149). We also excluded the health conscious part of the Oxford cohort (Great Britain) (n=47,651; 85% of the British cohort) and the French cohort (n=51,267) since anthropometry was self-reported (Park et al., 2011). Therefore, 258,177 (99,381 men and 158,796 women) participants from Denmark (Aarhus, Copenhagen), Germany (Heidelberg, Potsdam), Greece,

Italy (Florence, Varese, Ragusa, Turin), the Netherlands (Utrecht), Spain (Asturias, Granada, Murcia, Navarra, San Sebastian), and the United Kingdom (Cambridge, Oxford), representing 50% of the original cohort, were eligible for this analysis.

The study was approved by ethical review boards of the single centres and the International Agency for Research on Cancer in Lyon, France.

### *Assessment of lifetime alcohol use*

Lifetime alcohol use was assessed based on data collected during the recruitment procedure by applying questionnaires on lifestyle and diet during the past 12 month. Glasses alcoholic beverage used at certain ages and during the 12 month prior to the recruitment have been self-reported and transformed into grams alcohol used per day by applying gender specific definitions of a standard drink for each country included in the EPIC study. We favoured this approach, since the application of common standard drinks for the calculation of alcohol intake involve some methodological problems (Lemmens, 1994), and specific data in the form of 36,994 24-hour dietary recalls (Slimani, 1999) had been available. Variations of concentrations and amounts of alcohol used on weekdays vs. weekend days and filling levels were taken into account by calculating weighed averages of alcohol content of one glass wine, beer, and hard liquor (based on a sub-sample of EPIC participants (N=12,443) who reported the use of alcoholic beverages during the 24-hour dietary recall).

The average alcohol use in g/d at ages 20, 30, 40, and 50 years and at recruitment was then calculated as the sum of the number of glasses per week of the respective beverage multiplied with the calculated alcohol content per glass divided by seven. Because time intervals across points in time where information on alcohol use was available were not equal for all participants, lifetime use of alcohol was calculated as the weighted average of intakes at different ages, including recruitment, with weights equal to the total subject-specific time of investigation, i.e. the individual time until recruitment

Participants were categorized as ‘never users’ of alcohol when reported alcohol use was zero at all points in time and as ‘former users’ when use of alcohol was reported for past points in time but not for the 12 month before recruitment.

### *Assessment of anthropometric data*

Weight and height were measured by trained personnel with subjects wearing no shoes. Depending on study centre, WC (cm) was measured either at the narrowest torso circumference, at the midpoint between the lower ribs and iliac crest, or by a combination of methods, whereby in most centres, WC was measured at the narrowest torso circumference. Hip circumference (HC; cm) was measured horizontally at the level of the largest lateral extension of the hips, or over the buttocks. Body weight, WC and HC were corrected for differences in clothing worn during measurement. A constant was subtracted from the original measure depending on whether study participants were measured in light underwear (no correction), in normal clothing without shoes (weight minus 1.5 kg; circumference minus 2.0 cm), or in light clothing without shoes (weight minus 1.0 kg) (Haftenberger et al., 2002).

### *Assessment of data on confounding factors*

Standardized self-administered questionnaires were applied at recruitment to collect information on the attained educational level, physical activity during the 12 month prior to the recruitment, smoking status including number of cigarettes and duration of smoking, and in women also reproductive history and hormone replacement therapy. (Riboli et al., 2002). Dietary variables were derived from country specific validated food-frequency questionnaires which covered between 98 and 266 food items. Self-reported frequencies of consumption were transformed into calorie intake per day by applying a standardized food-composition table (Slimani et al., 2007).

### *Statistical Analysis*

Adjusted means of WC, WHR (WC divided by HC), and BMI (weight (kg) divided by squared height (m)) across categories of average lifetime use of alcohol were calculated for men and women separately using generalized linear models. Cut points for categorization of alcohol use were based on the assumption that any glass of alcoholic beverage (drink) contains in average 12 g/d alcohol: never users, former users, and lifetime users of alcohol in g/d of  $\leq 6$ ,  $>6-12$ ,  $>12-24$ ,  $>24-60$ ,  $>60-96$ ,  $>96$ . Means were adjusted for age (years, continuous), study centre, education (no graduation or primary school, technical or professional school, secondary school, university degree, unknown), physical activity (index, combining work activity and leisure time physical activity with gender specific cut points: inactive, moderately inactive, moderately active, active, unknown), non-alcoholic energy intake (kcal, continuous), smoking status (never smokers, ex-smokers for  $\geq 10$  or for  $<10$  years, smokers at recruitment of  $<15$  or of  $\geq 15$  cigarettes per day, status unknown), smoking duration ( $<10$  yrs,  $10- <20$  yrs,  $20- <30$  yrs,  $30- <40$  yrs, 40 or more, unknown), and prevalent diseases (self-reported myocardial infarction, stroke, cancer, diabetes, hypertension, unknown) at the time of recruitment. Models for women additionally included menopausal status (premenopausal, postmenopausal, unknown), and parity (nulliparous, 1-2,  $>2$  live birth, unknown) and models for WC in both genders height and weight. Linear regression was used to investigate the trend of the association of alcohol use and anthropometric measures among lifetime users (per 12 g/d increment) continuously.

Since abdominal adiposity was in the focus of this analysis, we investigated the relative contribution of alcohol to a positively deviating WC from that predicted by the BMI. Firstly, for men and women separately, positive residuals of linear regression analysis with BMI as the independent and WC as the dependent variable were utilized to create a dichotomized variable (yes, no) for a WC that was larger than predicted (WC<sub>lp</sub>) for a given BMI (Han et al.,

1998). Secondly, the relative contribution of each category of lifetime alcohol use, and alcohol from wine and from beer to a larger WC than predicted was investigated by employing logistic regression with the lifetime users of  $\leq 6$  g/d alcohol as the reference category, mutually controlling for alcohol from wine or from beer in the respective models. Models were further adjusted for alcohol from other beverages, and variables listed for the adjusted means. Heterogeneity of odds ratios (OR) for alcohol from wine and alcohol from beer across EPIC-centres was tested calculating Cochran's  $Q$  and  $I^2$  (Higgins et al., 2003). While Cochran's  $Q$  gives the test statistic for the heterogeneity,  $I^2$  describes the percentage of total variation across study centres, which is due to heterogeneity rather than due to chance.

All p-values presented are two-tailed and the level of significance was 0.05. Analyses were performed using SAS 9.1 (SAS Institute, Cary, NC).

## Results

Men and women who did use alcohol in the past but not at recruitment (former alcohol users) were older, more likely to be also former smokers (men) or have a prevalent disease (myocardial infarction, stroke, cancer, diabetes, or hypertension) than those who were lifetime alcohol users (table 1). Among lifetime heavy alcohol using men of  $>96$  g/d, proportion of long term smokers ( $>20$  years) and non-alcoholic calorie and dietary fat intake was highest. The highest proportion of university graduates was seen among men who used  $\leq 24$  g/d alcohol. Among women who used lifetime  $>24$  g/d alcohol average age was little younger and the percentage of smokers at the time of recruitment, nulliparity, or university degree was highest.

Lifetime alcohol use was positively associated with WC, WHR and BMI in men (table 2). Men who used lifetime on average  $>96$  g/d had a 1.1 cm larger WC and a  $1.0 \text{ kg/m}^2$  higher BMI than those who used  $\leq 6$  g/d alcohol. WC, WHR and BMI of men who never used

alcohol or who were former users were comparable with that of men who used  $\leq 24$  g/d. WC and WHR were highest among heavy alcohol users of  $>96$  g/d alcohol. Differences of means between lowest and highest category of alcohol use for WC, WHR and BMI were greater for beer than for wine.

In women lifetime use of alcohol was positively related to WC and WHR and U-shaped to BMI with the lowest BMI observed among women who used on average  $>6-24$  g/d alcohol. Conversely, the difference of WC between the lowest and the highest category of lifetime alcohol use was 1.7 cm; and WC and WHR increased steadily across categories of lifetime alcohol use (table 2). Women who never used alcohol during lifetime were heaviest (BMI  $27.6 \text{ kg/m}^2$ ), but their WC was comparable to those women who used low amounts of alcohol ( $\leq 12$  g/d).

While in men differences of means of WC, WHR and BMI between lowest and highest category of alcohol use were greater for beer than for wine it wasn't as clear in women (table 2).

In table 3 the OR of a WC<sub>lp</sub> reflect the relative risk of abdominal adiposity across categories of lifetime alcohol use. In men and in women the OR increased steadily across categories of lifetime alcohol use which was true for alcohol from wine and from beer. However, the OR for alcohol from beer were higher than that for the same amount of alcohol from wine, and the differences appeared more pronounced in women compared to men. The OR for wine and beer varied across countries (figure 1 and 2). Between 50% and 80% of the total variation across study centres was due to heterogeneity rather than due to chance. In general, OR for beer were higher in men and women residing in beer preferring countries (Denmark, Germany, The Netherlands, and UK). In the Mediterranean centres, the role of beer for WC<sub>lp</sub> was not so clear, though a positive relationship for beer was also seen for some

of these centres (e.g. Asturias, Navarra (men), and Varese (women). However, Wine was also positively associated with a WC<sub>lp</sub> in men and women of most centres.

## **Discussion**

In men and women participating in this large European cohort study, lifetime alcohol use was related to the risk of abdominal adiposity, whereas alcohol from beer played a prominent role **in men and in women as well**, though risk was also higher for alcohol from wine.

Lifetime alcohol use was also positively associated with general adiposity in men. Although differences of adjusted means of WC, WHR and BMI appeared small, on the population level they exhibit health relevant differences.

Positive associations between the use of alcohol and abdominal adiposity have consistently been reported for men and frequently for women in cross-sectional (Dallongeville et al., 1998; Han et al., 1998; Marti et al., 1991; Randrianjohany et al., 1993; Slattery et al., 1992; Troisi et al., 1991) or prospective studies (Grinker et al., 1995; Vadstrup et al., 2003; Vernay et al., 2004). Studies showing different results focused on the role of alcohol for the *change* of anthropometric measures (Halkjaer et al., 2004; Halkjaer et al., 2006; Koh-Banerjee et al., 2003).

Alcohol, in distinction to other sources of energy, cannot be stored. This is why it has absolute priority in metabolism using different pathways, e.g. increasing thermogenesis or decreasing lipolysis (Buemann & Astrup, 2001; Suter, 2005; Yeomans et al., 2003). Alcohol metabolism may also trigger endocrine changes, such as increased cortisol secretion or modified steroid metabolism in the liver (Bjorntorp, 1990; Sarkola et al., 2001; Suter, 2005). Androgen hormone status was shown to be related to fat distribution, whereas men with lower levels and women with higher levels of androgen sex hormones were at higher risk of abdominal fat accumulation (Blouin et al., 2008; Khaw & Barrett-Connor, 1992). Alcohol use

in other studies was associated with higher levels of androgen hormones in women and lower levels in men (Eriksson et al., 1994; Sarkola et al., 2000).

There was a role of beverage type for the degree of abdominal adiposity in our study, where alcohol from beer showed a higher risk of having a larger waist circumference than would be expected from the BMI than alcohol from wine. There was heterogeneity across centres of the EPIC study, and the Southern (except most of the Spanish) centres showed wider confidence intervals for alcohol from beer due to lower numbers of beer users in these centres. Conversely, wine use seemed to be common among women and men in almost all centres. This was indicated by the generally smaller confidence intervals for alcohol from wine in men and in women; whereas the confidence intervals for alcohol from beer were small only in countries or centres where beer was more common.

One prospective study in a Danish population found in women, but not men, high intakes of beer to be associated with gain in WC (Halkjaer et al., 2004). In cross-sectional studies beer intake was either not related to WHR or BMI (Bobak et al., 2003; Lukasiewicz et al., 2005) or it was related in both genders and all ethnic groups (Slattery et al., 1992; Wannamethee et al., 2005). However, comparable to our study, abdominal adiposity was also seen for other types of beverage, independent from BMI (Dallongeville et al., 1998).

Since there are many possible confounders (Suter, 2005), it also cannot be ruled out that residual confounding influenced our results. For instance, alcohol use in general and type of beverage in particular may be differentially related to smoking. Smoking has been shown to be associated with abdominal adiposity (Travier et al., 2009). In our analysis, in both genders, among current smokers at recruitment using lifetime alcohol heavily (>60 g/d) the BMI was lower than that of never or ex-smokers using the same amount of alcohol. In contrast, the WC among current smokers who used alcohol lifetime heavily was noticeable higher.

Our study has limitations: We had no information about the onset and times and reasons for cessation of alcohol use. The categories of average lifetime use of alcohol may misclassify never, former or lifetime users of alcohol due to misreporting or due to the design of the question that inquires only about the use of alcohol at defined ages. Furthermore, the retrospective direction of the information collected on lifetime alcohol use is prone to recall bias. This problem was already addressed in the 1958 British Birth Cohort Study where it was shown that a certain proportion of the individuals' retrospective reports about abstinence, occasional or regular drinking of alcohol were inconsistent (Caldwell et al., 2006). However, the opportunities to obtain information on lifetime use of alcohol in a population based cohort study are limited, and the method used in our study was judged to generate acceptable information (Friesema et al., 2004; Lemmens et al., 1997). In our study, the amount of alcoholic beverages used in history by comparable age cohorts at certain ages was validated by comparison of self-reported data with the respective per capita measures (Klipstein-Grobusch et al., 2002).

Further, information on lifetime alcohol use was not available in all centres, which is why we had to exclude participants of the respective centres from this analysis. Due to further exclusion of the health conscious part of the UK and the French cohort because anthropometric variables were self-reported, the final data set consisted of about 50% of the original cohort. To test the sensitivity of our results to these exclusions, we rerun the models with the cohorts included, and the associations remained unchanged.

Strengths of our study include a large sample size of men and women throughout Europe, information on the use of alcohol over adult life period, including never and former use of alcoholic beverages, and measured body weight, height, waist and hip circumference. We adjusted the models for dietary, lifestyle and health factors potentially confounding the

association and performed a sensitivity analysis by excluding individuals who reported a prevalent myocardial infarction, stroke, cancer, diabetes, or hypertension at recruitment.

Future research in this field may investigate biological pathways of alcohol as a possible long term determinant of abdominal adiposity including interaction of sex and stress related hormones, genetic variations and behavioural factors. It also would be important to investigate whether the risk of abdominal adiposity could be reversed by cutting down the alcohol use and how long it would take to see effects.

In conclusion, lifetime use of alcohol in men is positively related to abdominal and general adiposity, and in women it is related to abdominal adiposity. In this context, beer may contribute additionally to abdominal adiposity.

### **Acknowledgements**

This publication arises from the project PANACEA, which has received funding from the European Union, in the framework of the Public Health Programme (project number: 2005328). The work was further financially supported by the European Commission: Public Health and Consumer Protection Directorate 1993-2004; Research Directorate-General 2005; Ligue contre le Cancer, Société 3M, Mutuelle Générale de l'Éducation Nationale, Institut National de la Santé et de la Recherche Médicale (INSERM) (France); German Cancer Aid, German Cancer Research Center, Federal Ministry of Education and Research (Germany); Danish Cancer Society (Denmark); Health Research Fund (FIS) of the Spanish Ministry of Health, The participating regional governments and institutions (Spain); Cancer Research UK, Medical Research Council, Stroke Association, British Heart Foundation, Department of Health, Food Standards Agency, the Wellcome Trust (United Kingdom); Greek Ministry of Health and Social Solidarity, Hellenic Health Foundation and Stavros Niarchos Foundation (Greece); Italian Association for Research on Cancer, National Research Council (Italy); Dutch Ministry of Public Health, Welfare and Sports, Dutch Ministry of Health, Dutch Prevention Funds, LK Research Funds, Dutch ZON (Zorg Onderzoek Nederland), World Cancer Research Fund (WCRF) (the Netherlands); Swedish Cancer Society, Swedish Scientific Council, Regional Government of Skane (Sweden); Norwegian Cancer Society (Norway).

Special thank deserve Wolfgang Bernigau for his major support in conducting the statistical analysis.

### **Conflict of interest.**

The authors declare no conflict of interest.

## References

- Bingham, S.A., Gill, C., Welch, A., Day, K., Cassidy, A., Khaw, K.T. et al. (1994). Comparison of dietary assessment methods in nutritional epidemiology: weighed records v. 24 h recalls, food-frequency questionnaires and estimated-diet records. *Br J Nutr*, **72**, 619-43.
- Bjorntorp, P. (1990). Obesity and diabetes. In *The Diabetes Annual/5*, Alberti, K.G.M.M. & Krall, L.P. (eds) pp. 373-395. Elsevier: Amsterdam.
- Blouin, K., Boivin, A. & Tchernof, A. (2008). Androgens and body fat distribution. *J Steroid Biochem Mol Biol*, **108**, 272-80.
- Bobak, M., Skodova, Z. & Marmot, M. (2003). Beer and obesity: a cross-sectional study. *Eur J Clin Nutr*, **57**, 1250-3.
- Buemann, B. & Astrup, A. (2001). How does the body deal with energy from alcohol? *Nutrition*, **17**, 638-41.
- Caldwell, T.M., Rodgers, B., Power, C., Clark, C. & Stansfeld, S.A. (2006). Drinking histories of self-identified lifetime abstainers and occasional drinkers: findings from the 1958 British Birth Cohort Study. *Alcohol Alcohol*, **41**, 650-4.
- Dallongeville, J., Marecaux, N., Ducimetiere, P., Ferrieres, J., Arveiler, D., Bingham, A. et al. (1998). Influence of alcohol consumption and various beverages on waist girth and waist-to-hip ratio in a sample of French men and women. *Int J Obes Relat Metab Disord*, **22**, 1178-83.
- Duncan, B.B., Chambless, L.E., Schmidt, M.I., Folsom, A.R., Szklo, M., Crouse, J.R., 3rd & Carpenter, M.A. (1995). Association of the waist-to-hip ratio is different with wine than with beer or hard liquor consumption. Atherosclerosis Risk in Communities Study Investigators. *Am J Epidemiol.*, **142**, 1034-8.
- Eriksson, C.J., Fukunaga, T. & Lindman, R. (1994). Sex hormone response to alcohol. *Nature*, **369**, 711.

- Friesema, I.H., Veenstra, M.Y., Zwietering, P.J., Knottnerus, J.A., Garretsen, H.F. & Lemmens, P.H. (2004). Measurement of lifetime alcohol intake: utility of a self-administered questionnaire. *Am J Epidemiol*, **159**, 809-17.
- Grinker, J.A., Tucker, K., Vokonas, P.S. & Rush, D. (1995). Body habitus changes among adult males from the normative aging study: relations to aging, smoking history and alcohol intake. *Obes Res*, **3**, 435-46.
- Haftenberger, M., Lahmann, P.H., Panico, S., Gonzalez, C.A., Seidell, J.C., Boeing, H. et al. (2002). Overweight, obesity and fat distribution in 50- to 64-year-old participants in the European Prospective Investigation into Cancer and Nutrition (EPIC). *Public Health Nutr*, **5**, 1147-62.
- Halkjaer, J., Sorensen, T.I., Tjonneland, A., Togo, P., Holst, C. & Heitmann, B.L. (2004). Food and drinking patterns as predictors of 6-year BMI-adjusted changes in waist circumference. *Br J Nutr.*, **92**, 735-48.
- Halkjaer, J., Tjonneland, A., Thomsen, B.L., Overvad, K. & Sorensen, T.I. (2006). Intake of macronutrients as predictors of 5-y changes in waist circumference. *Am J Clin Nutr*, **84**, 789-97.
- Han, T.S., Bijnen, F.C., Lean, M.E. & Seidell, J.C. (1998). Separate associations of waist and hip circumference with lifestyle factors. *Int J Epidemiol*, **27**, 422-30.
- Higgins, J.P., Thompson, S.G., Deeks, J.J. & Altman, D.G. (2003). Measuring inconsistency in meta-analyses. *Bmj*, **327**, 557-60.
- Khaw, K.T. & Barrett-Connor, E. (1992). Lower endogenous androgens predict central adiposity in men. *Ann Epidemiol*, **2**, 675-82.
- Klipstein-Grobusch, K., Slimani, N., Krogh, V., Keil, U., Boeing, H., Overvad, K. et al. (2002). Trends in self-reported past alcoholic beverage consumption and ethanol intake from 1950 to 1995 observed in eight European countries participating in the

- European Investigation into Cancer and Nutrition (EPIC). *Public Health Nutr*, **5**, 1297-310.
- Koh-Banerjee, P., Chu, N.F., Spiegelman, D., Rosner, B., Colditz, G., Willett, W. & Rimm, E. (2003). Prospective study of the association of changes in dietary intake, physical activity, alcohol consumption, and smoking with 9-y gain in waist circumference among 16 587 US men. *Am J Clin Nutr*, **78**, 719-27.
- Laws, A., Terry, R.B. & Barrett-Connor, E. (1990). Behavioral covariates of waist-to-hip ratio in Rancho Bernardo. *Am J Public Health*, **80**, 1358-62.
- Lemmens, P.H. (1994). The alcohol content of self-report and 'standard' drinks. *Addiction*, **89**, 593-601.
- Lemmens, P.H., Volovics, L. & DeHaan, Y. (1997). Measurement of lifetime exposure to alcohol: data quality of a self-administered questionnaire and impact on risk assessment. *Contemporary Drug Problems*, **24**, 581-600.
- Lukasiewicz, E., Mennen, L.I., Bertrais, S., Arnault, N., Preziosi, P., Galan, P. & Hercberg, S. (2005). Alcohol intake in relation to body mass index and waist-to-hip ratio: the importance of type of alcoholic beverage. *Public Health Nutr*, **8**, 315-20.
- Marti, B., Tuomilehto, J., Salomaa, V., Kartovaara, L., Korhonen, H.J. & Pietinen, P. (1991). Body fat distribution in the Finnish population: environmental determinants and predictive power for cardiovascular risk factor levels. *J Epidemiol Community Health*, **45**, 131-7.
- Park, J.Y., Mitrou, P.N., Keogh, R.H., Luben, R.N., Wareham, N.J. & Khaw, K.-T. (2011). Effects of body size and sociodemographic characteristics on differences between self-reported and measured anthropometric data in middle-aged men and women: the EPIC-Norfolk study. **65**, 357-367.

- Pischon, T., Boeing, H., Hoffmann, K., Bergmann, M., Schulze, M.B., Overvad, K. et al. (2008). General and Abdominal Adiposity with Risk of Death in Europe. *New Engl J Med*, **359**, 2105-20.
- Randrianjohany, A., Balkau, B., Cubeau, J., Ducimetiere, P., Warnet, J.M. & Eschwege, E. (1993). The relationship between behavioural pattern, overall and central adiposity in a population of healthy French men. *Int J Obes Relat Metab Disord*, **17**, 651-5.
- Riboli, E., Hunt, K.J., Slimani, N., Ferrari, P., Norat, T., Fahey, M. et al. (2002). European Prospective Investigation into Cancer and Nutrition (EPIC): study populations and data collection. *Public Health Nutr*, **5**, 1113-24.
- Sarkola, T., Adlercreutz, H., Heinonen, S., von der Pahlen, B. & Eriksson, C.J.P. (2001). The Role of the Liver in the Acute Effect of Alcohol on Androgens in Women. *J Clin Endocrinol Metab*, **86**, 1981-1985.
- Sarkola, T., Fukunaga, T., Makisalo, H. & Peter Eriksson, C.J. (2000). Acute effect of alcohol on androgens in premenopausal women. *Alcohol Alcohol.*, **35**, 84-90.
- Slattery, M.L., McDonald, A., Bild, D.E., Caan, B.J., Hilner, J.E., Jacobs, D.R., Jr. & Liu, K. (1992). Associations of body fat and its distribution with dietary intake, physical activity, alcohol, and smoking in blacks and whites. *Am J Clin Nutr*, **55**, 943-9.
- Slimani, N., Deharveng, G., Charrondiere, R.U., van Kappel, A.L., Ocke, M.C., Welch, A. et al. (1999). Structure of the standardized computerized 24-h diet recall interview used as reference method in the 22 centers participating in the EPIC project. European Prospective Investigation into Cancer and Nutrition. *Comput Methods Programs Biomed*, **58**, 251-66.
- Slimani, N., Deharveng, G., Unwin, I., Southgate, D.A., Vignat, J., Skeie, G. et al. (2007). The EPIC nutrient database project (ENDB): a first attempt to standardize nutrient databases across the 10 European countries participating in the EPIC study. *Eur J Clin Nutr*, **61**, 1037-56.

- Suter, P.M. (2005). Is alcohol consumption a risk factor for weight gain and obesity? *Crit Rev Clin Lab Sci.*, **42**, 197-227.
- Travier, N., Agudo, A., May, A.M., Gonzalez, C., Luan, J., Besson, H. et al. (2009). Smoking and body fatness measurements: a cross-sectional analysis in the EPIC-PANACEA study. *Prev Med*, **49**, 365-73.
- Troisi, R.J., Heinold, J.W., Vokonas, P.S. & Weiss, S.T. (1991). Cigarette smoking, dietary intake, and physical activity: effects on body fat distribution--the Normative Aging Study. *Am J Clin Nutr*, **53**, 1104-11.
- Vadstrup, E.S., Petersen, L., Sorensen, T.I. & Gronbaek, M. (2003). Waist circumference in relation to history of amount and type of alcohol: results from the Copenhagen City Heart Study. *Int J Obes Relat Metab Disord.*, **27**, 238-46.
- Vernay, M., Balkau, B., Moreau, J.G., Sigalas, J., Chesnier, M.C. & Ducimetiere, P. (2004). Alcohol consumption and insulin resistance syndrome parameters: associations and evolutions in a longitudinal analysis of the French DESIR cohort. *Ann Epidemiol.*, **14**, 209-14.
- Wannamethee, S.G., Shaper, A.G. & Whincup, P.H. (2005). Alcohol and adiposity: effects of quantity and type of drink and time relation with meals. *Int J Obes (Lond)*, **29**, 1436-44.
- Yeomans, M.R., Caton, S. & Hetherington, M.M. (2003). Alcohol and food intake. *Curr Opin Clin Nutr Metab Care*, **6**, 639-44.

### Figure 1

Odds ratio of having a larger waist circumference than expected from BMI for increase of one more alcoholic drink (12 g alcohol) per day across centres of the EPIC study in men (Adjusted for age, centre, education, physical activity, smoking status, **smoking duration**, non-alcoholic calorie intake, prevalent chronic diseases)

### Figure 2

Odds ratio of having a larger waist circumference than expected from BMI for increase of one more alcoholic drink (12 g alcohol) per day across centres of the EPIC study in women (Adjusted for age, centre, education, physical activity, smoking status, **smoking duration**, non-alcoholic calorie intake, prevalent chronic diseases, menopausal status and number of live birth)

Table 1. Frequency distribution and description of characteristics at recruitment across categories of lifetime use of alcohol in a sub-sample of the EPIC study

	Use of alcohol g/d <sup>1</sup>	Overall	Never		Former		Lifetime			
			0	>0	≤6	>6–12	>12–24	>24–60	>60–96	>96
<b>Men</b>	N	99381	1715	4792	13843	15971	24919	29258	6006	2877
Age (mean, SD, in years)		53.9 (8.4)	54.0 (10.8)	55.9 (9.6)	54.0 (9.5)	54.8 (8.4)	54.2 (7.9)	53.3 (7.8)	52.8 (7.9)	52.5 (8.0)
non-alcoholic calorie intake (mean, SD, kcal <sup>2</sup> )		2269 (632)	2281 (679)	2262 (675)	2269 (648)	2230 (617)	2228 (608)	2284 (630)	2364 (639)	2494 (674)
Total fat intake (mean, SD)		98.3 (36.0)	98.3 (36.0)	94.4 (35.1)	95.2 (33.4)	93.7 (31.9)	94.6 (31.6)	98.0 (32.9)	105.4 (35.2)	114.5 (38.6)
University degree (%)		25.0	18.7	12.5	25.4	28.5	29.5	25.2	16.8	8.0
High/very high physical activity (%)		48.6	41.6	48.3	46.2	49.3	50.8	49.6	45.4	40.9
Smokers (%)		31.7	27.7	30.6	25.2	26.1	29.5	35.3	44.8	54.5
Ex-smokers (%)		38.6	24.2	42.5	33.3	38.4	40.9	41.0	35.4	29.3
>20 years of ever smoking (%)		65.4	66.6	70.1	58.5	60.6	63.3	67.2	76.0	83.0
Prevalent chronic diseases <sup>3</sup> (%)		11.4	13.9	22.7	12.3	12.2	10.1	10.1	10.2	12.6
<b>Women</b>	N	158796	19863	10906	70769	31045	20533	5495	185	
Age (mean, SD, in years)		52.9 (9.0)	52.5 (10.3)	54.5 (9.7)	52.7 (9.1)	53.2 (8.4)	52.8 (8.1)	52.2 (7.8)	51.7 (8.5)	
non-alcoholic calorie intake (mean, SD, kcal <sup>2</sup> )		1867 (520)	1824 (525)	1863 (536)	1874 (521)	1881 (506)	1868 (515)	1862 (539)	1907 (580)	
Total fat intake (mean, SD)		78.1 (27.2)	79.0 (28.7)	77.2 (27.8)	78.0 (27.3)	77.8 (25.9)	78.2 (26.4)	78.9 (28.2)	80.7 (31.5)	
University degree (%)		14.7	7.3	8.5	14.3	18.0	19.5	22.9	24.3	
High/very high physical activity (%)		63.3	78.6	72.4	63.0	56.9	57.2	53.6	55.1	
Smokers (%)		21.3	15.1	18.4	19.6	22.7	28.1	37.4	43.2	
Ex-smokers (%)		21.7	9.2	18.6	20.3	27.1	29.6	30.5	29.2	
>20 years of ever smoking (%)		52.3	44.7	54.5	49.0	53.3	57.6	64.9	63.5	
Prevalent chronic diseases <sup>3</sup> (%)		9.2	10.5	15.2	8.9	8.0	8.0	8.6	10.0	
Prämenopausal (%)		31.1	37.3	28.1	31.8	28.3	28.8	30.3	31.9	
Nulliparous (%)		13.0	10.5	13.3	12.0	13.7	15.9	20.9	27.0	
1-2 live birth (%)		59.1	53.1	51.4	60.7	61.5	60.0	58.1	51.4	

<sup>1</sup> 12 grams alcohol equivalents about one drink.<sup>2</sup> 1 kcal = 4.186kJ<sup>3</sup> Self-report of myocardial infarction, stroke, cancer, diabetes, hypertension at the time of enrolment into the study.

Table 2. Mean body measures according to categories of lifetime alcohol use in a sub-sample of the EPIC study

Use of alcohol		Never	Former	Lifetime						Trend <sup>2</sup>
	g/d <sup>1</sup>	0	>0	≤6	>6–12	>12–24	>24–60	>60–96	>96	
<b>Men</b>										
Total alcohol	N	1715	4792	13843	15971	24919	29258	6006	2877	
	WC (cm) <sup>3</sup>	95.4	95.3	95.1	95.1	95.3	95.7	96.0	96.2	+
	WHR <sup>4</sup>	0.944	0.942	0.942	0.942	0.944	0.951	0.957	0.961	+
	BMI (kg/m <sup>2</sup> ) <sup>4</sup>	27.3	27.1	27.3	27.2	27.3	27.5	27.9	28.3	+
Alcohol from beer	N	10431	10402	40716	16362	12968	7522	787	193	
	WC (cm) <sup>3,5</sup>	95.4	95.5	95.5	95.6	95.9	96.4	97.1	97.7	+
	WHR <sup>4,5</sup>	0.945	0.947	0.947	0.951	0.956	0.964	0.975	0.982	+
	BMI (kg/m <sup>2</sup> ) <sup>4,5</sup>	27.5	27.5	27.5	27.6	27.9	28.2	28.4	28.7	+
Alcohol from wine	N	7493	5813	43510	14736	12307	12248	2416	858	
	WC (cm) <sup>3,5</sup>	96.0	96.0	95.8	95.9	96.0	96.2	96.4	96.8	+
	WHR <sup>4,5</sup>	0.958	0.955	0.956	0.954	0.956	0.958	0.963	0.967	+
	BMI (kg/m <sup>2</sup> ) <sup>4,5</sup>	27.7	27.5	27.8	27.7	27.7	27.7	28.3	28.8	+
<b>Women</b>										
Total alcohol	N	19863	10906	70769	31045	20533	5495	185		
	WC (cm) <sup>3</sup>	83.1	83.3	82.9	83.2	83.7	84.5	84.6		+
	WHR <sup>4</sup>	0.818	0.818	0.812	0.813	0.818	0.827	0.830		+
	BMI (kg/m <sup>2</sup> ) <sup>4</sup>	27.6	27.2	27.1	26.7	26.7	26.9	27.1		–
Alcohol from beer	N	62331	14958	76526	3607	1133	231	10		
	WC (cm) <sup>3,5</sup>	83.5	83.6	83.6	84.5	85.1	86.4	84.5		+
	WHR <sup>4,5</sup>	0.817	0.819	0.817	0.827	0.834	0.854	0.839		+
	BMI (kg/m <sup>2</sup> ) <sup>4,5</sup>	26.9	27.0	26.7	26.6	26.7	27.1	26.6		–
Alcohol from wine	N	30132	11335	83641	20321	11129	2190	48		
	WC (cm) <sup>3,5</sup>	84.0	84.2	83.8	84.2	84.7	85.3	84.8		+
	WHR <sup>4,5</sup>	0.829	0.830	0.824	0.825	0.829	0.838	0.831		+
	BMI (kg/m <sup>2</sup> ) <sup>4,5</sup>	27.4	27.1	27.0	26.7	26.6	26.8	25.9		–

BMI body mass index; WC waist circumference; WHR waist-to-hip ratio

<sup>1</sup> 12 grams alcohol equivalents about one drink.

<sup>2</sup> estimated by linear regression in lifetime users only; + positive trend, –negative trend, significant at the 0.05 level

<sup>3</sup> adjusted for age, center, education, physical activity, smoking status, **smoking duration**, non-alcoholic calorie intake, prevalent chronic diseases, height and weight (women also for menopausal status and number of live birth).

<sup>4</sup> adjusted for age, center, education, physical activity, smoking status, **smoking duration**, non-alcoholic calorie intake, and prevalent chronic diseases, (women also for menopausal status and number of live birth).

<sup>5</sup> additionally mutually adjusted for alcohol from beer or from wine

Table 3. Odds ratios for having a waist circumference larger than predicted for a given body mass index across categories of lifetime alcohol use of **in a sub-sample of the EPIC study**

Use of alcohol		Never	Former	Lifetime				
	g/d <sup>1</sup>	0	>0	≤6	>6–12	>12–24	>24–60	>60
<b>Men</b>								
Total alcohol	N	1715	4792	13843	15971	24919	29258	4947
	OR (95% CI) <sup>2</sup>	1.02 (0.92–1.14)	1.07 (1.00–1.15)	REF	1.01 (0.96–1.06)	1.06 (1.02–1.11)	1.20 (1.15–1.26)	1.40 (1.32–1.49)
Alcohol from beer <sup>§</sup>	N	10431	10402	40716	16362	12968	7522	980
	OR (95% CI) <sup>2,4</sup>	0.98 (0.93–1.03)	1.03 (0.98–1.09)	REF	1.06 (1.02–1.10)	1.15 (1.10–1.20)	1.36 (1.29–1.44)	1.76 (1.53–2.02)
Alcohol from wine <sup>§</sup>	N	7493	5813	43510	14736	12307	12248	3274
	OR (95% CI) <sup>2,4</sup>	1.04 (0.99–1.10)	1.04 (0.98–1.11)	REF	1.05 (1.00–1.09)	1.06 (1.01–1.10)	1.13 (1.07–1.19)	1.28 (1.18–1.40)
P for difference between wine and beer		0.098	0.798		0.650	0.007	<0.001	<0.001
<b>Women</b>								
Total alcohol	N	19863	10906	70769	31045	20533		3257
	OR (95% CI) <sup>3</sup>	1.04 (1.00–1.07)	1.12 (1.08–1.18)	REF	1.10 (1.07–1.13)	1.31 (1.27–1.36)		1.63 (1.54–1.73)
Alcohol from beer <sup>§</sup>	N	62331	14958	76526	3607	1133		241
	OR (95% CI) <sup>3,4</sup>	0.98 (0.95–1.00)	1.00 (0.96–1.04)	REF	1.32 (1.23–1.42)	1.51 (1.33–1.71)		2.57 (1.93–3.45)
Alcohol from wine <sup>§</sup>	N	30132	11335	83641	20321	11129		2238
	OR (95% CI) <sup>3,4</sup>	1.05 (1.02–1.08)	1.14 (1.09–1.19)	REF	1.13 (1.10–1.17)	1.34 (1.28–1.40)		1.59 (1.45–1.74)
P for difference between wine and beer		<0.001	<0.001		<0.001	0.083		0.002

OR Odds ratio; 95% CI 95 percent confidence interval

<sup>1</sup> 12 grams alcohol equivalents about one drink.

<sup>2</sup> adjusted for age, centre, education, physical activity, smoking status, **smoking duration**, non-alcoholic calorie intake, prevalent chronic diseases

<sup>3</sup> adjusted for age, centre, education, physical activity, smoking status, **smoking duration**, non-alcoholic calorie intake, prevalent chronic diseases, menopausal status and number of live birth

<sup>4</sup> additionally mutually adjusted for alcohol from beer and from wine.

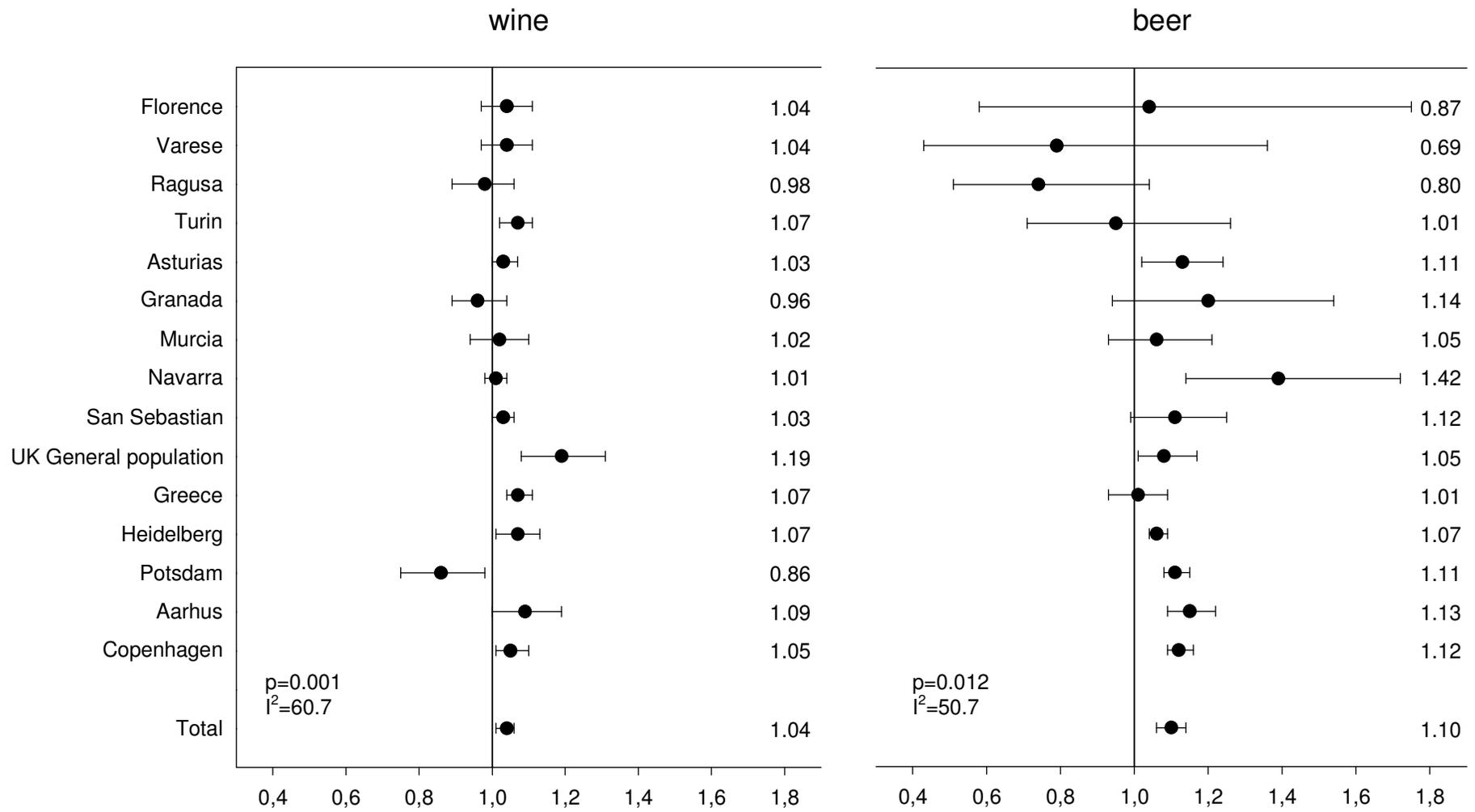


Figure 1

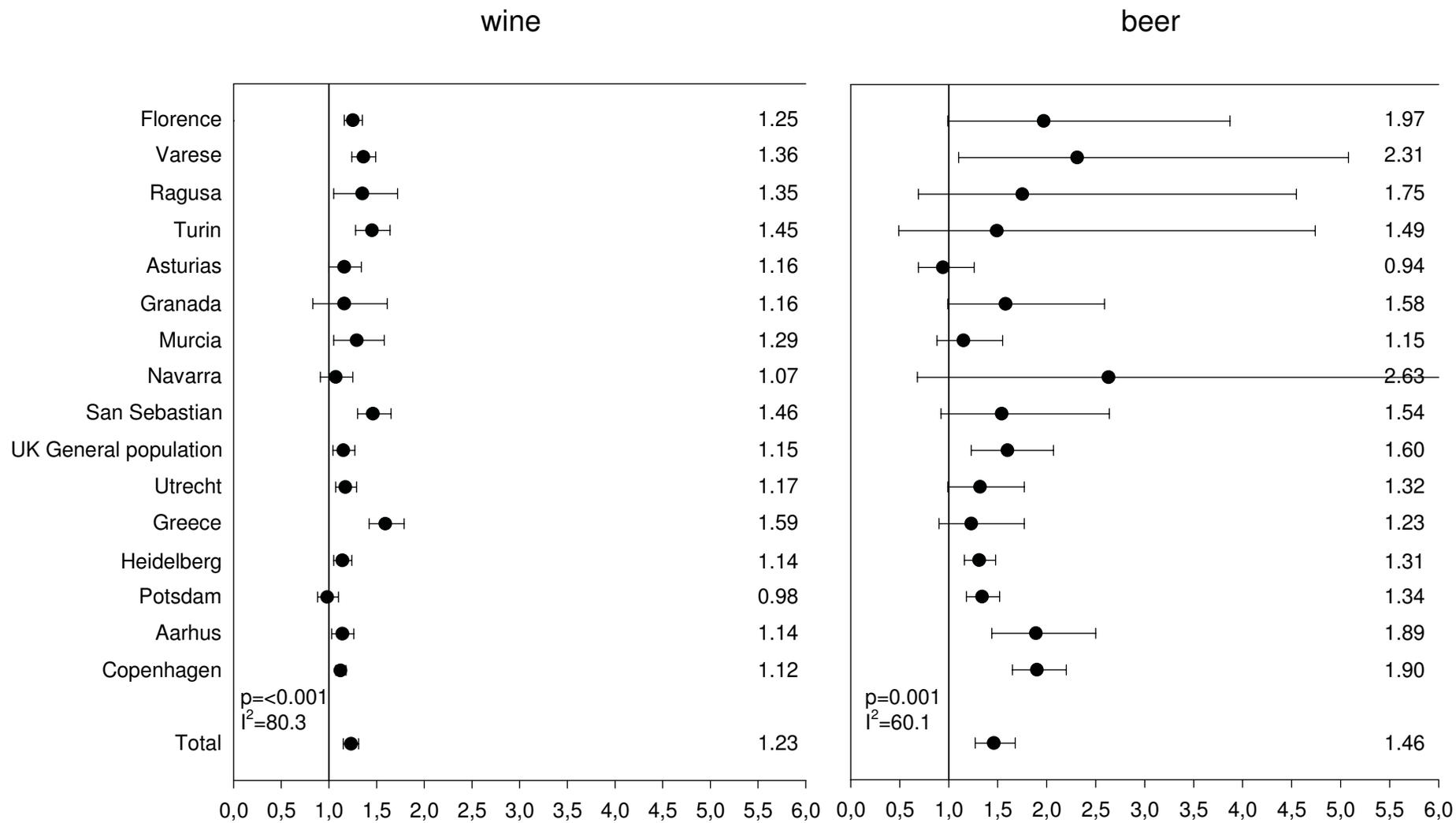


Figure 2