Eur J Nutr (2007)
DOI 10.1007/s00394-007-0674-7

ORIGINAL CONTRIBUTION

Helmut Schröder
Jose Antonio Morales-Molina
Silvia Bermejo
Diego Barral
Eduardo Soler Mándoli
María Grau
Monica Guxens
Elisabet de Jaime Gil
Marisol Domínguez Álvarez
Jaume Marrugat

Relationship of abdominal obesity with alcohol consumption at population scale

Received: 1 March 2007
Accepted: 19 July 2007
Published online: 20 September 2007

H. Schröder (✉) · M. Guxens · J. Marrugat
Lipids and Cardiovascular Epidemiology Research Unit
Institut Municipal d'Investigació Mèdica
IMIM Hospital de Mar
Parc de Recerca Biomèdica de Barcelona (PRBB)
c/Doctor Aiguader 88
08003 Barcelona, Spain
Tel.: +34-93/316-0400
Fax: +34-93/316-0410
E-Mail: hschroeder@imim.es

J.A. Morales-Molina
Dept. of Pharmacy
IMIM-Hospital de Mar
Barcelona, Spain

S. Bermejo · E.S. Mándoli
Dept. of Anesthesiology
IMIM-Hospital de Mar
Barcelona, Spain

D. Barral
Pharmacology Research Unit
IMIM-Hospital de Mar
Barcelona, Spain

D. Barral · M. Grau
Universitat Autònoma de Barcelona
Barcelona, Spain

M. Grau
Preventive Medicine and Public Health
IMAS-UPF-ASPB
Barcelona, Spain

E. de Jaime Gil
IMIM-Hospital de Mar
Barcelona, Spain

M.D. Álvarez
Dept. of Pneumology
IMIM-Hospital de Mar
Barcelona, Spain

Abstract *Background* The high energy content of alcohol makes its consumption a potential contributor to the obesity epidemic. *Aim of the study* To determine whether alcohol consumption is a risk factor for abdominal obesity, taking into account energy underreporting. *Methods* The subjects were Spanish men (n = 1491) and women (n = 1563) aged 25–74 years who were examined in 1999–2000, in a population-based cross-sectional survey in northeastern Spain (Girona). Dietary intake, including alcohol consumption, was assessed using a food frequency questionnaire. Anthropometric variables were measured. *Results* The mean consumption of alcohol was 18.1 ± 20.7 g/d in men and 5.3 ± 10.4 g/d in women. 19.3% of men and 2.3% of women reported alcohol consumption of more than 3 drinks per day. The consumption of alcohol was directly associated with total energy intake in men ($P < 0.001$) and women ($P = 0.001$). The proportion of energy underreporting significantly ($P < 0.001$) decreased with higher amounts of alcohol drinking in both genders. Multiple logistic regression analysis, controlled for energy underreporting, smoking, educational level, leisure-time physical activity, energy, and diet quality, revealed that consuming more than 3 drinks of alcohol (>30 g ethanol) was significantly associated with the risk of abdominal obesity (Odds ratio 1.80; 1.05, 3.09) and exceeding recommended energy consumption (Odds ratio 1.97; 1.32, 2.93) in men. A very small number (2.13%) of women in this population reported high levels of alcohol consumption. *Conclusions* Alcohol consumption in elevated amounts was associated with risk of abdominal obesity in men, independent of energy underreporting.

Key words waist – alcoholic beverages – energy underreporting

EJN 674

Introduction

Prevalence of obesity has increased dramatically in the past years in industrialized western societies [1]. A study of the rising prevalence of abdominal obesity in the United States population observed a three-fold increase (12.7% to 38.2% in men and from 19.4% to 59.9% in women) from 1960 to 2000 [2]. In the present population we observed an increase in abdominal obesity from 17.5% to 20.7% in men between 1995 and 2000 [3]. Abdominal obesity, regardless of general obesity, is a risk factor for coronary heart disease (CHD), type 2 diabetes hypertension, high oxidized-LDL cholesterol, and total mortality [4–9]. Changes in lifestyle with negative modifications in diet and physical activity are linked to the increase in abdominal obesity [10, 11].

Alcohol consumption is an important element of lifestyle in western societies [12]. Europe has the highest alcohol consumption worldwide, and Spaniards are among the highest alcohol consumers in the European community [12]. Although observational studies are inconclusive, when daily energy requirements are met with a normal diet, additional alcohol consumption should contribute to obesity development [13, 14]. Several studies have identified alcohol consumption as a risk factor for abdominal deposition of fat [15–18]. However, inadequate control for important confounders such as dietary energy intake from foods or physical activity makes it difficult to estimate the independent association between alcohol consumption and abdominal obesity.

The widespread occurrence of energy underreporting can be considered an important confounder in associating energy intake and obesity [19]. In epidemiological surveys, this may bias the relationship found between alcohol consumption and abdominal obesity. Data on the association between alcohol consumption and abdominal obesity among south European populations are limited; furthermore, to our knowledge, energy underreporting has not been incorporated into the analysis. The aim of the present study was to determine the association of abdominal obesity and alcohol consumption at population scale, taking into account the confounding effects of energy underreporting.

Materials and methods

Subjects

A representative population sample of free-living Spanish men and women from the province of Girona, aged 25–74 years, was drawn from participants in a survey conducted by the REGICOR (Gerona Heart Registry) investigators from 1999 to 2001. After excluding a priori the implausibly low and high total energy intakes (less than 800 kcal and more than 5,000 kcal), eligible participants included 1,402 men and 1,466 women.

All participants signed an informed consent form to allow their personal data to be stored in a computer database and permit the acquisition and frozen conservation of biological samples (i.e. serum, plasma and DNA) for the necessary analyses. The protocol was approved by an Ethics Committee and the results of the examination were sent to participants.

Assessment of alcohol intake

Alcohol consumption was recorded on a validated food frequency questionnaire. The average alcohol grade (%) of wine, beer, and spirits was defined as 11%, 5%, and 40% respectively. Alcohol intake (g/day) was calculated by multiplying the amount of the beverage (ml) by the respective grade (%) and the constant 0.80 to transform alcohol volumes into weight. One drink is equivalent to 10 g of ethanol. Pearson correlation coefficient for alcohol consumption between the reference method (monthly 24 h recalls over 1 year) and the food frequency questionnaire (FFQ) was 0.81. This finding indicates that the FFQ provides a reasonable estimate of alcohol consumption

Anthropometric measurements

Waist circumference was measured by locating the lower costal rib and the iliac crest, in the narrowest zone, in the supine decubitus and horizontal positions; measurement was taken with a tape, measured in centimetres, and rounded to 0.5 cm.

Dietary assessment

Food consumption and nutrient intake were measured by a validated food frequency questionnaire (FFQ) [20] administered by a trained interviewer. The FFQ form asked about normal intake of 165 food items over the previous year. For each food item, participants were asked to indicate their usual consumption from a nine-category frequency ordinal scale, ranging from never or less than once a month to six or more times a day. Rather than standard questions on portion size, the FFQ asked about specific medium servings, defined by natural (e.g. one orange, one slice of bread) or household units (e.g. one spoon, one cup, one glass). An optical reader recorded the data from the FFQ. Energy consumption and nutrient intake were calculated using the *Medisystem 2000* software (Conaycite, Madrid).

Diet quality

We computed the Mediterranean diet score to calculate overall diet quality for each participant. The characteristics of the Mediterranean diet scoring system, based on the traditional food consumption of the Mediterranean region, were described by Trichopoulous et al. [21]. In brief, the score was calculated, with the exception of red wine, according to the tertile distribution of energy-adjusted food consumption [22]. The lowest tertile was coded as 1, medium as 2, and highest as 3, for cereals, fruits, vegetables, legumes, fish, olive oil, and nuts. For meat and dairy products, the highest tertile was coded as 1, medium as 2, and lowest as 3. Red wine consumption was computed as alcohol intake proceeding from red wine (0 g and more than 20 g of alcohol = 1, and up to 20 g of alcohol = 3). The values of distribution of all dietary components were calculated. The resulting Mediterranean diet scores ranged from 10 to 30.

Recommended energy consumption and energy underreporting

The Estimated Energy Requirement (EER) was calculated to estimate the prevalence of inadequate energy intake in the study population [23]. The equation to predict EER includes age, weight (wt), height (ht), and physical activity (PA):

$$\text{EER for men} = 662 - 9.53 \times \text{age (y)} + \text{PA} \times [15.91 \times \text{wt (kg)} + 539.6 \times \text{ht (m)}]$$

$$\text{EER for women} = 354 - 6.91 \times \text{age (y)} + \text{PA} \times [9.93 \times \text{wt (kg)} + 726 \times \text{ht (m)}]$$

Physical activity levels (PAL) were also included in the calculation: sedentary ($\text{PAL} \geq 1 < 1.4$), low active ($\text{PAL} \geq 1.4 < 1.6$), active ($\text{PAL} \geq 1.6 < 1.9$), and very active ($\text{PAL} \geq 1.9 < 2.5$)]. The corresponding PA value for sedentary, low active, active, and very active PAL is 1.0, 1.12, 1.27, and 1.45, respectively.

The physical activity level in the present population was calculated using the corresponding walking equivalence. Dietary Reference Intake (DRI) for energy was defined as the EER that corresponds to a normal BMI (18.5–24.9) [23].

Energy underreporting was determined by the quotient of reported energy intake to the predicted basal metabolic rate (<1.3). The basal metabolic rate was predicted from equations based on sex, age, body weight, and height [24].

Leisure-time physical activity

Leisure-time physical activity was measured by the Minnesota leisure-time physical activity questionnaire, previously validated for Spanish women and men [25, 26].

Smoking

Information on smoking habits of the participants was obtained by a structured interview. Participants were categorized as people who had never smoked, former smokers (> 1 year), and current smokers (at least 1 cigarette/day on average during the previous year). The latter were asked for the average daily number of cigarettes smoked.

Educational status

Maximum level of education attained was elicited and for analysis purposes was recorded as basic education, secondary school, and university.

Statistical analysis

The general linear modelling procedures (PROC GLM; SAS Institute Inc Cary, NC; version 8.0) were used to analyze the relationship between lifestyle variables and alcohol consumption.

Adjusted odds ratios were calculated to investigate the association of alcohol consumption with abdominal obesity and DRI for energy (PROC LOGISTIC procedure of SAS; SAS Institute Inc Cary, NC; version 8.0). Differences were considered significant if $P < 0.05$.

Results

The mean consumption of alcohol was 18.1 ± 20.7 g/d in men and 5.3 ± 10.4 g/d in women. Among the women subjects, 2.3% reported consuming more than 3 drinks per day. Hence, sufficient statistical power for this group is lacking. For this reason we categorized alcohol consumption as less than 1 drink/d, 1–2 drinks/d, 3 drinks/d, and more than 3/d drinks in men and less than 1 drink/d, 1–2 drinks/d, and more than 2 drinks/d in women. Wine was the predominate alcoholic beverage (10.8 g ± 12.6) in men and 4.1 g ± 8.2 in women) followed by beer (4.5 g ± 9.9

Table 1 Lifestyle variables according to amount of alcohol consumption by men and women

	N	Age[a] (y)	Education[b,c] (%)	LTPA[a,d] (METs ·min/d)	Smoker[b] (%)	Diet quality[a,e] (Unit)
Men						
Alcohol intake (drinks/day)[f]						
< 1	606	49.8 (48.7–50.6)	11.7 (9.2–14.2)	400 (370–432)	24.3 (20.7–27.9)	18.3 (18.0–18.5)
1–2	298	50.8 (49.3–52.3)	12.1 (8.5–15.7)	334 (290–378)	26.9 (21.7–32.0)	17.9 (17.6–18.3)
> 2 ≤ 3	228	53.8 (52.1–55.5)	9.6 (5.6–13.7)	382 (330–423)	28.1 (22.2–34.0)	18.0 (17.7–18.4)
> 3	270	48.7 (47.1–50.3)	10.0 (6.2–13.8)	350 (303–396)	44.9 (39.4–54.0)	17.7 (17.3–18.0)
P for linear trend[g]		0.911	0.337	0.255	< 0.001	0.019
Women						
Alcohol intake (drinks/day)[f]						
< 1	1,162	49.8 (49.0–50.6)	13.4 (11.4–14.2)	322 (304–342)	17.4 (15.2–19.6)	18.1 (17.9–18.2)
1–2	200	50.4 (48.5–50.6)	12.1 (7.3–16.8)	323 (279–369)	17.3 (11.9–22.6)	18.2 (17.8–18.5)
> 2	104	51.4 (48.8–54.0)	13.7 (7.1–20.3)	291 (229–354)	21.8 (14.3–29.2)	17.9 (17.3–18.4)
P for linear trend[g]		0.240	0.858	0.354	0.377	0.491

[a]Results are expressed as mean (95% Confidence Interval)
[b]Results are expressed as percentage of subjects (95% Confidence Interval)
[c]University degree
[d]LTPA—Leisure-time physical activity
[e]Determined by adherence to the energy-adjusted Mediterranean diet score
[f]One drink is equivalent to 10 g of ethanol
[g]Significance for *P* of trend by analysis of variance (continuous variables) and logistical regression (categorical variables)

Table 2 Energy intake and degree of energy underreporting by category of alcohol consumption for men and women

	N	Energy[a,c] (MJ/d)	Energy[a,d] (MJ/d)	Energy[a,e] (MJ/d)	Energy underreporters[b,f] (%)
Men					
Alcohol intake (drinks/day)[g]					
< 1	606	10.6 (10.3–10.9)	0.09 (0.06–0.11)	10.7 (10.4–11.0)	46.8 (42.9–50.6)
1–2	298	11.0 (10.6–11.4)	0.40 (0.36–0.43)	11.4 (10.9–11.8)	36.6 (31.1–42.1)
> 2 ≤ 3	228	10.9 (10.4–11.4)	0.75 (0.71–0.79)	11.6 (11.1–12.1)	35.0 (28.7–41.2)
> 3	270	10.9 (9.9–11.3)	1.49 (1.45–1.53)	12.3 (11.9–12.8)	26.9 (17.8–35.9)
P for linear trend[h]		0.545	< 0.001	< 0.001	< 0.001
Women					
Alcohol intake (drinks/day)[g]					
< 1	1,162	10.5 (10.3–10.7)	0.04 (0.03–0.05)	10.6 (10.4–10.8)	34.2 (31.5–36.9)
1–2	200	11.1 (10.6–11.5)	0.35 (0.33–0.38)	11.4 (10.9–11.9)	21.1 (14.7–27.5)
> 2	104	10.8 (10.1–11.5)	1.01 (0.88–1.04)	11.8 (11.1–12.5)	17.3 (8.5–26.2)
P for linear trend[h]		0.446	< 0.001	0.001	< 0.001

[a]Results are expressed as mean (95% Confidence Interval)
[b]Results are expressed as percentage of subjects (95% Confidence Interval)
[c]Energy proceeding from food and non-alcoholic beverages
[d]Energy proceeding from alcoholic beverages
[e]Energy proceeding from food, non-alcoholic beverages, and alcoholic beverages
[f]Energy intake/basal metabolic rate <1.3
[g]One drink is equivalent to 10 g of ethanol
[h]Significance for *P* of trend by analysis of variance (continuous variables) and logistical regression (categorical variables)

in men and 0.9 g ± 4.5 in women) and spirits (2.8 g ± 8.2) in men and 0.3 g ± 1.4 g in women) in the present population. Prevalence of abdominal obesity in the present population was 20.7% in men and 29.5% in women.

Energy underreporting was significantly associated with both the outcome (abdominal obesity) and the predictor (alcohol consumption) variable. The prevalence of abdominal obesity was significantly higher ($P < 0.001$) in the male and female participants who underreported energy intake (61.0% compared with 36.4% and 43.9% compared with 22.8%, respectively). Logistic regression analysis revealed a significant association ($P = 0.001$) of abdominal obesity and energy underreporting.

Higher prevalence of smoking and lower overall diet quality was associated with higher alcohol consumption in men (Table 1). Total energy intake increased with alcohol consumption in both genders (Table 2). In contrast, energy intake provided by

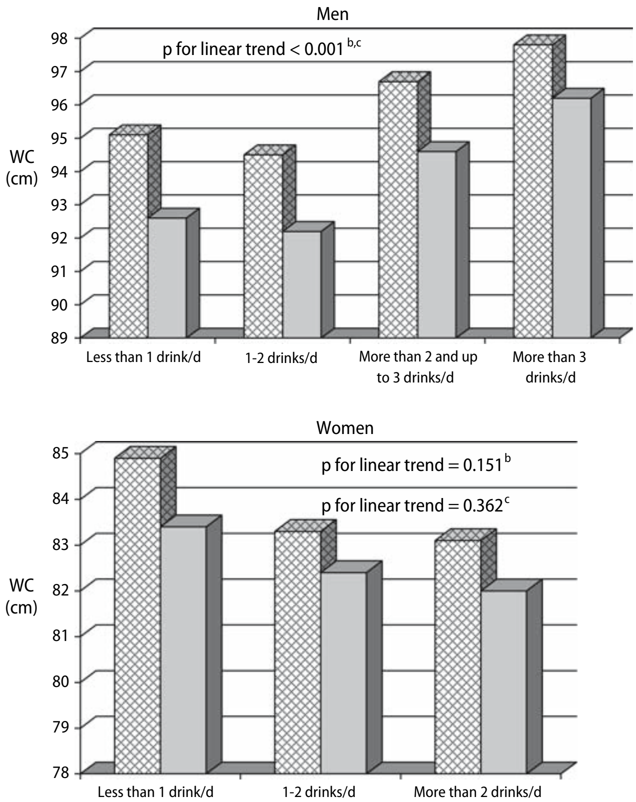

Fig. 1 Adjusted[a] association between waist circumferences (WC) and categories of alcohol consumption of men and women. Superscript (**a**) Adjusted for age, energy intake of food, leisure-time physical activity, educational status, smoking, and diet quality; Superscript (**b**) Energy underreporter included; Superscript (**c**) Energy underreporter excluded. Left Column: Entire population. Right column: Energy underreporter excluded

foods remained stable across alcohol drinking categories in men and women (Table 2). Total energy underreporting was less frequent in male and female participants with higher amounts of alcohol consumption (Table 2). In men, waist circumference was directly associated with alcohol consumption after adjusting for confounders (Fig. 1). This association remained significant after excluding energy underreporters from analysis. Waist circumference increased across categories of alcohol consumption in men but not in women (Fig. 1).

Multiple logistic regression analysis, adjusted for age, diet quality, leisure-time physical activity, smoking, body mass index, educational level, and energy consumption proceeding from foods and non-alcoholic caloric beverages, revealed a higher risk of abdominal obesity with increasing amount of alcohol consumption in men. Excluding energy underreporters from analysis attenuated this association; however, it remained significant (Table 3). The relative risk of exceeding the recommended amount of energy consumption increased with higher amounts of alcohol drinking in men and women. After excluding energy underreporters from analysis, this association was attenuated in women but not in men (Table 4).

Discussion

This study has shown that alcohol consumption is directly associated with waist circumference and with a higher risk of abdominal obesity in men but not in women in the present population. Excluding energy underreporters slightly attenuated these associations. After controlling for energy underreporting we observed that increasing alcohol consumption significantly increased the risk of exceeding recommended energy intakes in male but not in the small number of female participants (2.13%) with elevated alcohol consumption, even after establishing a lower number of drinks per day to characterize women as consuming a high quantity of alcohol. Further study is needed to determine whether a significant relationship between alcohol consumption and abdominal obesity exists among women who consume higher amounts of alcohol.

Obesity is rapidly reaching epidemic proportions worldwide and has been associated with numerous comorbidities and increased risk of premature death [27, 28]. Central deposition of adipose tissue is directly related with cardiovascular morbidity and mortality, independent of general obesity [4–9].

In the long run, daily energy intake that exceeds daily energy expenditure is the driving force for weight gain. Alcohol may represent 5–10% of energy intake in adults, which is a significant component of the diet. Alcohol is the second highest source of energy, on a per gram basis, of all the macronutrients. In contrast to other energy sources, there are no specific regulatory mechanisms for alcohol consumption [29]. In the present population, higher alcohol consumption was not associated with energy compensation in the overall diet. This finding concurs with other cross-sectional studies that report a failure to reduce food intake in response to energy intake from alcohol [30]. By definition, excess energy intake through alcohol consumption without compensatory energy expenditure is a formula for weight gain and therefore a risk factor for obesity.

A large US prospective study reported no significant association between changes in waist circumference and alcohol consumption during 9 years of follow-up [31]. Furthermore, lower waist circumference was related to higher alcohol consumption in healthy female twins [32]. In contrast, however, recently published data from numerous European epidemiological studies pointed to a direct association between alcohol consumption and visceral fat accumulation [15–18, 33]. Differences in total alcohol

Table 3 Odds ratio and 95% confidence interval[a] (CI) of abdominal obesity according to categories of alcohol consumption in men and women

	Total population Odds (95% CI)	Energy underreporters excluded[b] Odds (95% CI)
Men		
Alcohol intake (drinks/day)[c]		
< 1 (Reference)	1	1
1–2	1.10 (0.76–1.60)	0.98 (0.54–1.75)
> 2 ≤ 3	1.45 (0.97–2.14)	1.52 (0.85–2.71)
> 3	2.15 (1.47–2.13)	1.80 (1.05–3.09)
P for linear trend[d]	< 0.001	0.018
Women		
Alcohol intake (drinks/day)[c]		
< 1 (Reference)	1	1
1–2	0.85 (0.59–1.23)	0.73 (0.46–1.16)
> 2	0.82 (0.50–1.34)	(0.53–1.59)
P for linear trend[d]	0.286	0.390

[a]Adjusted for age, smoking, leisure-time physical activity, educational status, diet quality, and energy consumption proceeding from foods and non-alcoholic beverages
[b]Energy intake/basal metabolic rate <1.3
[c]One drink is equivalent to 10 g of ethanol
[d]Significance for *P* of trend by analysis of logistical regression

Table 4 Odds ratio and 95% confidence interval[a] (CI) of exceeding recommended energy intake according to categories of alcohol consumption in men and women

	Entire population Odds (95% CI)	Energy underreporters excluded[a] Odds (95% CI)
Men		
Alcohol intake (drinks/day)[b]		
< 1 (Reference)	1	1
1–2	1.20 (0.93–1.82)	0.97 (0.64–1.45)
> 2 ≤ 3	1.34 (0.93–1.94)	1.22 (0.76–1.91)
> 3	2.18 (1.56–3.04)	(1.32–2.93)
P for linear trend[c]	< 0.001	< 0.001
Women		
Alcohol intake (drinks/day)[b]		
< 1 (Reference)	1	1
1–2	1.24 (0.91–1.69)	1.12 (0.68–1.84)
> 2	1.65 (1.08–2.54)	1.10 (0.78–1.55)
P for linear trend[c]	0.01	0.716

[a]Energy intake/basal metabolic rate <1.3
[b]One drink is equivalent to 10 g of ethanol
[c]Significance for *P* of trend by analysis of logistical regression

consumption among cohorts may well explain these conflicting findings. Mean alcohol intake of the American cohort and the twin study was only 11.5 g and 5.7 g respectively, considerably lower than that reported in the present population and among other European cohorts [15, 17].

In the present population we observed no significant association of abdominal obesity with alcohol consumption under 3 drinks per day. In contrast, males consuming more than 3 drinks a day were at a 115% higher risk of abdominal obesity. The magnitude of this association was slightly reduced after excluding energy underreporters from analysis. Our findings are in line with recent published data from European cohorts. The consumption of three or more units of alcohol (approximately ≥ 30 g of alcohol) was associated with a significant increase in the risk of abdominal obesity in British men [17]. The strongest association between abdominal obesity and alcohol drinking was observed among the men and women participating in the Copenhagen City Heart Study who reported consumption of 4 or more alcoholic drinks (48 g or more of alcohol) per day [15].

The question is whether alcohol consumption is a potential risk factor for energy imbalance. To address this question we calculated energy intake recommendations according to age, sex, and physical activity [23]. After controlling for energy underreporting we found a significantly higher risk of exceeding the energy intake recommendations among men consuming more than 3 drinks per day. This supports the study's significant association of abdominal obesity in men with the consumption of more than 3 drinks per day.

The mechanisms linking alcohol consumption with an enhanced visceral lipid deposition are not completely understood. Alcohol consumption leads to a suppression of fat oxidation and thereby favours lipid storage [34]. Furthermore, alcohol increases the release of glucocorticoids via stimulation of the hypothalamic-pituitary-adrenal axis [35]. Increased cortisol secretion has been reported with an altered fat distribution pattern [36]. Cortisol binds to glucocorticoid receptors, which have a particularly high density in visceral fat deposits; this promotes lipid accumulation and retention in visceral adipose tissue [36].

Epidemiological studies investigating the association of alcohol consumption and abdominal obesity face methodological problems such as intentional misreporting of alcohol consumption, particularly among heavy alcohol consumers, and total energy underreporting. In the present study we observed a significant decrease of the prevalence of underreporting with increasing alcohol consumption in both genders. Furthermore, waist circumference was not significantly associated with energy consumption in men and women. However, after controlling for energy underreporting, waist circumference significantly increased with each 100kcal (0.12 cm in men and 0.14 cm in women). We also analyzed the association of alcohol consumption with waist circumference and abdominal obesity after excluding energy underreporters. With the exception of the relationship between alcohol consumption and recommended energy intakes, we did not find significant changes in the direction and magnitude of associations after excluding energy underreporters from analysis. Similarly, choosing different cut-offs for the characterization of energy underreporters did not significantly change the present findings (data not shown).

The strength of the present study is the relatively large number of participants, the representative character of the study design, and the adjustment for several important confounders. A limitation of the present study is the low percentage of female participants who consumed higher quantities of alcohol. Misreporting of self-reported alcohol consumption, particularly among heavy alcohol consumers, cannot be excluded. However, this is a general characteristic for epidemiological studies addressing the association between alcohol consumption and disease outcome. Furthermore, the cross-sectional nature of the study design precludes drawing causal relationships.

In summary, waist circumference increased across categories of alcohol consumption in men. A significant association of alcohol consumption with abdominal obesity and exceeding energy intake recommendations was found among men reporting consumption of more than 3 alcoholic drinks per day. Controlling for energy underreporting did not significantly change these associations.

Acknowledgments We appreciate the English revision made by Dr. Elaine M. Lilly (Writers First Aid).This research was supported by grant 2FD097-0297-CO2-01 from Fondo Europeo de Desarrollo Regional (FEDER) and by parts of the Ministerio de Sanidad y Consumo, Instituto de Salud Carlos III, Red HERACLES RD06/0009, CIBER: Epidemiología y salud pública CB06/02/0029, CIBER: Fisiopatología de la obesidad y nutrición CB06/03/0028, Fondo de Invesigación Sanitaria ISCIII CP 03/00115.

References

1. Seidell JC (2005) Epidemiology of obesity. Semin Vasc Med 5:3–14
2. Okosun IS, Chandra KM, Boev A, Boltri JM, Choi ST, Parish DC, Dever GE (2004) Abdominal adiposity in U.S. adults: prevalence and trends, 1960–2000. Prev Med 39:197–206
3. Schroder H, Elosua R, Vila J, Martin H, Covas MI, Marrugat J (2007) Secular trends of obesity and cardiovascular risk factors in a Mediterranean population. Obesity 15:557–562
4. Bigaard J, Frederiksen K, Tjonneland A, Thomsen BL, Overvad K, Heitmann BL, Sorensen TI (2005) Waist circumference and body composition in relation to all-cause mortality in middle-aged men and women. Int J Obes (Lond) 29:778–784
5. Rexrode KM, Carey VJ, Hennekens CH, Walters EE, Colditz GA, Stampfer MJ, Willett WC, Manson JE (1998) Abdominal adiposity and coronary heart disease in women. JAMA 280:1843–1848
6. Despres JP (2006) Is visceral obesity the cause of the metabolic syndrome? Ann Med 38:52–63
7. Wang Y, Rimm EB, Stampfer MJ, Willett WC, Hu FB (2005) Comparison of abdominal adiposity and overall obesity in predicting risk of type 2 diabetes among men. Am J Clin Nutr 81:555–563
8. Zhu S, Wang Z, Heshka S, Heo M, Faith MS, Heymsfield SB (2002) Waist circumference and obesity-associated risk factors among whites in the third National Health and Nutrition Examination Survey: clinical action thresholds. Am J Clin Nutr 76:743–749
9. Weinbrenner T, Schroder H, Escurriol V, Fito M, Elosua R, Vila J, Marrugat J, Covas MI (2006) Circulating oxidized LDL is associated with increased waist circumference independent of body mass index in men and women. Am J Clin Nutr 83:30–35
10. Koh-Banerjee P, Wang Y, Hu FB, Spiegelman D, Willett WC, Rimm EB (2004) Changes in body weight and body fat distribution as risk factors for clinical diabetes in US men. Am J Epidemiol 159:1150–1159
11. Trichopoulou A, Gnardellis C, Lagiou A, Benetou V, Naska A, Trichopoulos D (2001) Physical activity and energy intake selectively predict the waist-to-hip ratio in men but not in women. Am J Clin Nutr 74:574–578
12. Henley on Thames, World Avertising Research Center LTD. World Drink Trends 2003
13. Halkjaer J, Sorensen TI, Tjonneland A, Togo P, Holst C, Heitmann BL (2004) Food and drinking patterns as predictors of 6-year BMI-adjusted changes in waist circumference. Br J Nutr 92:735–748
14. Wannamethee SG, Shaper AG (2003) Alcohol, body weight, and weight gain in middle-aged men. Am J Clin Nutr 77:1312–1317
15. Vadstrup ES, Petersen L, Sorensen TI, 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 27:238–246
16. Lukasiewicz E, Mennen LI, 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 8:315–320
17. Wannamethee SG, Shaper AG, Whincup PH (2005) Alcohol and adiposity: effects of quantity and type of drink and time relation with meals. Int J Obes (Lond) 29:1436–1444
18. Laitinen J, Pietilainen K, Wadsworth M, Sovio U, Jarvelin MR (2004) Predictors of abdominal obesity among 31-y-old men and women born in Northern Finland in 1966. Eur J Clin Nutr 58:180–190
19. Johansson G, Wikman A, Ahren AM, Hallmans G, Johansson I (2001) Underreporting of energy intake in repeated 24-hour recalls related to gender, age, weight status, day of interview, educational level, reported food intake, smoking habits and area of living. Public Health Nutr 4:919–927
20. Schroder H, Covas MI, Marrugat J, Vila J, Pena A, Alcantara M, Masia R (2001) Use of a three-day estimated food record, a 72-hour recall and a food-frequency questionnaire for dietary assessment in a Mediterranean Spanish population. Clin Nutr 20:429–437

21. Trichopoulou A, Kouris-Blazos A, Wahlqvist ML, Gnardellis C, Lagiou P, Polychronopoulos E, Vassilakou T, Lipworth L, Trichopoulos D (1995) Diet and overall survival in elderly people. BMJ 311:1457–1460
22. Willett W (2007) Nutritional Epidemiology. Oxford University Press 1998
23. Standing Committee on the Scientific Evaluation of Dietary Reference Intakes FaNBIoM2 (2007) Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids. National Academy Press, Washington DC
24. FAO/WHO/UNU (2007) Energy and protein requirements. Technical Report Series No 724, World Health Organization, Geneva, 1985
25. Elosua R, Garcia M, Aguilar A, Molina L, Covas MI, Marrugat J (2000) Validation of the Minnesota leisure time physical activity questionnaire in Spanish women. Investigators of the MARATDON Group. Med Sci Sports Exerc 32:1431–1437
26. Elosua R, Marrugat J, Molina L, Pons S, Pujol E (1994) Validation of the Minnesota leisure time physical activity questionnaire in Spanish men. The MARATHOM Investigators. Am J Epidemiol 139:1197–1209
27. Haslam DW, James WP (2005) Obesity. Lancet 366:1197–1209
28. Obesity: preventing, managing the global epidemic (2000) Report of a WHO consultation. World Health Organ Tech Rep Ser 894:i-253
29. Yeomans MR (2004) Effects of alcohol on food and energy intake in human subjects: evidence for passive and active over-consumption of energy. Br J Nutr 92 Suppl 1:S31-S34
30. Yeomans MR, Caton S, Hetherington MM (2003) Alcohol and food intake. Curr Opin Clin Nutr Metab Care 6:639–644
31. Koh-Banerjee P, Chu NF, 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 78:719–727
32. Greenfield JR, Samaras K, Jenkins AB, Kelly PJ, Spector TD, Campbell LV (2003) Moderate alcohol consumption, estrogen replacement therapy, and physical activity are associated with increased insulin sensitivity: is abdominal adiposity the mediator? Diabetes Care 26:2734–2740
33. Gonzalez CA, Pera G, Agudo A, Amiano P, Barricarte A, Beguiristain JM, Chirlaque MD, Dorronsoro M, Martinez C, Navarro C, Quiros JR, Rodriguez M, Tormo MJ (2000) Factors associated with the accumulation of abdominal fat estimated with anthropometric indexes. Med Clin (Barc) 114:401–406
34. Buemann B, Astrup A (2001) How does the body deal with energy from alcohol? Nutrition 17:638–641
35. Gianoulakis C (1998) Alcohol-seeking behavior: the roles of the hypothalamic-pituitary-adrenal axis and the endogenous opioid system. Alcohol Health Res World 22:202–210
36. Bjorntorp P (2001) Do stress reactions cause abdominal obesity and comorbidities? Obes Rev 2:73–86