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# Different associations between body-composition and alcohol when assessed by exposure frequency or by quantitative estimates of consumption



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## ABSTRACT

**Background:** Alcohol intake is widely believed to contribute to excess body fatness, especially among young men, however evidence is inconsistent. We have addressed this research question by investigating associations between reported alcohol-consumption and body-composition from large representative national surveys in a high alcohol-consuming country with high obesity prevalence.

**Methods:** Secondary analysis of combined cross-sectional nationally-representative Scottish Health Surveys (1995-2010). Reported alcohol drinking-frequency was divided into 5 groups, from 'non-frequent drinking' (reference) to daily/'almost every day' among 35,837 representative adults (mean age: 42.7, SD 12.7, range 18-64 years). Quantitative alcohol-consumption was categorised into 7 groups: from '1-7 to ≥50 10g units/week'. Regression models against measured BMI and waist-circumference (WC) were adjusted for age, physical activity, income, smoking, deprivation category and economic status.

**Results:** Among alcohol-consuming men, heavier drinking (21-28units/week) was associated with higher BMI by +1.4kg/$m^2$ (95% CI: 1.38,1.43), and higher WC by +3.4cm (3.2, 3.6) than drinking 1-7units/week. However, those who reported daily drinking frequency were associated with lower BMI by -2.45kg/$m^2$ (-2.4, -2.5) and lower WC by -3.7cm (95% CI: -3.3, -4.0) than those who reported less-frequent drinking. Similar associations were found for women. Most of these associations were restricted to subjects aged >30y. Unexplained variances in BMI and WC are large.

**Conclusions:** Quantitative alcohol consumption was positively associated, but frequency of consumption inversely, with BMI and WC among alcohol-consuming adults. Surveys need to evaluate both quantity and frequency of consumption. Lowest BMI and WC was associated with a 'Mediterranean' drinking style, relatively little but more frequently.


**Keywords:** alcohol, obesity, BMI, waist-circumference, body-composition.

## INTRODUCTION

Obesity, with all its health consequences[1], develops through imbalance between energy intake and expenditure, under interacting (epi-)genetic and numerous environmental factors[2-4]. Its rapid recent increase implies that lifestyle/environmental changes are dominant[5-7]. There is a strong popular belief that alcohol contributes importantly to overweight and obesity, particularly among young men[8] because alcohol intakes (7kcal/g), second only to fat (9kcal/g) and energy density have increased over the same period, especially in young adults. This seems plausible because alcohol cannot be stored so is preferentially oxidized, allowing greater storage of triglycerides from dietary fat and carbohydrates, and is often consumed additionally to normal meals, resulting in excess calorie intake[9]. However, epidemiological evidence is weak and conflicting. The large Nurses' Health Study 1980-2010 suggested lower BMI with greater alcohol consumption in women, or perhaps a biphasic relationship, while the Health Professionals Follow-Up Study 1986-2010 found no relationship in men for amounts up to >50g/day[10,11]. A well-designed systematic review of 14 cross-sectional and 13 prospective cohort-studies, 1984-2010[12], updated with three more recent multinational cross-sectional studies[13-15], shows that some studies find light-to-moderate alcohol-consumption associated with lower weight than never-drinking, former-drinking and heavy-drinking[14, 16-18], while others show that alcohol contributed to BMI[15]. Spirits have been associated with weight, but wine inversely[9].

These conflicting results could in part be methodological. There is no realistic way to estimate alcohol exposure objectively, which inevitably limits research. Some studies used self-reported height and weights, potentially introducing errors and bias[19]. Some failed to adjust for important possible confounders such as income[17], socioeconomic status and physical activity, while others may have over-adjusted for causal intermediates. Many used BMI as sole body-composition measure, but alcohol could affect body mass through effect on muscle, or bone mass, potentially in the opposite direction to an effect on body fat. Waist-circumference (WC) is better than BMI to indicate fatness and predict health problems, being less affected by variations in other tissues[20,21].

The present study sought robust associations among alcohol consumers between exposure to alcohol (frequency and dose consumed), and body-composition (both BMI and WC), to

answer the research question whether alcohol contributes to obesity. Scotland is particularly suited to this research, having an obesity prevalence close to US and Mexico[2], with 27% of adults obese and a further 38% overweight[1], and a wide range of alcohol-consumption: 20-30% drink over recommended weekly limits (>21units/week), and 33-45% exceed recommended daily limits[22].

## SUBJECTS/METHODS

### Patients and setting

The Scottish Health Survey (SHeS**)** reports cross-sectional data on nationally representative samples selected randomly from electoral roles. All participants receive a personal interview by a trained individual, plus a separate nurse-visit for further assessment including anthropometric measurements, for all subjects from 1995-2003, but only for a randomly-chosen subsample 2008-2010[23]. Methods changed in subsequent survey-years, and appropriate data were no longer available.

### Anthropometric and lifestyle measurements

Participants were visited at home by a trained nurse who recorded demographic information including age, sex, ethnicity, smoking status, alcohol consumption medical history, and treatment by standard health and lifestyle questionnaires. The trained nurse also measured weight, height and waist circumference by calibrated instruments. Participants were asked to wear light clothing and stand straight in a relaxed position, feet 25–30cm apart. WC was measured midway between the iliac crest and lowest rib. Categorical variables were computed for BMI (WHO cut-offs 25, 30, 40kg/m$^2$)[2] and WC ('action levels': 94 and 102cm in men; 80 and 88cm in women)[20]. For quantitative analyses, alcohol consumption included 2 variables: weekly alcohol consumption (volumes of drinks were converted to 10g 'units')[22] which were categorised into non-drinkers/ex-drinkers, drinkers of 1 to <7, 7 to <14, 14 to <21, 21 to <28, 28 to <35, 35 to <50, 50 units/week, and alcohol drinking/exposure frequency which were categorised into alcohol drinking almost every day, 5 or 6 days/week, 3 or 4 days/week, 1 or 2 days/week, non-frequent drinkers and non-drinkers (**Appendix table 1**).

**Scottish Index of Multiple Deprivation**

The Scottish Index of Multiple Deprivation (SIMD) is the Scottish Government's official tool for identifying areas and concentrations of deprivation in Scotland by incorporating several different aspects of deprivation (multiple-deprivations) and combining them into a single index. SIMD comprises seven domains: income, employment, education, housing, health, crime, and geographical access[24]. The present study categorised SIMD into five groups ranging from least deprived (first category) to most deprived (fifth category) (**Appendix table 1**).

**Data handling and statistical analysis**

Raw databases were requested from SHeS. The merged databases 1995-2010 included 36,026 (non-pregnant) adults of mean age 42.7, SD 12.7, range 18-64 years. Given the very large sample size, despite some variables being unavailable in earlier surveys, complete-case-analyses were performed and Central Limit Theorem applied, permitting parametric tests[25]. Details of missing cases are shown in **Table 1** and excluded cases in **Table 2** footnote. Generalized linear regression models were developed for BMI and WC (principal outcomes, dependent variables)[26] within alcohol categories (independent variables), for all participants, then separately by sex, and arbitrary age groups (younger=18-30 and older= 31-64 years); this age was chosen because, very broadly, Scottish peoples' alcohol drinking habits commonly change with maturity, and age 30 is close to the median for marriage/parenthood. Data were presented as both unadjusted and adjusted for age, sex, physical activity, SIMD, socioeconomic status, income and smoking status (never smokers, former smokers and current smokers). Two alcohol-exposure variables were examined: 1) 'alcohol drinking-frequency' as exposures per day or per week, and 2) 'weekly alcohol-consumption' in units/week, summated from reported consumptions of 6 main alcoholic drinks (normal-beer, lager, cider, shandy; strong beer, lager, cider; sherry, martini; spirits, liqueurs; wine; alcoholic soft-drink "alcopops") using standard measurements (glass, pint, can, bottle). The most common specific drinks (wine, beer, spirits and 'alcopops') were also tested separately. It was decided *a priori* to exclude 'non-drinkers' and ex-drinkers from regression analyses because they comprise at least three distinct subgroups (never-drinkers for religious or other reasons, reformed former-alcoholics, and those advised to abstain from alcohol on medical grounds) who will vary in components of body composition, so cannot be considered a single

category, nor be separated. Associations between explanatory variables were examined using chi-squared tests. Analysis of variance (ANOVA) was conducted to compare differences in BMI or WC between groups of alcohol consumption status. Multicollinearity, suggested by $R^2$>80%, was tested across explanatory variables. SPSS version 23.0 (SPSS Inc., Chicago, IL) was used for analyses.

**RESULTS**

The final sample comprised 20,008 non-pregnant women (mean BMI=27kg/m$^2$, 95%CI:26.9, 27.1; WC=82.8cm, 95%CI:82.3, 83.1) and 15,829 men (BMI=27.2kg/m$^2$, 95%CI:27.1, 27.2; WC=93.6cm, 95%CI:93.4, 93.9) (**Appendix table 2, Figure 1**). **Table 2** shows that among BMI and WC distributions: 32.2% of men and 40.6% of women were normal weight, 43.4% of men and 32.7% of women were overweight and 23.5% of men and 25.0% of women were obese, and 54.6% of men and 47.6 % of women had 'healthy' WCs (<80cm women, <94cm men)[20]. Both sexes were similarly distributed by SIMD and socioeconomic status, but almost 60% had low incomes (<£11,000p.a.). High level of physical activity was reported by 42% of men and 34% of women while zero/low physical activity was reported by 26.6% of men, 25.3% of women. There were 33.0% of male and 32.6% of female current smokers.

**Table 3** shows that among the 35,837 SHeS participants, 1,612 (476 men, 1,136 women) were never drinkers, 1,741 (734 men, 1,007 women,) former drinkers and the remaining 32,484 (14,619 men, 17,865 women) current drinkers of alcohol. Around 30% of men (n=4,560) reported drinking 1 to <7units/week, 17% (n=2,705) 7 to <14units/week, followed by 15% (n=2,397) and 14 to <21units/week. Over half of the women (n=10,603) reported drinking 1 to <7units/week and 19% (n=3,793) 7 to <14units/week (**Table 3, Figure 2**). Nearly 40% drank once/twice a week, more men than women drinking more frequently, and mostly at weekends (**Appendix table 3**).

**Table 4** shows that mong the men, current drinkers of moderate amount of alcohol (14-21 units/week) had lower BMI than ex-drinkers while current drinkers of between 7-35 units/week had WC than ex-drinkers ($p<0.05$). Men who consumed ≥50 units/week also had lower BMI and WC than ex-drinkers ($p<0.05$). There were no differences in either BMI or WC between male drinkers of any quantity of alcohol and non-drinkers. Among women,

current drinkers of any amount of alcohol had lower BMI than ex-drinkers ($p<0.01$) while current drinkers of between 7-28 units/week had lower BMI than non-drinkers ($p<0.001$). Female current drinkers up to 21 units/week also had lower WC than ex-drinkers and non-drinkers ($p<0.001$).

Regression analyses were conducted primarily amongst only those who consumed some alcohol (n=32,484). Never-drinkers (n=1,612) and former-drinkers (1,741) were excluded because these statuses could confound anthropometry, *e.g.* those with chronic illness and previously excessive-drinkers whose BMI and WC are affected by other factors. Illustrating this, 66.1% of ex-drinkers and 51.7% of non-drinkers were taking medicines (excluding contraceptive pill in women), vs. 38.6% of current drinkers. Those taking medications were 53.1%, 11.3% and 18.8% of individuals drinking 1 to <7, 7 to <14 and 14 to <21units/week, respectively. This difference was unrelated to age: mean ages of 'non-drinkers', 'ex-drinkers' and 'drinkers' were similar (43.5, 47.4, 42.4years). Non-drinkers are not considered further in this analysis.

**Generalised linear models for BMI**

Lower quantitative alcohol-consumption, but higher drinking-frequency, were significantly associated with lower BMI. Analysing by sex and age groups, the effect remained statistically significant ($p<0.05$) only among older participants (31-64 years). Regressions between alcohol-consumption and BMI were stronger in men, while associations with drinking-frequency were similar between sexes. Drinking 14-21units/week was associated with higher BMI by 0.8kg/m$^2$ (95%CI: 0.3, 1.2) in men and 0.7kg/m$^2$ (0.13, 1.52) in women aged 31-64 years (reference-category 1-7units/week). Light-drinking men (1 drink/drinking-day) had mean BMI 26.5kg/m$^2$ (26.3, 26.6) while heavier drinkers (>4 drinks/drinking-day) had BMI 27.5kg/m$^2$ (27.4, 27.7). Women in the same drinking categories had mean BMI 25.1kg/m$^2$ (25.0, 25.2) vs. 25.9kg/m$^2$ (25.5, 26.3).

Compared to the reference frequency-categories (infrequent-drinking, once/twice per month or less), after adjusting for covariates, drinking every day was associated with lower BMI, by -2.45kg/m$^2$ (-2.4, -2.5) in men, -3.1kg/m$^2$ (-2.8, -3.4) in women aged 31-64 years old. On the other hand, heavier drinking (21-28 units/week) was associated with higher BMI by 1.4kg/m$^2$

(1.38, 1.43) in men and 0.9kg/m$^2$ (0.7, 1.1) in women aged 31-64 years, compared to reference category 1-7units/week (**Figures 1 & 2**). Analyses for trend were significant ($p<0.002$) in all the **Figures 1 & 2** for alcohol-frequency, quantitative-consumption and for BMI.

Each unit alcohol-consumption on the heaviest drinking-day of the week was associated with greater BMI, by 0.06kg/m$^2$ (95%CI:0.04, 0.07) in men and 0.09kg/m$^2$ (0.05, 0.1) in women, assuming that confounders remain constant. Conclusions did not change when the smaller categories of quantity of alcohol-consumption were combined. No associations were found with BMI for specific drinks - beer, wine, spirits or alcopops, in any of the sex/age groups, after adjustment for covariates but without attempting to adjust for the other beverages.

**Generalised linear models for waist circumference**

Greater frequency of alcohol drinking was associated with lower WC in both sexes, whereas weekly consumption (units/week) was positively associated with WC. Analysed by age group, using an arbitrary cut-point 30years (broadly an age which marks marriage and parenthood, which commonly introduce behavioural changes) to identify 'younger/older' drinkers, these associations remained statistically significant only for 31-64year-old participants (**Figures 3 & 4**). Compared to infrequent drinkers aged 31-64 years old, WC of every-day male drinkers was lower by 3.7cm (95%CI:3.3, 4.0) and of every-day female drinkers by 4.8cm (4.6, 4.0).

Quantity of alcohol consumed, was associated with larger waists. Compared to 31-64 year olds drinking 1-7 units/week, the WC of men who drank 21-28 units/week was greater by 3.4cm (95%CI:3.2, 3.6) and women by 3.3cm (2.3, 4.3). As with BMI, relationships remained when the smaller categories of alcohol-consumption were combined.

Each extra unit alcohol consumed on the heaviest drinking-day of the week was related to 0.1cm (95%CI:0.05, 0.2) larger WC in men, with no association for women. No associations were found for wine or alcopops, and the effect of beer consumption on men's WC was minor (0.06 cm; 95%CI: 0.02, 0.1). Each 1 unit/week of spirits was related to slightly higher

WC both in men by 0.1cm (0.04, 0.2) and women by 0.2cm (0.02, 0.4) but only in those aged 31-64 years.

Analysis for trend was significant ($p<0.002$) for all relationships shown in **Figures 1-4**, between alcohol and body-composition. No multicollinearity ($R^2$ <60%) was observed between explanatory variables. Potential multicollinearity between frequency and quantity of alcohol-consumption was further eliminated by interaction analysis. **Appendix tables 3-5** provide cross-tabulations of frequency and quantitative consumption sub-categories.

## DISCUSSION

We aimed to clarify the currently conflicting literature on alcohol and body-composition, using a large database providing wide ranges of alcohol exposures, BMI and WC. The results indicate different, indeed opposite, associations, depending on whether *frequency* or *amount* of alcohol exposure is examined. Including WC adds confidence that these effects relate to body-fat rather than to other components of BMI, such as muscle or body water such as oedema[27]. Adjusted for possible confounding factors, alcohol-drinking frequency was inversely correlated with BMI and WC, while units consumed correlated positively with BMI (and WC, especially for men). Quantitative alcohol intake (units/week) was also controlled for drinking-frequency and vice versa, and relationships remained (data not shown). Only one previous study has found different effects from quantity or frequency of exposure: Breslow et al found an inverse relationship between alcohol-drinking frequency and BMI, while those reporting greater alcohol-consumption/drinking-day had higher BMI[17]. In our much larger study we found very small effects on BMI from greater alcohol-consumption on the heaviest drinking-day, much less than reported by Breslow et al[17], probably because different cut-offs were used.

Uncertainties over the components of body-weight which affect BMI limit its value as an indicator of body-fat, but WC is a better indicator of total body fat[27]. We found alcohol-consumption had similar associations with BMI and WC. This strengthens the conclusion that the associations relate predominantly to body-fat. Previous studies have not reported data on both quantitative exposure and drinking frequencies, related to body-composition. Wakabayashi et al reported that large WC (>85cm) was more frequent among heavier-

drinking Japanese men (>22g ethanol/day)[13]. Vadstrup et al found larger WC in a relatively large sample of Danes who drank >28 alcoholic-drinks/week, than 1-6/week[28], but Koh-Banerjee et al found no associations between alcohol-consumption and WC in US men aged 40-75years[29]. Our conclusions broadly agree with Tolstrup et al who observed less subsequent waist-gain with greater drinking frequencies among Danes[30]. Coulson et al have recently published a small study among Australian adults, suggesting greater body fat, BMI, and WC in those consuming >5units/day[31].

We found associations between alcohol and body composition to be largely restricted to older people (31-64 years), rejecting popular beliefs about 'beer-bellies' in younger people[8]. With age and inactivity, muscle-mass falls, body-fat increases and metabolic rate declines[32], possibly increasing vulnerability to alcohol. Similar associations between BMI and quantitative alcohol intake were also observed in 1,691 participants aged 35-60years from Lukasiewicz et al[9] and in 9,193 aged 27-62 years from Chakraborty et al[14]. However, Wakabayashi et al observed weaker or no associations between BMI or WC and drinking-frequency in older men (45-70years)[13]. It is theoretically possible that the menopause has some effect on the relationship between alcohol consumption and obesity[33]. We did not have data on menopausal status, but our data showed no clear difference between subgroups of women divided by age 50years. The influence of age was really very minor, and the results of our study were very similar for men and for women. There are many other factors such as environmental pressure among older women including career status. Our study is not about mechanisms, and these cross-sectional data cannot elucidate mechanisms, but the data do not suggest any specific impact of the menopause.

We focused on alcohol itself, rather than specific drinks which contain other calorie-sources and which have cultural associations. The literature on specific drinks is somewhat conflicting. Spirits and wine consumption have been associated with greater BMI[9], but Lukasiewicz et al[9] and Halkjaer et al[34] observed lower WC in 50-64-year-old Danes as wine consumption increased from 1 glass/week to daily. Studies have found few associations with intake of beer, the most frequently studied in search of evidence for 'beer bellies'[8,9]. Our regression analyses revealed no important associations between BMI, WC and specific alcoholic beverages.

The relationships between problem-drinking and overeating with addiction is increasingly recognised, with hypotheses that recreational drug or alcohol consumption compete with food (especially in comfort eating) for brain reward sites. Overeating and obesity may act as protective factors reducing drug reward and addiction. However, the present paper is an epidemiological analysis to establish how usual alcohol exposure and consumption relate to body composition, to guide future research. The database was representative of the general population, so will have included some problem drinkers, but it was not designed to study addicted alcoholics.

**Strengths and limitations**

The SHeS provides a very large, representative, database of Scottish adults. Most anthropometric measurements (over 98%) were measured, minimizing errors and self-reporting bias. As with all studies of alcohol, consumptions were self-reported, so potentially subject to some recall-bias, with respondents providing socially-desirable or 'right' answers. Questions asked about 'usual' weekly alcohol-consumption, which may not capture occasional heavy drinking[35]. Other sources of uncertainty arise, such as variation between age-groups in recall or in social desirability of responses, but while absolute amounts will always be uncertain, ranking by category of intake is less likely to be affected. This analysis spanned 16 years, during which obesity prevalence rose, and response rates (mean 64%) fell progressively from 81% to 55%[23]. Non-responders may have included more heavy-drinkers and very obese people, who are less willing to discuss or quantify their problem[36]. About 40% of men and women reported high physical activity which may be over-reported[37,38].

The cross-sectional nature of the study excludes proof of causality or evidence on mechanisms behind changes in body-composition; indeed reverse-causality seems possible, as bigger people (high body weight) metabolise alcohol more rapidly than smaller people. The only way alcohol could affect body fat is by changing energy balance, whose major variable components (calorie intake and physical activity) are not reliably measurable objectively in free-living subjects[39-41]. Alcohol might have *direct* effects, providing 7kcal/g, or *indirect* effects on food consumption and physical activity, or on metabolism. It commonly enhances food consumption while itself is the least satiating macronutrient, and second only

to fat in energy-density. Alcohol is also the priority fuel for metabolism (with necessary energy expenditure) as it cannot be stored. Alcohol oxidation suppresses lipolysis in peripheral tissues, favouring positive energy balance[42]. Thus dietary food-energy is not a confounder, but an essential part of any mechanism linking alcohol to obesity.

Although self-reported food consumption was collected, frequent intentional misreporting, plus uncertainties around recall amongst alcohol-consumers, make these data inadequate to differentiate direct and indirect influences of alcohol on body composition.

**Conclusions**

Quantitative alcohol consumption was positively associated, but frequency of alcohol intake was inversely associated, with BMI and WC in Scottish, alcohol-consuming adults. The lowest BMI and WC was associated with what might be considered a more 'Mediterranean' lifestyle, drinking relatively little but relatively frequently. These data clarify some previous confusion and indicate a need for future surveys and research to evaluate both quantity and frequency of alcohol consumption in relation to body composition and obesity.

**Transparency declaration**

The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported, and that no important aspects of the study have been omitted. The reporting of this work is compliant with STROBE guidelines.

## REFERENCES


1. Keenan K, Grant I, Ramsay J. Scottish Health Survey (2011) Obesity topic report. Available at http://www.scotland.gov.uk/Publications/2011/10/1138/3 (Accessed January 2017).
2. World Health Organisation. Obesity and overweight. Fact Sheet No 311. Available at http://www.who.int/mediacentre/factsheets/fs311/en/index.html (Accessed January 2017).
3. Gesta S, Bluher M, Yamamoto Y et al (2006) Evidence for a role of developmental genes in the origin of obesity and body fat distribution. Proc Nat Acad Sci USA 103: 6676-6681.
4. Han TS, Lean ME (2016) A clinical perspective of obesity, metabolic syndrome and cardiovascular disease. JRSM Cardiovasc Dis 5: 2048004016633371.
5. Zaccagni L, Rinaldo N, Bramanti B et al (2017) Relation between lifestyle behaviors and body composition patterns among healthy young Italians: a cross-sectional study. The Journal of sports medicine and physical fitness. J Sports Med Phys Fitness. doi: 10.23736/S0022-4707.17.07871-9. [Epub ahead of print]
6. Rask-Andersen M, Karlsson T, Ek WE et al (2017) Gene-environment interaction study for BMI reveals interactions between genetic factors and physical activity, alcohol consumption and socioeconomic status. PLoS Genetics 13: e1006977.
7. Linnér RK, Marioni RE, Rietveld CA et al (2017) An epigenome-wide association study of educational attainment (n= 10,767). bioRxiv 114637.
8. Schutze M, Schulz M, Steffen A et al (2009) Beer consumption and the 'beer belly': scientific basis or common belief? Eur J Clin Nutr 63: 1143–1149.
9. Lukasiewicz E, Mennen LI, Bertrais S et al (2005) Alcohol intake in relation to body mass index and waist-to-hip ratio: the importance of type of alcoholic beverage. Pub Health Nutr 8: 315-320.
10. Cao Y, Willett WC, Rimm EB et al (2015) Light to moderate intake of alcohol, drinking patterns, and risk of cancer: results from two prospective US cohort studies. BMJ 35: h4238.
11. Colditz GA, Giovannucci E, Rimm EB et al (1991) Alcohol intake in relation to diet and obesity in women and men. Am J Clin Nutr 54: 49-55.

12. Sayon-Orea C, Martinez-Gonzalez MA, Bes-Rastrollo M (2011) Alcohol-consumption and body weight: a systematic review. Nutr Rev 69: 419-431.
13. Wakabayashi I (2011) Age-dependent inverse association between alcohol-consumption and obesity in Japanese men. Obesity 19: 1881-1886.
14. Chakraborty S (2014) Analysis of NHANES 1999-2002 data reveals noteworthy association of alcohol-consumption with obesity. Annals Gastroenterol 27: 1-9.
15. Shelton NJ, Knott CS (2014) Association between alcohol calorie intake and overweight and obesity in English adults, Am J Public Health 104: 629-631.
16. Alcacera MA, Marques-Lopes I, Fajo-Pascual M et al (2008) Lifestyle factors associated with BMI in a Spanish graduate population: the SUN study. Obes Facts 1: 80-87.
17. Breslow RA, Smothers BA (2005) Drinking patterns and body mass index in never smokers: National Health Interview Survey, 1997-2001. Am J Epidemiol 161: 368-376.
18. Williamson DF, Forman MR, Binkin NJ et al (1987) Alcohol and body weight in United States adults. Am J Pub Health 77: 1324-1330.
19. Merrill RM, Richardson JS (2009) Validity of self-reported height, weight, and body mass index: findings from the National Health and Nutrition Examination Survey, 2001-2006. Prev Chronic Dis 6: A121.
20. Lean MEJ, Han TS, Morrison CE (1995) Waist-circumference as a measure for indicating need for weight management. BMJ 311: 158-161.
21. Han TS, Van Leer EM, Seidell JC, Lean MEJ (1996) Waist-circumference as a screening tool for cardiovascular risk factors: evaluation of receiver operating characteristics. Obes Res 4: 533-547.
22. Scottish Health Survey. The Scottish Health Survey, Main report 2010 www.scotland.gov.uk/Resource/Doc/358842/0121284.pdf (Accessed June 2016).
23. The Scottish Government. Scottish Health Survey; reports and publications 2012; Available at www.scotland.gov.uk/Topics/Statistics/Browse/Health/scottish-health-survey/ Publications#a2 (Accessed June 2016).
24. http://www.isdscotland.org/Products-and-Services/GPD-Support/Deprivation/SIMD/ (Accessed June 2016).
25. Motulsky H (1995) Intuitive Biostatistics (1st edition), chapter 37: Choosing a test. New York, Oxford University Press.

26. Feise R (2002) Do multiple outcome measures require p-value adjustment? BMC Medical Research Methodology 2: 8.
27. Lean MEJ, Han TS, Deurenberg P (1996) Predicting body-composition by densitometry from simple anthropometric measurements. Am J Clin Nutr 63: 4-14.
28. 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 27: 238-246.
29. Koh-Banerjee P, Chu N, Spiegelman D et al (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.
30. Tolstrup JS, Halkjaer J, Heitmann BL et al (2008) Alcohol drinking-frequency in relation to subsequent changes in waist-circumference. Am J Clin Nutr 87: 957-963.
31. Coulson CE, Williams LJ, Brennan SL et al (2013) Alcohol-consumption and body-composition in a population-based sample of elderly Australian men. Aging Clin Exp Res 25: 183-192.
32. Norgan N (2005) Laboratory and field measurements of body-composition. Pub Health Nutr 8: 1108-1122.
33. Milic J, Glisic M, Voortman T et al (2018) Menopause, ageing, and alcohol use disorders in women. Maturitas 111: 100-109.
34. Halkjaer J, Tjonneland A, Thomsen BL et al (2006) Intake of macronutrients as predictors of 5-y changes in waist-circumference. Am J Clin Nutr 84: 789-797.
35. Stockwell T, Donath S, Cooper-Stanbury M et al (2004) Under-reporting of alcohol-consumption in household surveys: a comparison of quantity-frequency, graduated-frequency and recent recall. Addiction 99: 1024-1033.
36. Lara J, Scott J, Lean MEJ (2004) Intentional mis-reporting of food consumption and its relationship with body mass index and psychological scores in women. J Hum Nutr Diet 17: 209-218.
37. Rzewnicki R, Vanden Auweele Y, De Bourdeaudhuij I (2003) Addressing over-reporting on the International Physical Activity Questionnaire (IPAQ) telephone survey with a population sample. Pub Health Nutr 6: 299-305.
38. Adams SA, Matthews CE, Ebbeling CB et al (2005) The effect of social desirability and social approval on self-reports of physical activity. Am J Epidemiol 161: 389-398.

39. Lennox A, Bluck L, Page P. (2014). Misreporting in the National Diet and Nutrition Survey Rolling Programme (NDNS RP): summary of results and their interpretation. London: PHE. (http://www.foodstandards.gov.scot/downloads/Appendix_X.pdf: accessed May 2018).
40. Lichtman SW, Pisarska K, Berman ER et al (1992) Discrepancy between self-reported and actual caloric intake and exercise in obese subjects. NEJM; 327:1893-1898.
41. Rasmussen LB, Matthiessen J, Biltoft-Jensen A, Tetens I (2007) Characteristics of misreporters of dietary intake and physical activity. Public Health Nutr; 10:230-237.
42. Jéquier E (2002) Pathways to obesity. Int J Obes 26(S2): S12.

## LEGENDS

**Figure 1:** Associations between alcohol drinking-frequency and BMI ($kg/m^2$) in a) men and b) women; reference category: non-frequent drinking: *p <0.05, **p <0.001. Adjustment for weekly alcohol-consumption, age (when all responders were included), income, physical activity, Scottish Index of Multiple Deprivation, economic status and smoking.

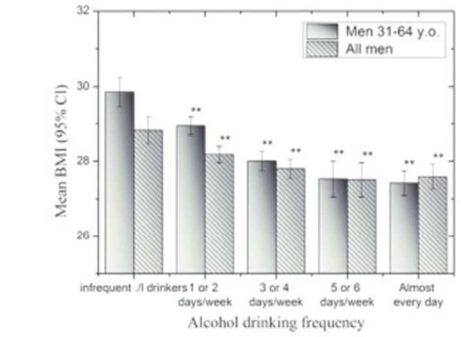
**Figure 2:** Associations between weekly alcohol-consumption (units) and BMI ($kg/m^2$) in a) men and b) women; reference category: non-frequent drinking: *p <0.05, **p <0.001. Adjustment for alcohol drinking-frequency, age (when all responders were included), income, physical activity, Scottish Index of Multiple Deprivation, economic status and smoking.

**Figure 3:** Associations between alcohol drinking-frequency and WC (cm) in a) men, b) women; reference category: non-frequent drinking: *p <0.05, **p <0.001. Adjustment for weekly alcohol-consumption, age (when all responders were included), income, physical activity, Scottish Index of Multiple Deprivation, economic status and smoking.

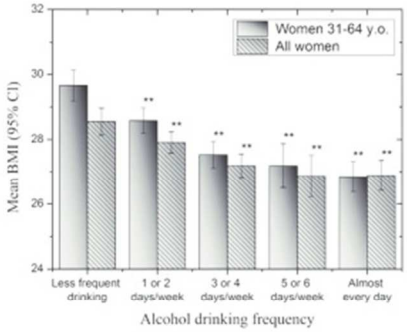
**Figure 4:** Associations between weekly alcohol-consumption and WC (cm) in a) men and b) women; reference category: 1-7 units/week: *p <0.05, **p <0.001. Adjustment for alcohol drinking-frequency, age (when all responders were included), income, physical activity, Scottish Index of Multiple Deprivation, economic status and smoking.

**Appendix Figure 1:** Distribution histograms for a) waist circumference for men, b) waist circumference for women, c) body mass index for men, and d) body mass index for women.

**Appendix Figure 2:** Weekly alcohol consumption (units per week) in men and women.




a)




b)

Figure 1

209x297mm (72 x 72 DPI)

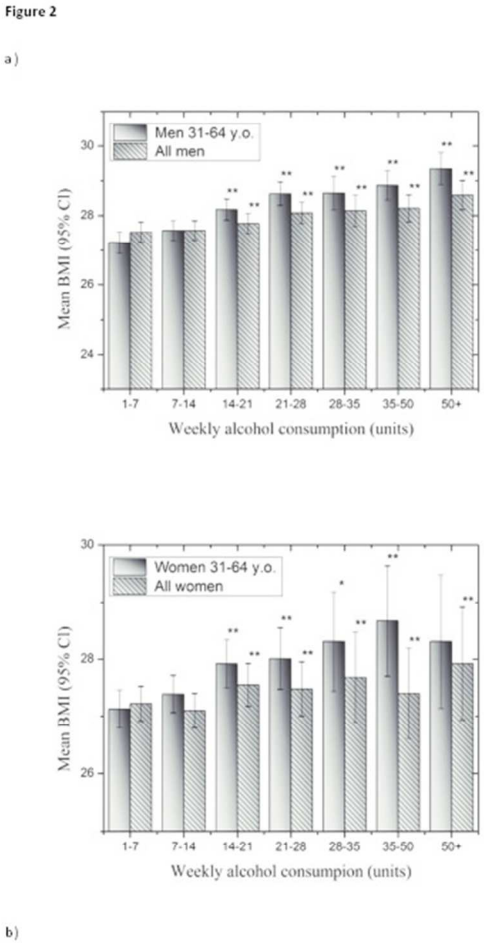
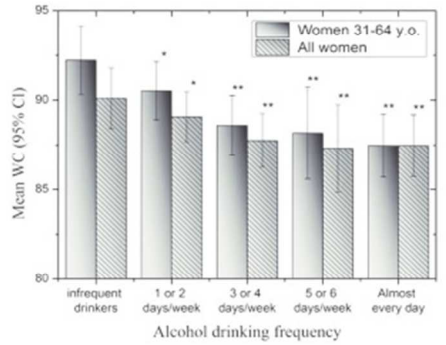



Figure 2

209x297mm (72 x 72 DPI)

Figure 3


a)

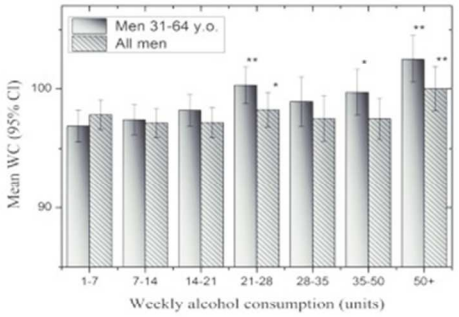



b)

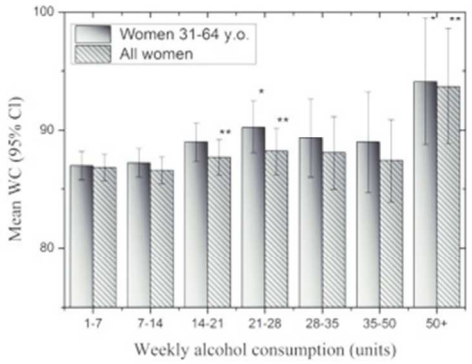
Figure 3

209x297mm (72 x 72 DPI)

Figure 4




a)




b)

Figure 4

209x297mm (72 x 72 DPI)

**Table 1.** Missing values among variables

| Variable | Available | Missing | Total |
|---|---|---|---|
| | | | |
| BMI* | 32,145 | 3,881 | 36,026 |
| WC | 18,729 | 17,297 | 36,026 |
| Drinking frequency | 22,175 | 13,851 | 36,026 |
| Alcohol quantity | 35,837 | 189 | 36,026 |
| Sex | 36,026 | 0 | 36,026 |
| Age | 36,026 | 0 | 36,026 |
| Activity Level | 35,949 | 77 | 36,026 |
| Deprivation | 21,096 | 14,930 | 36,026 |
| Employment | 35,948 | 78 | 36,026 |
| | | | |
| BMI vs Alcohol quantity | 18,169 | 17,857 | 36,026 |
| BMI vs Drinking frequency | 16,382 | 19,644 | 36,026 |
| WC vs Alcohol quantity | 6,131 | 29,895 | 36,026 |
| WC vs Drinking frequency | 5,618 | 30,408 | 36,026 |
| | | | |
| All | 5,618 | 30,408 | 36,026 |

*Missing are already excluded for BMI (see footnote for Table 2), those counted here are those with unrealistic values, which are excluded from Table 2

**Table 2.** Classification of male and female participants according to BMI and WC groups, smoking status, physical activity level, socioeconomic status, Scottish Index of Multiple Deprivation and income quintiles, as described in the Scottish Health Surveys [10-12].

| | Males (N=15,932)* | | Females (N=20,094)* | |
|---|---|---|---|---|
| **Years†** | **N** | **%** | **N** | **%** |
| 1995 | 3424 | 21.2 | 4203 | 20.9 |
| 1998 | 3259 | 20.5 | 4044 | 20.1 |
| 2003 | 2662 | 16.7 | 3297 | 16.4 |
| 2008 | 2015 | 12.7 | 2551 | 12.7 |
| 2009 | 2346 | 14.7 | 3062 | 15.3 |
| 2010 | 2226 | 14.0 | 2937 | 14.6 |
| **BMI (kg/m$^2$)** | | | | |
| <18.5 | 122 | 0.9 | 316 | 1.8 |
| 18.5-24.9 | 4614 | 32.2 | 7227 | 40.6 |
| 25-29.9 | 6220 | 43.4 | 5829 | 32.7 |
| ≥30 | 3367 | 23.5 | 4450 | 25 |
| **WC (cm)** | | | | |
| Women <80 and men <94 | 4582 | 54.6 | 4920 | 47.6 |
| Women 80-87.9 and men 94-101.9 | 1946 | 23.2 | 2350 | 22.7 |
| Women ≥88 and men ≥102 | 1857 | 22.1 | 3074 | 29.7 |
| **Cigarette smoking status** | | | | |
| Current smoker | 5233 | 33 | 6532 | 32.6 |
| Ex-smoker | 3752 | 23.6 | 4322 | 21.6 |
| Non-smoker | 6896 | 43.4 | 9197 | 45.9 |
| **Summary activity level** | | | | |
| Low | 4234 | 26.6 | 5072 | 25.3 |
| Medium | 4930 | 31 | 8234 | 41.1 |
| High | 6730 | 42.3 | 6749 | 33.7 |
| **National socioeconomic status classification** | | | | |
| Managerial and professional occupations | 5142 | 33.2 | 6460 | 33.6 |
| Intermediate occupations | 3903 | 25.2 | 6080 | 31.6 |
| Routine and manual occupations | 6338 | 41 | 6493 | 33.8 |
| **Scottish Index of Multiple Deprivation** | | | | |
| 5$^{th}$ (least deprived) | 1711 | 18.5 | 2168 | 18.3 |
| 4$^{th}$ | 2132 | 23.1 | 2622 | 22.1 |
| 3$^{rd}$ | 1891 | 20.4 | 2385 | 20.1 |
| 2$^{nd}$ | 1786 | 19.3 | 2276 | 19.2 |
| 1$^{st}$ (most deprived) | 1729 | 18.7 | 2396 | 20.2 |
| **Income quintiles** | | | | |
| 1$^{st}$ (≥£39520) | 2103 | 13.2 | 2205 | 11 |
| 2$^{nd}$ (≥£24834-<39520) | 2058 | 12.9 | 2403 | 12 |
| 3$^{rd}$ (≥£17256-<24834) | 1545 | 9.7 | 1938 | 9.6 |
| 4$^{th}$ (≥£10995-<17256) | 1146 | 7.2 | 1765 | 8.8 |
| 5$^{th}$ (≤£10994) | 9080 | 57 | 11783 | 58.6 |

*Numbers within categories do not necessarily add to the total due to missing data. Percentages may not add exactly to 100% due to rounding. †The merged databases 1995-2010 included 36,026 (non-pregnant) adults aged 18-64years (1995: n=7627; 1998: n=7303; 2003: n=5959; and annually for 2008: n=4566; 2009: n=5408; 2010: n=5163). Those lacking valid data for sex, age, height, weight and height or waist, and alcohol-consumption (BMI: 7048; WC: 18,966) were excluded from analysis. Implausible values (arbitrary criteria) were treated as 'missing data': WC >140cm (n=48), BMI <14kg/m$^2$ (n=19), >200 alcohol units/week (n=54) and >50units on the heaviest day (n=27).

**Table 3.** BMI and WC (Unadjusted data, median and inter-quartile range: 25th and 75th centiles) for alcohol drinking consumption and frequency, for men and women.

| | n | | BMI | | | | WC | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Men | Women | Men | | Women | | Men | | Women | |
| | | | Median | $25^{th}$-$75^{th}$ | Median | $25^{th}$-$75^{th}$ | Median | $25^{th}$-$75^{th}$ | Median | $25^{th}$-$75^{th}$ |
| **Alcohol drinking quantity (units/week)** | | | | | | | | | | |
| Non-drinkers | 476 | 1136 | 26.2 | 23.3-30.0 | 26.3 | 22.8-31.2 | 93.5 | 85.5-102.7 | 82.7 | 73.7-95.8 |
| Ex-drinkers | 734 | 1007 | 27.1 | 24.3-30.8 | 27.2 | 22.9-32.0 | 95.2 | 86.1-105.1 | 83.5 | 74.3-97.1 |
| 1 to <7 | 4560 | 10603 | 27.0 | 24.2-30.2 | 26.1 | 23.0-30.3 | 93.2 | 85.9-102.1 | 81. | 73-90.8 |
| 7 to <14 | 2705 | 3793 | 26.6 | 24.1-29.3 | 25.4 | 22.9-29.0 | 92. | 85.5-99.5 | 79.9 | 72.9-88.1 |
| 14 to < 21 | 2397 | 1771 | 26.5 | 23.9-29.4 | 25.5 | 22.9-28.7 | 91.1 | 84.6-99.3 | 79.7 | 72.7-88.1 |
| 21 to <28 | 1778 | 873 | 26.6 | 24.1-29.6 | 25.5 | 22.9-29.2 | 92.5 | 85.1-100.1 | 82.1 | 74.2-90.6 |
| 28 to <35 | 902 | 327 | 26.7 | 23.9-29.2 | 25.3 | 22.9-28.7 | 91.6 | 85.2-99.3 | 79.3 | 72.5-87.2 |
| 35 to <50 | 1145 | 294 | 26.7 | 24.3-29.5 | 25.2 | 22.5-29.6 | 93.1 | 86.2-100.7 | 80.8 | 75-89.5 |
| ≥50 | 1082 | 200 | 26.6 | 23.2-29.8 | 25.8 | 22.7-29.2 | 92.5 | 84.2-101.1 | 81.5 | 75.3-90.8 |
| **Alcohol drinking frequency (days/week)** | | | | | | | | | | |
| Almost every day | 1687 | 1103 | 26.8 | 24.0-29.4 | 25.3 | 22.7-28.4 | 94.3 | 86.8-101.5 | 80.9 | 73.4-88.9 |
| 5 or 6 | 707 | 499 | 26.6 | 23.9-29.3 | 25.4 | 22.8-29.0 | 91.1 | 85.2-99.0 | 80.5 | 73.7-89.3 |
| 3 or 4 | 2925 | 2175 | 26.5 | 24.0-29.3 | 25.4 | 23.0-28.5 | 92.2 | 85.4-99.7 | 80.2 | 73.5-88.0 |
| 1 or 2 | 6021 | 7058 | 27.2 | 24.3-30.3 | 26.4 | 23.1-30.9 | 93.2 | 85.3-102.5 | 81.3 | 72.9-92 |
| Non frequent drinkers | 3215 | 6943 | 26.2 | 22.6-31.0 | 27.5 | 22.8-31.5 | 91.4 | 84.9-103.4 | 87.6 | 80.8-101.5 |
| Non-drinkers | 476 | 1136 | 26.9 | 24.2-30.7 | 26.8 | 22.9-31.8 | 94.0 | 86.1-102.9 | 83.3 | 74.1-96.4 |

**Table 4.** Analysis of variance to compare differences in BMI or WC between groups of alcohol drinkers (referent group) with ex-drinkers and non-drinkers in men and in women.

| | Mean differences in BMI (p-values), kg/m$^2$ | | | | Mean differences in WC (p-values), cm | | | |
|---|---|---|---|---|---|---|---|---|
| | Men | | Women | | Men | | Women | |
| **Drinker (referent )** | **Ex-Drinker** | **Non-Drinker** | **Ex-Drinker** | **Non-Drinker** | **Ex-Drinker** | **Non-Drinker** | **Ex-Drinker** | **Non-Drinker** |
| 1 to <7 units/week | -0.17 (1.000) | 0.52 (0.926) | **-0.91 (<0.001)** | -0.23 (1.000) | -1.41 (1.000) | 0.42 (1.000) | **-3.34 (<0.001)** | -1.87 (0.06) |
| 7 to <14 units/week | -0.58 (0.139) | 0.11 (1.000) | **-1.65 (<0.001)** | **-0.97 (<0.001)** | **-2.82 (0.004)** | -0.99 (1.000) | **-4.59 (<0.001)** | **-3.13 (<0.001)** |
| 14 to <21 units/week | **-0.68 (0.027)*** | 0.01 (1.000) | **-1.74 (<0.001)** | **-1.06 (<0.001)** | **-3.2 (0.001)** | -1.36 (1.000) | **-4.78 (<0.001)** | **-3.32 (<0.001)** |
| 21 to <28 units/week | -0.54 (0.357) | 0.15 (1.000) | **-1.61 (<0.001)** | **-0.93 (0.024)** | **-2.63 (0.024)** | -0.79 (1.000) | -2.9 (0.072) | -1.44 (1.000) |
| 28 to <35 units/week | -0.67 (0.155) | 0.02 (1.000) | **-1.77 (<0.001)** | -1.09 (0.128) | **-3.14 (0.006)** | -1.3 (1.000) | **-5.03 (0.002)** | -3.57 (0.103) |
| 35 to <50 units/week | -0.48 (1.000) | 0.21 (1.000) | **-1.61 (0.002)** | -0.93 (0.633) | -2.13 (0.309) | -0.3 (1.000) | -3.9 (0.195) | -2.44 (1.000) |
| ≥50 units/week | **-0.77 (0.023)** | -0.08 (1.000) | **-1.69 (0.008)** | -1.01 (0.952) | **-2.92 (0.012)** | -1.09 (1.000) | -1.6 (1.000) | -0.13 (1.000) |

Results are differences row-column (p-value). Bold results indicate significantly different between groups.

*Example of interpretation: BMI of those who drink 14-21 units of alcohol is 0.68 kg/m$^2$ lower than BMI of ex-drinkers (p=0.027).

## Appendix 1. Survey variable transformations

The relevant information from all 6 surveys available (1995-2010) was merged into a single new SPSS database. Derived variables were created for the present analyses, to create categorical variables from continuous data, collapsing some categorical variables, and to generate new complex-variables. Data collected varied very slightly between surveys. Some of the derived variables could only be created from data collected after 1998.

The derived variables computed for both 1995 and 1998 were restricted to: 'economic status', 'socioeconomic status-3groups', 'summary activity level', and for 1995 'grouped alcohol-consumption per week-women', 'grouped alcohol-consumption per week-men'. Variables included only since 2003 were coded as missing data for earlier surveys. Data missing for 1995 and 1998 were 'equivalised income', 'which day did they drink most', 'number of days per week any activities 30min+(10-29)min sessions included', 'Scottish Index of Multiple Deprivation'. Data were not available from the 1995 survey for: 'units of alcopops per week', 'units of alcohol drunk on the heaviest day', 'whether drank over recommended limits last week'; and for 1998 'how often eat crisps', 'how often eat biscuits'. In all years except 1995, beer consumption was classified under two questions: 'units of strong beer per week' and 'units of normal beer per week'. To generate comparable variables from the six survey years, these data were collated in one variable named 'units of beer per week'. After merging survey data, derived variables were computed from the categorical variables 'alcohol drinking-frequency', 'weekly alcohol-consumption (units)'. Amongst participants who 'did not drink at all in the last 12 months', those who used to drink before this period were classified as ex-drinkers, whereas the ones who never drank were classified as non-drinkers. Physical activity was estimated from data collected routinely in the Scottish Health Surveys on activity duration (minimum duration considered was 10min), intensity and frequency of the activity, were used to assess: physical activities included sports and structured exercise, but also walking, housework and other physical jobs incurred within daily lives. We used one of the derived variables created from the original SHS analysis, which divided activity levels into low, medium and high.

**Appendix Table 1:** Values of categorical variables used in the Generalised Linear Models

| | |
|---|---|
| Weekly consumption of alcohol | 1= 1 or more than 1 but less than 7 units |
| | 2= 7 or more but less than 14 units |
| | 4= 14 or more but less than 21 units |
| | 5= 21 or more but less than 28 units |
| | 6= 28 or more but less than 35 units |
| | 7= 35 or more but less than 50 units |
| | 8= 50 units or more |
| Alcohol drinking frequency | 1= Non-frequent drinking (from 1 or 2 /month to 1 or 2/year) |
| | 2= 1 or 2 days/week |
| | 3= 3 or 4 days/week |
| | 4= 5 or 6 days/week |
| | 5= Almost every day |
| Summary activity level | 1= low |
| | 2= medium |
| | 3= high |
| Scottish Index of Multiple Deprivation | 1= 5$^{th}$-least deprived |

| | |
|---|---|
| (SIMD) | 2= 4th |
| | 3= 3rd |
| | 4= 2nd |
| | 5= 1st |
| Economic status | 0= paid employment outside home |
| | 1= not paid employment (various reasons) |

**Appendix Table 2:** Descriptive characteristics for anthropometric and alcohol variables[1, 2]

| | | | All | Men | Women |
|---|---|---|---|---|---|
| Body mass index (kg/m$^2$) | Mean | | 27.1 | 27.1 | 27 |
| | 95% Confidence Interval | Lower Bound | 27 | 27.1 | 26.9 |
| | | Upper Bound | 27.1 | 27.2 | 27.1 |
| | Median | | 26.3 | 26.7 | 25.9 |
| | Inter quartile Range | | 6.4 | 5.7 | 7 |
| | Minimum | | 14.6 | 15.8 | 14.6 |
| | Maximum | | 59.1 | 49.3 | 59.1 |
| Waist circumference (cm) | Mean | | 87.7 | 93.6 | 82.8 |
| | 95% Confidence Interval | Lower Bound | 87.5 | 93.3 | 82.6 |
| | | Upper Bound | 87.8 | 93.8 | 83.1 |
| | Median | | 86.6 | 92.6 | 80.8 |
| | Inter quartile Range | | 19.2 | 15.6 | 17.3 |
| | Minimum | | 54.2 | 60.3 | 54.2 |
| | Maximum | | 139.9 | 139.6 | 139.9 |
| Alcohol units drunk on the heaviest day in the last 7 | Mean | | 6.8 | 8.5 | 5.2 |
| | 95% Confidence Interval | Lower Bound | 6.7 | 8.3 | 5.2 |
| | | Upper Bound | 6.9 | 8.6 | 5.3 |
| | Median | | 5 | 6 | 4 |
| | Inter quartile Range | | 7 | 9 | 5 |
| | Minimum | | 0.44 | 0.4 | 0.4 |
| | Maximum | | 50 | 50 | 49.5 |

| | | | | | |
|---|---|---|---|---|---|
| Weekly alcohol consumption (units) | Mean | | 13.6 | 19.8 | 8.6 |
| | 95% Confidence Interval | Lower Bound | 13.4 | 19.5 | 8.4 |
| | | Upper Bound | 13.8 | 20.2 | 8.7 |
| | Median | | 8 | 14.2 | 5.1 |
| | Inter quartile Range | | 15.8 | 21.2 | 10 |
| | Minimum | | 0.01 | 0.03 | 0.01 |
| | Maximum | | 197.7 | 197.7 | 189.8 |

[1]: Zero values have been excluded for alcohol variables
[2]: Without extreme values

**Appendix Table 3:** Frequency of alcohol consumption for men and women

| | Men | | Women | |
|---|---|---|---|---|
| | **N** | **%** | **N** | **%** |
| **Almost every day** | 1733 | 11.2 | 1107 | 5.7 |
| **Five or six days a week** | 710 | 4.6 | 499 | 2.6 |
| **Three or four days a week** | 2926 | 18.9 | 2175 | 11.2 |
| **Once or twice a week** | 6021 | 38.9 | 7057 | 36.4 |
| **Once or twice a month** | 1889 | 12.2 | 3580 | 18.5 |
| **Once every couple of months** | 744 | 4.8 | 1678 | 8.7 |
| **Once or twice a year** | 582 | 3.8 | 1685 | 8.7 |
| **Not at all in the last 12 months** | 57 | 0.4 | 116 | 0.6 |
| **Never** | 826 | 5.3 | 1490 | 7.7 |

**Appendix Table 4:** Drinking frequency and quantity cross-tabulation (excluding non- and ex-drinkers)

| | 1 < 7 | 7 < 14 | 14 < 21 | 21 < 28 | 28 < 35 | 35 < 50 | 50 + | Total |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| Daily/almost every day | 66 | 365 | 513 | 434 | 312 | 450 | 634 | 2,774 |
| 5 or 6 days/week | 65 | 220 | 235 | 248 | 110 | 173 | 152 | 1,203 |
| 3 or 4 days/week | 455 | 1,289 | 1,135 | 878 | 427 | 510 | 391 | 5,085 |
| 1 or 2 days/week | 4,591 | 4,328 | 2,252 | 1,085 | 379 | 304 | 101 | 13,040 |
| infrequent drinkers | 9,797 | 294 | 30 | 4 | 1 | 1 | 4 | 10,131 |
| | | | | | | | | |
| Total | 14,974 | 6,496 | 4,165 | 2,649 | 1,229 | 1,438 | 1,282 | 32,233 |

**Appendix Table 5**: Alcohol units by consumption frequency (n and %)

| | Female | Male | Total |
|---|---|---|---|
| Ex-drinkers | 1,007 | 734 | 1,741 |
| | 5.03 | 4.64 | 4.86 |
| Non-drinkers | 1,136 | 476 | 1,612 |
| | 5.68 | 3.01 | 4.5 |
| 1 < 7 | 10,603 | 4,560 | 15,163 |
| | 52.99 | 28.81 | 42.31 |
| 7 < 14 | 3,793 | 2,705 | 6,498 |
| | 18.96 | 17.09 | 18.13 |
| 14 < 21 | 1,771 | 2,397 | 4,168 |
| | 8.85 | 15.14 | 11.63 |
| 21 < 28 | 873 | 1,778 | 2,651 |
| | 4.36 | 11.23 | 7.4 |
| 28 < 35 | 327 | 902 | 1,229 |
| | 1.63 | 5.7 | 3.43 |
| 35 < 50 | 294 | 1,145 | 1,439 |
| | 1.47 | 7.23 | 4.02 |
| 50 + | 204 | 1,132 | 1,336 |
| | 1.02 | 7.15 | 3.73 |
| Total | 20,008 | 15,829 | 35,837 |
| | 100 | 100 | 100 |

**Appendix Table 6**: Which day did subjects drink the heaviest (n and %)?

| | Female | Male | Total |
|---|---|---|---|
| sunday | 1,262 | 1,177 | 2,439 |
| | 17.25 | 17.72 | 17.47 |
| monday | 452 | 506 | 958 |
| | 6.18 | 7.62 | 6.86 |
| tuesday | 460 | 443 | 903 |
| | 6.29 | 6.67 | 6.47 |
| wednesday | 459 | 492 | 951 |
| | 6.27 | 7.41 | 6.81 |
| thursday | 506 | 514 | 1,020 |
| | 6.91 | 7.74 | 7.31 |
| friday | 1,301 | 1,117 | 2,418 |
| | 17.78 | 16.82 | 17.32 |
| saturday | 2,878 | 2,393 | 5,271 |
| | 39.33 | 36.03 | 37.76 |
| Total | 7,318 | 6,642 | 13,960 |
| | 100 | 100 | 100 |

| | Freq. | Percent | Cum. |
|---|---|---|---|
| sunday | 2,439 | 17.47 | 17.47 |
| monday | 958 | 6.86 | 24.33 |
| tuesday | 903 | 6.47 | 30.8 |
| wednesday | 951 | 6.81 | 37.61 |
| thursday | 1,020 | 7.31 | 44.92 |
| friday | 2,418 | 17.32 | 62.24 |
| saturday | 5,271 | 37.76 | 100 |
| Total | 13,960 | 100 | |

**Appendix Table 1:** Values of categorical variables used in the Generalised Linear Models

| | |
|---|---|
| Weekly consumption of alcohol | 1= 1 or more than 1 but less than 7 units |
| | 2= 7 or more but less than 14 units |
| | 4= 14 or more but less than 21 units |
| | 5= 21 or more but less than 28 units |
| | 6= 28 or more but less than 35 units |
| | 7= 35 or more but less than 50 units |
| | 8= 50 units or more |
| Alcohol drinking frequency | 1= Non-frequent drinking (from 1 or 2 /month to 1 or 2/year) |
| | 2= 1 or 2 days/week |
| | 3= 3 or 4 days/week |
| | 4= 5 or 6 days/week |
| | 5= Almost every day |
| Summary activity level | 1= low |
| | 2= medium |
| | 3= high |
| Scottish Index of Multiple Deprivation | 1= 5$^{th}$-least deprived |

| | |
|---|---|
| Scottish Index of Multiple Deprivation (SIMD) | 1= 5th-least deprived |
| | 2= 4th |
| | 3= 3rd |
| | 4= 2nd |
| | 5= 1st |
| Economic status | 0= paid employment outside home |
| | 1= not paid employment (various reasons) |

**Appendix Table 2:** Descriptive characteristics for anthropometric and alcohol variables[1, 2]

| | | | All | Men | Women |
|---|---|---|---|---|---|
| Body mass index (kg/m$^2$) | Mean | | 27.1 | 27.1 | 27 |
| | 95% Confidence Interval | Lower Bound | 27 | 27.1 | 26.9 |
| | | Upper Bound | 27.1 | 27.2 | 27.1 |
| | Median | | 26.3 | 26.7 | 25.9 |
| | Inter quartile Range | | 6.4 | 5.7 | 7 |
| | Minimum | | 14.6 | 15.8 | 14.6 |
| | Maximum | | 59.1 | 49.3 | 59.1 |
| Waist circumference (cm) | Mean | | 87.7 | 93.6 | 82.8 |
| | 95% Confidence Interval | Lower Bound | 87.5 | 93.3 | 82.6 |
| | | Upper Bound | 87.8 | 93.8 | 83.1 |
| | Median | | 86.6 | 92.6 | 80.8 |
| | Inter quartile Range | | 19.2 | 15.6 | 17.3 |
| | Minimum | | 54.2 | 60.3 | 54.2 |
| | Maximum | | 139.9 | 139.6 | 139.9 |
| Alcohol units drunk on the heaviest day in the last 7 | Mean | | 6.8 | 8.5 | 5.2 |
| | 95% Confidence Interval | Lower Bound | 6.7 | 8.3 | 5.2 |
| | | Upper Bound | 6.9 | 8.6 | 5.3 |
| | Median | | 5 | 6 | 4 |
| | Inter quartile Range | | 7 | 9 | 5 |
| | Minimum | | 0.44 | 0.4 | 0.4 |
| | Maximum | | 50 | 50 | 49.5 |

| | | | | | |
|---|---|---|---|---|---|
| Weekly alcohol consumption (units) | Mean | | 13.6 | 19.8 | 8.6 |
| | 95% Confidence Interval | Lower Bound | 13.4 | 19.5 | 8.4 |
| | | Upper Bound | 13.8 | 20.2 | 8.7 |
| | Median | | 8 | 14.2 | 5.1 |
| | Inter quartile Range | | 15.8 | 21.2 | 10 |
| | Minimum | | 0.01 | 0.03 | 0.01 |
| | Maximum | | 197.7 | 197.7 | 189.8 |

[1]: Zero values have been excluded for alcohol variables
[2]: Without extreme values

**Appendix Table 3:** Frequency of alcohol consumption for men and women

| | Men | | Women | |
|---|---|---|---|---|
| | **N** | **%** | **N** | **%** |
| **Almost every day** | 1733 | 11.2 | 1107 | 5.7 |
| **Five or six days a week** | 710 | 4.6 | 499 | 2.6 |
| **Three or four days a week** | 2926 | 18.9 | 2175 | 11.2 |
| **Once or twice a week** | 6021 | 38.9 | 7057 | 36.4 |
| **Once or twice a month** | 1889 | 12.2 | 3580 | 18.5 |
| **Once every couple of months** | 744 | 4.8 | 1678 | 8.7 |
| **Once or twice a year** | 582 | 3.8 | 1685 | 8.7 |
| **Not at all in the last 12 months** | 57 | 0.4 | 116 | 0.6 |
| **Never** | 826 | 5.3 | 1490 | 7.7 |

**Appendix Table 4:** Drinking frequency and quantity cross-tabulation (excluding non- and ex-drinkers)

| | 1 < 7 | 7 < 14 | 14 < 21 | 21 < 28 | 28 < 35 | 35 < 50 | 50 + | Total |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| Daily/almost every day | 66 | 365 | 513 | 434 | 312 | 450 | 634 | 2,774 |
| 5 or 6 days/week | 65 | 220 | 235 | 248 | 110 | 173 | 152 | 1,203 |
| 3 or 4 days/week | 455 | 1,289 | 1,135 | 878 | 427 | 510 | 391 | 5,085 |
| 1 or 2 days/week | 4,591 | 4,328 | 2,252 | 1,085 | 379 | 304 | 101 | 13,040 |
| infrequent drinkers | 9,797 | 294 | 30 | 4 | 1 | 1 | 4 | 10,131 |
| | | | | | | | | |
| Total | 14,974 | 6,496 | 4,165 | 2,649 | 1,229 | 1,438 | 1,282 | 32,233 |

**Appendix Table 5**: Alcohol units by consumption frequency (n and %)

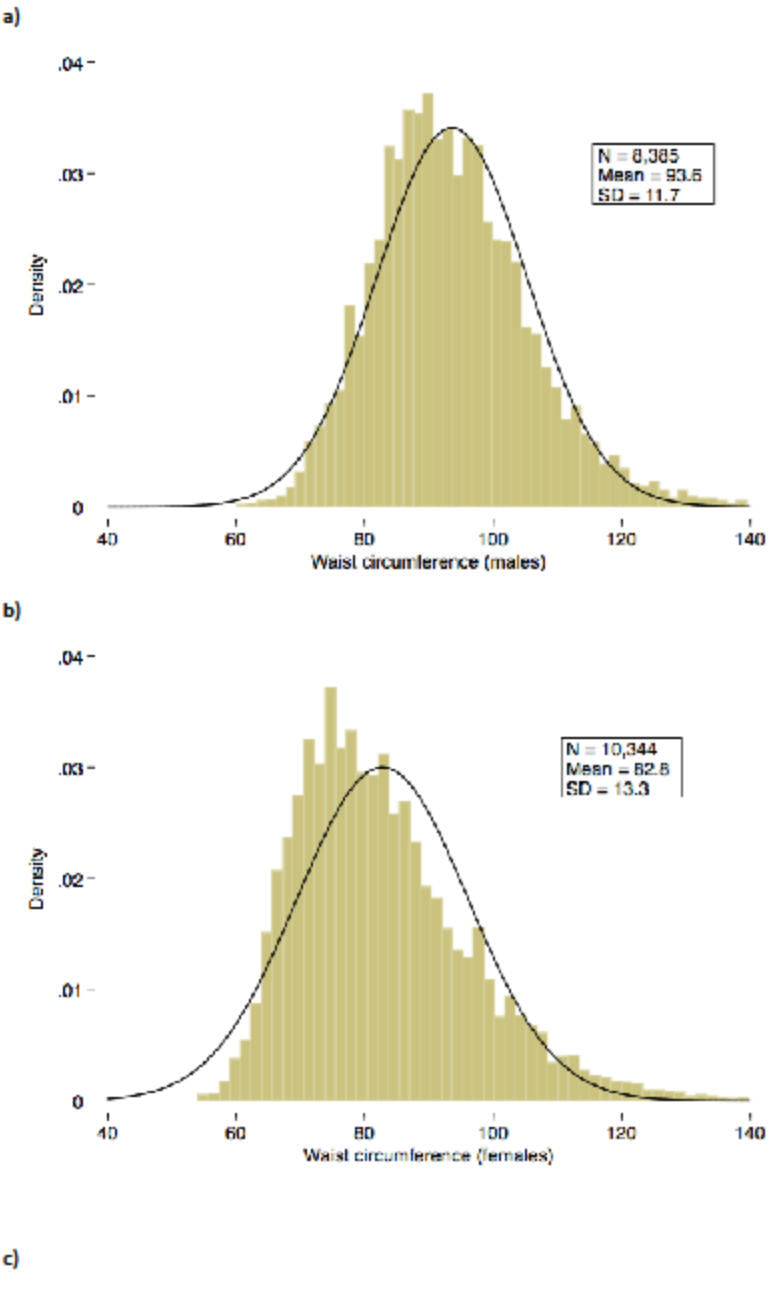
| | Female | Male | Total |
|---|---|---|---|
| Ex-drinkers | 1,007 | 734 | 1,741 |
| | 5.03 | 4.64 | 4.86 |
| Non-drinkers | 1,136 | 476 | 1,612 |
| | 5.68 | 3.01 | 4.5 |
| 1 < 7 | 10,603 | 4,560 | 15,163 |
| | 52.99 | 28.81 | 42.31 |
| 7 < 14 | 3,793 | 2,705 | 6,498 |
| | 18.96 | 17.09 | 18.13 |
| 14 < 21 | 1,771 | 2,397 | 4,168 |
| | 8.85 | 15.14 | 11.63 |
| 21 < 28 | 873 | 1,778 | 2,651 |
| | 4.36 | 11.23 | 7.4 |
| 28 < 35 | 327 | 902 | 1,229 |
| | 1.63 | 5.7 | 3.43 |
| 35 < 50 | 294 | 1,145 | 1,439 |
| | 1.47 | 7.23 | 4.02 |
| 50 + | 204 | 1,132 | 1,336 |
| | 1.02 | 7.15 | 3.73 |
| Total | 20,008 | 15,829 | 35,837 |
| | 100 | 100 | 100 |

**Appendix Table 6**: Which day did subjects drink the heaviest (n and %)?

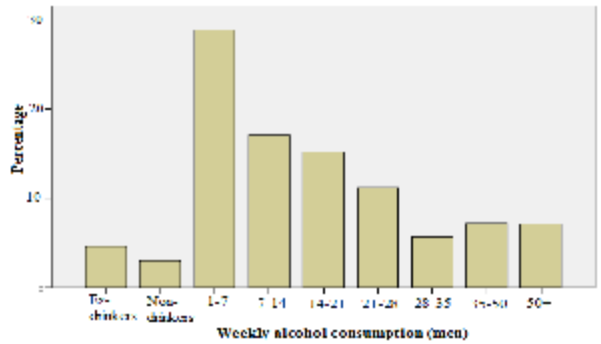
| | Female | Male | Total |
|---|---|---|---|
| sunday | 1,262 | 1,177 | 2,439 |
| | 17.25 | 17.72 | 17.47 |
| monday | 452 | 506 | 958 |
| | 6.18 | 7.62 | 6.86 |
| tuesday | 460 | 443 | 903 |
| | 6.29 | 6.67 | 6.47 |
| wednesday | 459 | 492 | 951 |
| | 6.27 | 7.41 | 6.81 |
| thursday | 506 | 514 | 1,020 |
| | 6.91 | 7.74 | 7.31 |
| friday | 1,301 | 1,117 | 2,418 |
| | 17.78 | 16.82 | 17.32 |
| saturday | 2,878 | 2,393 | 5,271 |
| | 39.33 | 36.03 | 37.76 |
| Total | 7,318 | 6,642 | 13,960 |
| | 100 | 100 | 100 |

| | Freq. | Percent | Cum. |
|---|---|---|---|
| sunday | 2,439 | 17.47 | 17.47 |
| monday | 958 | 6.86 | 24.33 |
| tuesday | 903 | 6.47 | 30.8 |
| wednesday | 951 | 6.81 | 37.61 |
| thursday | 1,020 | 7.31 | 44.92 |
| friday | 2,418 | 17.32 | 62.24 |
| saturday | 5,271 | 37.76 | 100 |
| Total | 13,960 | 100 | |

**Figure 1**


a)
.04
.03
.02
.01
0
Density
N = 8,385
Mean = 93.6
SD = 11.7
40
60
80
100
120
140
Waist circumference (males)
b)
.04
.03
.02
.01
0
Density
N = 10,344
Mean = 82.6
SD = 13.3
40
60
80
100
120
140
Waist circumference (females)
c)

**Appendix Figure 2**



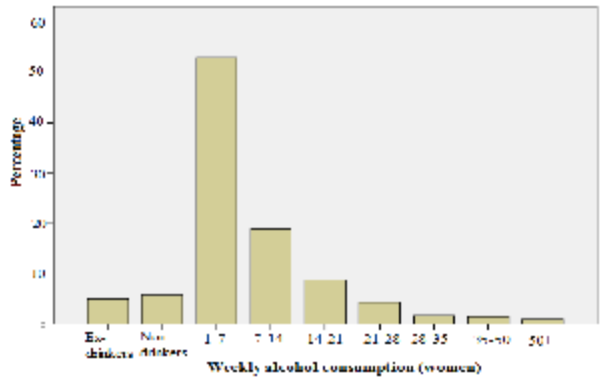
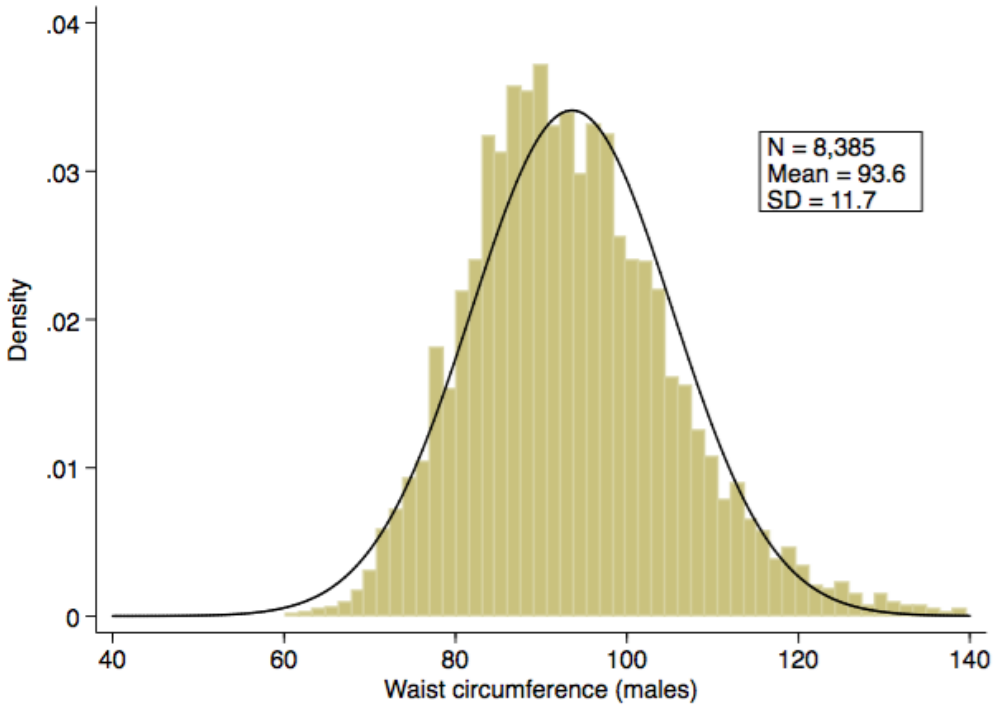
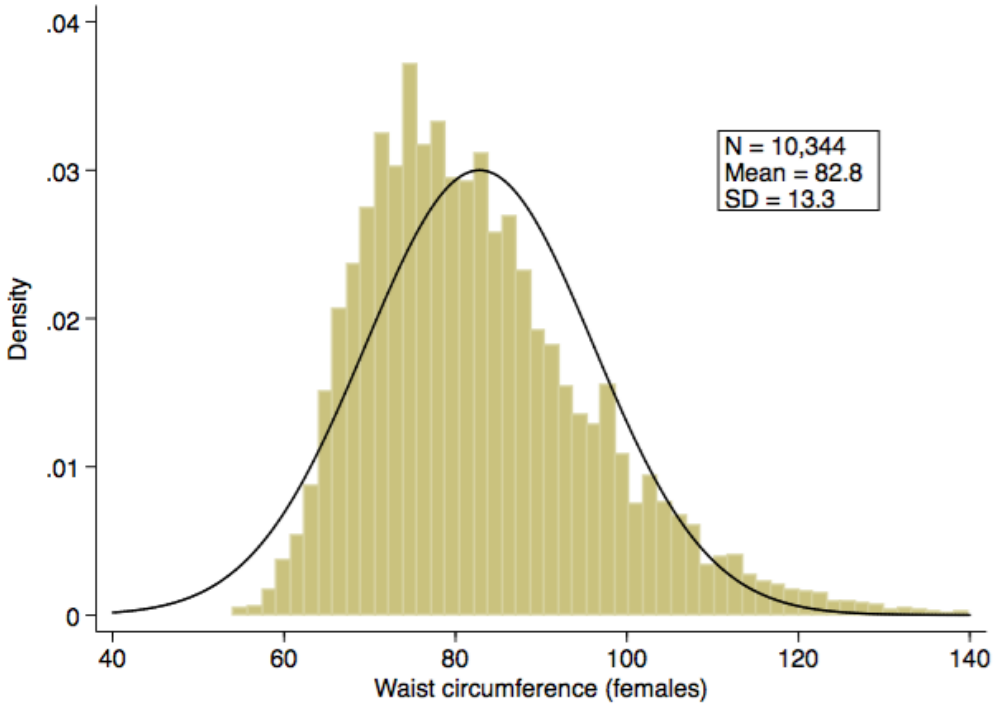



**Figure 1**

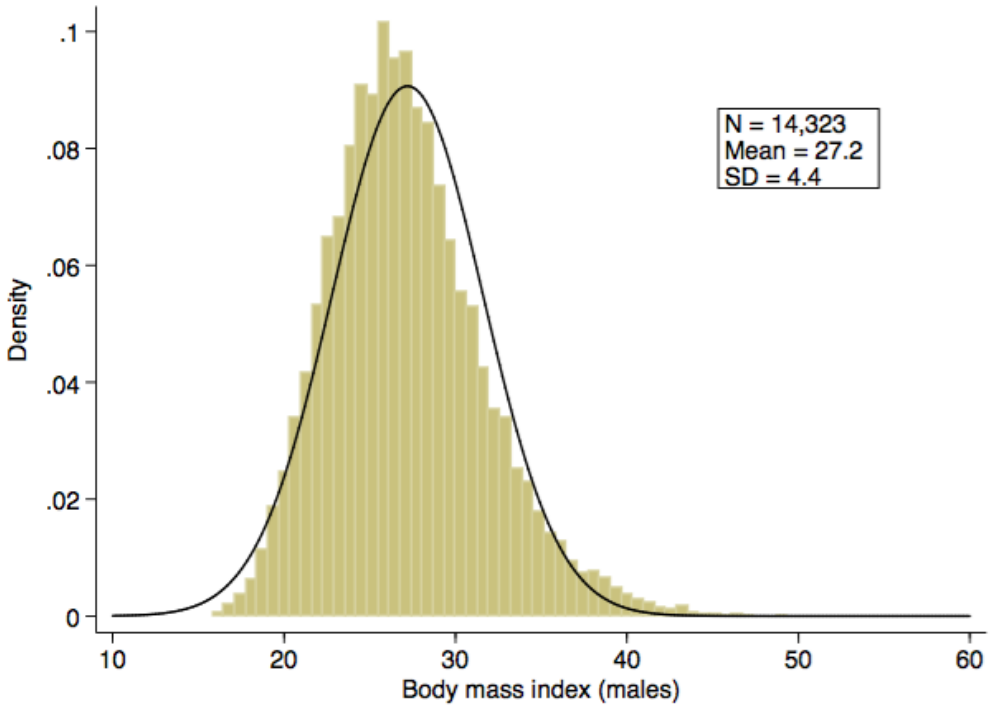
a)


.04
.03
.02
.01
0
Density
N = 8,385
Mean = 93.6
SD = 11.7
40
60
80
100
120
140
Waist circumference (males)

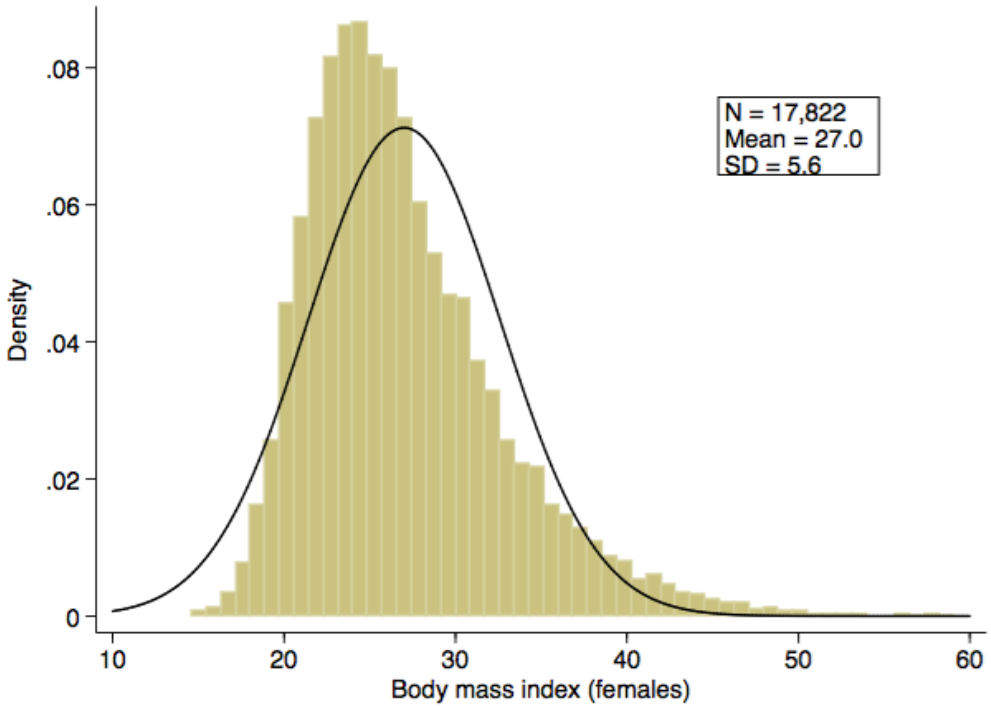
b)


.04
.03
.02
.01
0
Density
N = 10,344
Mean = 82.8
SD = 13.3
40
60
80
100
120
140
Waist circumference (females)

c)


N = 14,323
Mean = 27.2
SD = 4.4
Density
.1
.08
.06
.04
.02
0
10
20
30
40
50
60
Body mass index (males)

d)


N = 17,822
Mean = 27.0
SD = 5.6
Density
.08
.06
.04
.02
0
10
20
30
40
50
60
Body mass index (females)

**Appendix Figure 2**