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REVIEW

How alcohol consumption influences obesity in middle-aged men: A systematic review

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SUMMARY
Total alcohol intake may influence overweight and obesity in some (particularly heavy) drinkers, but the magnitude of weight gain appears clinically marginal. Robust evidence to support that reducing alcohol consumption may address the obesity epidemic is lacking and warrants further research. Study findings nonetheless favour current practice, encouraging clinicians to recognise and address drinking behaviours as one of many lifestyle factors pertinent to individual weight management.

Key Words
Alcohol drinking; obesity; body mass index; energy intake

ABSTRACT

Background

Every gram of alcohol consumed contains 29kJ (6.93 calories) and increases energy intake. Studies have identified a link between alcohol consumption and weight gain, noting that heavy drinking is associated with increased adiposity. However, the contribution of light-moderate drinking to adiposity, particularly in men, remains controversial. Given that 50 per cent of men worldwide are overweight or obese, and that middle-aged men represent a significant proportion of drinkers, investigating the relationship between alcohol and obesity in this population is important to inform public health policy and primary care interventions targeting obesity through alcohol reduction.

Aims

To identify and synthesise evidence demonstrating the extent to which alcohol consumption influences overweight and obesity among middle-aged men and determine if tackling alcohol consumption will provide a means for weight reduction in this group.

Method

A systematic review of the literature assessed papers published in English between 2000–2019 focusing on obesity—measuring body mass index (BMI), waist circumference (WC), or waist-to-hip ratio (WHR)—and alcohol consumption among men aged 45–64 years. Relevant randomised controlled trials, cohort studies, and case-controlled studies were included. Studies were critically evaluated using Critical Appraisal Skills Program (CASP) checklists.

Conclusion

Frequent, light-moderate alcohol consumption was associated with maintenance of normal weight in middle-aged men. Although heavy drinking was linked to obesity, effect sizes were modest. Spirits, but not beer or wine intake, were associated with weight gain. A major limitation was that many studies did not adjust for the potential confounding effects of energy intake and expenditure, smoking, ethnicity, and socioeconomic status. While alcohol may influence overweight and obesity in some drinkers, there is insufficient evidence to support public health policy and primary care interventions focusing on obesity through alcohol reduction.

BACKGROUND

With each gram of alcohol containing 29kJ (6.93 calories), it is widely acknowledged as a calorie-dense food, but of poor nutritional value.[1] Alcohol is also consumed in addition to, rather than as a replacement for, other energy sources, increasing total energy intake.[2] Hence, increased alcohol consumption may contribute to weight gain, particularly where additional intake is not countered by equivalent energy expenditure.

Previous studies examining the relationship between alcohol intake and measures of overweight and obesity have shown inconsistent results. These range from positive[3–5] to negative[6–8] and no association[9,10] among cross-sectional and longitudinal data.

A lack of consensus largely arises from methodological differences.[1] Different means of obesity measurement (ie, BMI, WC, and (WHR)) and variable consideration of potential confounders (ie, smoking, energy intake, physical activity, education, and socioeconomic status) contribute to the heterogeneity of findings.

Inconsistencies in findings may also be attributed to differences in beverage preferences across study samples. For example, drinking spirits may be more influential in weight gain,[11] while wine may be protective.[12] Due to a complex interaction of geographic, economic, and cultural influences, the prevalent beverage consumed differs greatly between countries,[13] and therefore impacts pooled findings.

Evidence from randomised controlled trials is also conflicting.[14,15] Small samples and short follow-up periods render it difficult to ascertain the true long-term effects of alcohol intake on weight. Nonetheless, reviews concur that heavier drinking is correlated with overweight and obesity.[1,16] Controversy remains over the contribution of light-moderate drinking to adiposity, particularly in men.[17]

Evidence suggests that men constitute a greater percentage of drinkers than women,[1,18] and that those aged 45–64 years drink most often.[19,20] It is adult men who also face an obesity epidemic—with 39 per cent overweight and 11 per cent obese—and as such are at increased risk of cardiovascular disease, diabetes, cancer, and premature mortality.[21] To date, no review has targeted middle-aged men

regarding alcohol intake and obesity.

Given the link between heavy drinking and weight gain,[1] and the knowledge that consumption patterns and beverage preference are moderated by gender,[22] evaluating current evidence on the link between alcohol and overweight and obesity among middle-aged men is warranted to inform future public health measures and clinical practice. To overcome the aforementioned heterogeneity in data, this review will report on the influence of alcohol separately on central (WC, WHR) and general obesity (BMI) and the effects of different types of alcohol on body weight.

METHOD

The author undertook a systematic review to identify evidence demonstrating the extent to which alcohol influences overweight and obesity among middle-aged men. Two questions underpinned the review:

1. Will limiting alcohol consumption reduce overweight and obesity among middle-aged men?
2. Will addressing one health issue (alcohol intake) significantly affect another (obesity)?

CINAHL, Medline, and PsycINFO databases were searched using the following MeSH, DE, and keyword terms:

[((MH "Alcohol Drinking+") OR TI "alcohol drinking" OR AB "alcohol drinking" OR (MH "Alcoholic Beverages+") OR DE "Alcoholic Beverages" OR DE "Beer" OR DE "Liquor" OR DE "Wine" OR DE "Alcohol Drinking Patterns" OR DE "Binge Drinking" OR DE "Social Drinking" OR TI "alcohol drinking patterns" OR AB "alcohol drinking patterns")]

AND

[((MH "Overweight+") OR DE "Overweight" OR TI "overweight" OR AB "overweight" OR (MH "Obesity+") OR DE "Obesity" OR (MH "Weight Gain+") OR DE "Weight Gain" OR (MH "Body Mass Index") OR DE "Body Mass Index" OR (MH "Energy Intake+") OR TI "energy intake" OR AB "energy intake" OR (MH "Waist Circumference+") OR TI "waist circumference" OR AB "waist circumference" OR (MH "Waist-Hip Ratio") OR TI "waist-hip ratio" OR AB "waist-hip ratio")].

The limiters English, Jan 2000–Dec 2019, Male and Middle Aged: 45–64 years were subsequently applied.

Randomised controlled trials, cohort studies, and case-controlled studies published in English between Jan 2000–Dec 2019 that quantified alcohol consumption, reported obesity measures (ie, BMI, WC, or WHR) and assessed adult populations stratified by age and sex were included. Reference lists were also hand-searched to identify other relevant papers. Studies not meeting these criteria were excluded.

Papers were identified, extracted from the three databases, and downloaded into Endnote. Duplicates were removed. The author undertook a primary relevance assessment, reviewing titles and abstracts against the inclusion criteria. Full-text articles were further assessed for eligibility. The selection and attrition process for retrieved papers is summarised in a PRISMA flowchart (Figure 1). To minimise bias, studies were critically evaluated using Critical Appraisal Skills Program (CASP) checklists.[23]

RESULTS

Overview

The study author reviewed 28: 19 cross-sectional (Table 1) and eight longitudinal studies (Table 2), and one randomised controlled trial (Table 3). Populations were obese, non-obese, or mixed, and sourced from workplaces, general practices, or the community. Sample sizes ranged from 21 to 61,582 men. Owing to multiple studies on similar cohorts, the total number of pooled participants could not be reported. Follow-up periods ranged from 5 to 24 years among longitudinal studies.

Variability in Exposure and Outcome Measures

Considerable variability in the measurement of alcohol and obesity was evident between studies. Drinkers were classified as light, moderate, intermediate, or heavy consumers of alcohol, with the definitions of each differing significantly (Table 4). The reporting of obesity results also varied (Table 5). Such variability in quantifying and reporting alcohol intake and obesity limited comparisons between studies and minimised subsequent conclusions on the effects of categories of alcohol consumption (no, light, moderate, or heavy intake) on adiposity.

Variable consideration of potential confounding factors further restricted comparison and commentary. Statistical models adjusted for between none and 30 factors when analysing the relationship between alcohol intake and obesity. Many studies adjusted for these factors (Figure 2), but to varying degrees. For example, physical activity ranged from leisure time physical activity[25,27,28] or walking at least 1hr/day[24], to any exercise in the last two weeks[32], hours of physical activity/wk,[29,30,36,56] and MET hrs/wk.[31,33,38,42]

Controlling for energy intake and expenditure was particularly important to validate associations between alcohol intake and obesity. If total energy intake or expenditure varied significantly between two individuals consuming dissimilar amounts of alcohol, differences in adiposity could be attributable to alcohol and/or non-alcoholic calories and/or physical activity. Given that alcohol represented a low proportion of total energy intake—ranging from 2.6–9.45 per cent where reported[24,30,34,36,37]—conclusions made about the effects of alcohol on weight were further weakened in models that did not adjust for these confounders.

Fourteen studies adjusted for energy intake and expenditure.[24–36,38] Ten of these studies represented higher quality evidence, given their robust adjustments for dietary intake, physical activity, and smoking, their large samples and objective assessment of alcohol and adiposity variables.[24,25,27–31,33–35]

General Obesity

All studies examining total alcohol intake in relation to general obesity used measures of BMI or body weight. Four of nine assessing light intake found that light drinkers had lower BMIs compared to other drinking cohorts[24–26,28,32,39–42]—and in accordance with critical appraisal, these represented higher quality evidence.

Four of seven studies established that moderate intake was related to lower BMI.[24,28,30,32,39,42,43] Convincingly, six of six studies concluded heavier drinkers had higher BMIs.[24–26,39–42]

In longitudinal studies where increased alcohol intake was positively associated with overall weight change at follow-up,[29,31] this correlation was affected towards the null when results were adjusted for drinking frequency.[29] Moreover, the absolute effect sizes were moderate with a one-drink increase in total alcohol over 4 years correlating with clinically marginal weight gain (0.23lb).[33]

Central Obesity

Alcohol intake positively correlated with measures of central obesity. All four papers assessing WHR concluded that increasing alcohol intake was associated with increases in WHR.[25,28,42,44] Where studies adjusted for confounders (ie, age, energy intake, expenditure, and smoking), this association held for WC.[25,26,28,34] A minority of studies finding no correlation with central obesity markers were less accurate, with wide confidence intervals[35] or standard of error.[37] Importantly, effect sizes were modest with one-drink per day increases correlating with ~1cm increase in WC.[28]

Influence of Alcohol Consumption Patterns

Drinking frequency also influenced the relationship between alcohol and obesity. BMI and WC were inversely correlated with frequency of alcohol intake;[26,43,45] however, these associations were particularly weak in men.[43] This relationship held for wine but not beer or spirits.[45] At follow-up, no association was found between baseline drinking frequency and 5–year change in WC.[29] However, when considering changes in drinking patterns over 5 years, Wannamethee et al.[39] found that stable heavy drinkers and light drinkers who had adopted heavy consumption patterns had persistently high BMIs.

Influence of Alcohol Subtype

Beer

Several studies examined the effect of different types of alcohol on adiposity outcomes. Beer was not associated with obesity in most cross-sectional studies[24,27,28,37] and only positively associated when analyses were unadjusted for important confounders such as energy intake, expenditure, and smoking.[46] Beer intake was associated with change in weight[30,31] but not WC over long-term follow-up.[30,36] The magnitude of weight change was invariably modest.[31] No association with weight gain was found in a randomised, longitudinal cross-over trial.[47]

Wine

Overall, wine consumption was not associated with obesity.[27,28,37] Any correlations with positive changes in weight or WC were weak[31] and more pronounced for heavier drinkers.[36] The association of wine intake differed by country, being significantly correlated with obesity in Northern Ireland but not France, where wine is more frequently consumed.[46]

Spirits

Statistically significant associations between spirits and BMI, WC, and WHR were consistently observed in cross-sectional data.[24,28,37,46] Over long-term follow-up, spirit intake positively correlated with changes in general obesity.[31,33] The clinical relevance of the magnitude of change was controversial, with spirits associated with 0.28–0.54 lb weight gain over four years.[31,33]

DISCUSSION

In summary, the results indicated that total alcohol intake may influence overweight and obesity in some drinkers, with the magnitude of weight change ranging from none to moderate. Overall, frequent, light-moderate consumption of alcohol was associated with normal weight, while heavy drinking consistently correlated with central and general obesity.

Other influential factors included alcohol subtype and drinking frequency. Where beverage preferences were considered, only spirits consumption correlated with statistically significant but clinically equivocal weight gain.

Overall, the quality of evidence varied. Few papers reported alcohol as a percentage of daily energy intake,[24,30,34,36,37] and many did not adjust for non-alcoholic calories.[42,44–46] Where appropriate adjustments for confounders were made, either no or modest associations were observed.[30,31,36,38] Additionally, the inability of cross-sectional and longitudinal data to infer causal relationships limited the conclusions made on the influence of alcohol on overweight and obesity.

Comparison with Literature

Previous reviews agreed that alcohol likely influences overweight and obesity,[1,2,17] though the extent of this relationship in middle-aged men was undetermined.

The literature generally supports our finding that light-moderate drinkers are less likely than heavier drinkers to be overweight or obese,[5,22,48] and concurs that the results for BMI in men are modest.[13] The fact that men generally accumulate weight in the android region (so it may be years before central adiposity impacts BMI) may explain this.[32] Given the associations of abdominal adiposity with poor health outcomes,[21] the notion that alcohol may influence central obesity remains relevant.

Our finding that heavy drinking was associated with high BMI is corroborated by others.[13,22] The SUN study[49] found heavier drinkers to have 0.9–1.2kg/m^2 higher BMIs than teetotallers. Interestingly, heavy drinkers consumed more non-alcohol calories than any other intake category, [13]

giving credence to the theory that alcohol may play only a small role in weight gain.
Where no association between heavy drinking and BMI or WC was found, heavier drinkers comprised a much smaller comparator group.[50] Consequently, results had wider confidence intervals, which compromised the ability to accurately detect significant differences between alcohol intake categories.

Similar to others,[3,22] our cross-sectional data showed an inverse relationship between drinking frequency and obesity. It is theorised that frequent drinkers consuming moderate amounts of alcohol may live healthier lifestyles—ie, are more physically active[51]—that mitigate against weight gain.[1]

The differing effects of beer, wine, and spirits on weight gain in this review are mirrored elsewhere. Similar to our findings, several authors concluded no relationship between beer and obesity.[3,9] Beer only contributed to central obesity when consumed in high quantities[11,17] or in studies where the proportion of beer drinkers differed significantly among the countries examined.[13] The latter skewed confidence intervals, impacting the validity of the association shown.

Our findings regarding wine were corroborated by others who concluded either inverse[3] or no association between wine intake and obesity.[16] Though one[52] study argued that the positive correlation between alcohol and weight gain was independent of beverage type, its wine-drinking cohort was comparatively small.

Studies support our finding that spirit consumption is positively associated with weight gain.[11,16] Where no association was found,[53] there had been no adjustment for the effect of other beverage consumption.

Strengths and Limitations
A strength of this review was the diversity of populations represented, including Western Europe, the UK, US, South America, and Asia, which supports the generalisability of review findings. Among studies themselves, the use of the World Health Organization BMI definition criteria as appropriate to the specific cohort (ie, Asia-Pacific or Western) strengthened data validity. On the other hand, international studies not published in English were excluded. These papers may have further informed review findings.

Several limitations within studies also warrant consideration. First, methods of data collection: anthropometry was occasionally, and alcohol always, self-reported. This may have introduced a misclassification bias that skewed associations between alcohol and BMI towards the null (if participants claimed to be taller and lighter than in reality). Though most alcohol intake questionnaires were validated, the true effect size may have been underestimated by a reporting bias.

Second, much variation existed among study definitions of variables. There was no consensus between papers on what constituted light, moderate, intermediate, or heavy drinking. Such variety

impeded the pooling of any combination of data that might otherwise have identified more definitive results.

Third, many studies did not adjust for the potential confounding effects of energy intake and expenditure, smoking, ethnicity, and socioeconomic status. Given that smokers have a higher mean BMI than non-smokers,[44] and that certain drinking patterns may be associated with varied dietary and exercise behaviours,[54] controlling for these factors is crucial for valid analysis of the association between alcohol intake and overweight and obesity. Moreover, where considered, confounders were controlled for to varying degrees between studies. Many longitudinal studies adjusted only for baseline data, enabling residual confounding due to changes in the aforementioned variables during follow-up.

Fourth, the heterogeneity between cohorts further complicated comparisons in this review. Populations were non-obese, obese, or mixed. Cohorts ranged from African and Caribbean[55] to Caucasian[31,33,37,45] and Asian[35,42,44,56] ethnicities.

Finally, cross-sectional data carried an additional risk of reverse causality bias, where one's perceived obesity may have influenced underreporting or cessation of alcohol drinking, weakening the positive correlation observed between alcohol and adiposity.

The single randomised controlled trial[47] exemplified the challenges inherent in intervention studies in this area. It is difficult to achieve a measurable effect as a single cohort may differ in a multitude of confounding ways that cannot be controlled for. Ethical considerations also dictate the limitations of trial design, particularly regarding trial length and quantity of alcohol administered. This means trial periods are often too short to demonstrate any real weight gain effects.

Clinical Implications

This review offers fresh insight into the ways in which alcohol may influence weight in middle-aged men (ie, drinking frequency and beverage preference). Alcohol may contribute to modest weight gain in some, particularly heavier drinkers. However, it is likely that myriad factors, including alcohol, non-alcoholic calories, physical activity, smoking, and age, among other patterns—that may or may not be influenced by alcohol consumption—contribute to body habitus.

Given that many of the associations between alcohol intake and weight gain observed were deemed statistically but not clinically significant, there is insufficient evidence to support that reducing alcohol consumption may effectively address the obesity epidemic.

Despite the modest correlations shown, it is important to understand that even clinically insignificant weight gain may translate to exponential increases in mortality risk over time.[21,47,55] Therefore, while public health campaigns controlling alcohol drinking may not curb overweight and obesity, clinicians should continue to recognise and address drinking behaviours as one of many lifestyle factors

pertinent to individual weight management.

Future Directions

Future research should seek to universally define light, moderate, and heavy drinking and adjust for non-alcoholic calories, smoking, and physical activity in all analyses. This may elicit fewer inconsistencies in interpretation of the evidence and enable more robust data to emerge. Moreover, randomised controlled trials with longer follow-ups and consistent consideration of confounders may prove useful, though ethically challenging. Further consideration of patterns of alcohol consumption in relation to other lifestyle habits may provide the insight needed to effectively address obesity through multi-faceted health policy and primary care interventions.

CONCLUSION

This review has demonstrated that the relationship between alcohol consumption and overweight and obesity in men is nuanced. The overwhelmingly observational nature of the evidence weakens any association between alcohol and overweight and obesity shown. Overall, data suggest that alcohol is not a significant, sole contributor to clinically significant weight gain. However, spirit intake and heavy drinking may influence long-term weight gain, while beer and wine consumption and regular, light-moderate drinking may have no effect. Given a growing body of literature asserting that alcohol is additive to total energy intake and that alcohol subtypes are associated with specific dietary and lifestyle habits, it is reasonable to suggest that alcohol likely has some influence on overweight and obesity, which is probably compounded by other lifestyle factors associated with drinking (ie, energy intake, exercise, smoking, cultural practices, and marketing).

However, this review found insufficient evidence to support that reducing alcohol consumption may effectively address the obesity epidemic. Current evidence does not justify a strong focus on alcohol reduction in public health campaigns, policy, or education in preventing or mitigating weight gain and obesity.

Consequently, future observational and experimental research is warranted, exploring in greater depth the relationship between alcohol consumption patterns, drinking frequency, other associated lifestyle habits and adiposity, with longer follow-up periods and consistent consideration of confounders. Such research may provide better quality and more definitive evidence to shape future public health policy and primary care interventions on obesity through alcohol reduction.

REFERENCES

1. Traversy G, Chaput JP. Alcohol consumption and obesity: An update. *Curr Obes Rep*. 2015 Jan;4(1):122–30. Doi: 10.1007/s13679-014-0129-4
2. Sayon-Orea C, Martinez-Gonzalez, MA, Bes-Rastrollo M. Alcohol consumption and body weight: a systematic review. *Nutr Rev*. 2011 Aug;69(8):419–31. Doi: 10.1111/j.1753-4887.2011.00403

3. Dorn JM, Hovey K, Muti P, et al. Alcohol Drinking Patterns Differentially Affect Central Adiposity as Measured by Abdominal Height in Women and Men. *J Nutr*. 2003 Aug;133(8):2655–62. Doi: 10.1093/jn/133.8.2655
4. Chaput J, Leblanc C, Pérusse L, et al. Risk Factors for Adult Overweight and Obesity in the Quebec Family Study: Have We Been Barking Up the Wrong tree? *Obesity* (Silver Spring). 2009 Oct;17(10):1964–70. Doi: 10.1038/oby.2009.116
5. MacInnis RJ, Hodge AM, Dixon HG, et al. Predictors of increased body weight and waist circumference for middle-aged adults. *Public Health Nutr*. 2014 May;17(5):1087–97. Doi: 10.1017/S1368980013001031
6. Rohrer JE, Rohland BM, Denison A, et al. Frequency of use and obesity in community medicine patients. *BMC Fam Pract*. 2005 Apr;6(17):1–8. Doi: 10.1186/1471-2296-6-17
7. Liangpunsakul S, Crabb DW, Qi R. Relationship between alcohol intake, body fat, and physical activity–a population-based study. *Ann Epidemiol*. 2010 Sep;20(9):670–5. Doi: 10.1016/j.annepidem.2010.05.014
8. de Munter JS, Tynelius P, Magnusson C, et al. Longitudinal analysis of lifestyle habits in relation to body mass index, onset of overweight and obesity: Results from a large population-based cohort in Sweden. *Scand J Public Health*. 2015 May;43(3):236–45. Doi: 10.1177/1403494815569865
9. Bobak M, Skodova Z, Marmot M. Beer and obesity: a cross-sectional study. *Eur J Clin Nutr*. 2003 Oct;57(10):1250–3. Doi: 10.1038/sj.ejcn.1601678
10. Liao C, Gao W, Cao W, et al. The association of cigarette smoking and alcohol drinking with body mass index: a cross-sectional, population-based study among Chinese adult male twins. *BMC Public Health*. 2016 Apr;16(1):1–9. Doi: 10.1186/s12889-016-2967-3
11. Vadstrup ES, Petersen L, Sorensen, TIA, et al. 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*. 2003 Feb;27(2):238–46. Doi: 10.1038/sj.ijo.802203
12. Tresserra-Rimbau A, Medina-Remon A, Lamuela-Raventos RM, et al. Moderate red wine consumption is associated with a lower prevalene of the metabolic syndrome in the PREDIMED population. *Br J Nutr*. 2015 Apr;113(Suppl 2):S121–30. Doi: 10.1017/S0007114514003262
13. Bergmann M, Schütze M, Steffen A, et al. The association of lifetime alcohol use with measures of abdominal and general adiposity in a large-scale European cohort. *Eur J Clin Nutr*. 2011 Oct;65(10):1079–87. Doi: 10.1038/ejcn.2011.70
14. Beulens JW, van Beers RM, Stolk RP, et al. The effect of moderate alcohol consumption on fat distribution and adipocytokines. *Obesity* (Silver Spring). 2006 Jan;14(1):60–6. Doi: 10.1038/oby.2006.8
15. Sobell MB, Peterson AL, Sobell LC, et al. Reducing alcohol consumption to minimize weight gain and facilitate smoking cessation among military beneficiaries. *Addict Behav*. 2017 Jun;75(12):145–51. Doi: 10.1016/j.addbeh.2017.06.018

16. Sayon-Orea C, Bes-Rastrollo M, Nuñez-Cordoba JM, et al. Type of alcoholic beverage and incidence of overweight/obesity in a Mediterranean cohort: the SUN project. *Nutrition*. 2011 Jul-Aug;27(7–8):802–8. Doi: 10.1016/j.nut.2010.08.023
17. Bendsen NT, Christensen R, Bartels EM, et al. Is beer consumption related to measures of abdominal and general obesity? A systematic review and meta-analysis. *Nutr Rev*. 2013 Feb;71(2):67–87. Doi: 10.1111/j.1753-4887.2012.00548
18. French DJ, Sargent-Cox KA, Kim S, et al. Gender differences in alcohol consumption among middle-aged and older adults in Australia, the United States and Korea. *Aust N Z J Public Health*. 2014 Aug;38(4):332–9. Doi: 10.1111/1753-6405.12227
19. Wilsnack RW, Wilsnack SC, Kristjanson AF, et al. Gender and alcohol consumption: patterns from the multinational GENACIS project. *Addiction*. 2009 Sept;104(9):1487–1500. Doi: 10.1111/j.1360-0443.2009.02696.x
20. National Drug Strategy Household Survey 2016: detailed findings. Publication No. PHE 214. [internet]. Canberra, ACT: Australian Institute of Health and Welfare; 2017 [cited 2020 Jan 16]. Available from: https://www.aihw.gov.au/getmedia/15db8c15-7062-4cde-bfa4-3c2079f30af3/21028a.pdf.aspx?inline=true
21. World Health Organization. Overweight and obesity fact sheet [Internet]. 2017 [cited 2019 Dec 2]. Available from: http://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight
22. Arif AA, Rohrer JE. Patterns of alcohol drinking and its association with obesity: data from the third national health and nutrition examination survey, 1998–1994. *BMC Public Health*. 2005 Dec;5(126):106. Doi: 10.1186/1471-2458-5-126
23. Critical Skills Appraisal Programme. CASP Cohort Study Checklist. 2018 [cited 2019 Dec 11] . Available from: https://casp-uk.net/casp-tools-checklists/
24. Lukasiewicz E, Mennen LI, Bertrais S et al. Alcohol intake in relation to body mass index and waist-to-hip ratio: the importance of type of alcoholic beverage. *Public Health Nutr*. 2005 May;8(3):315–20. Doi: 10.1079/phn2004680
25. Rouillier P, Boutron-Ruault M, Bertrais S, et al. Alcohol and atherosclerotic vascular disease risk factors in French Men: Relationships are linear, j-shaped, and u-shaped. *Alcohol Clin Exp Res*. 2005 Jan;29(1):84–8. Doi: 10.1097/01.alc.0000150005.52605.fa
26. Tolstrup JS, Heitmann BL, Tjønneland AM, et al. The relation between drinking pattern and body mass index and waist and hip circumference. *Int J Obes (Lond)*. 2005 May;29(5):490–7. Doi: 10.1038/sj.ijo.0802874
27. Rouillier P, Bertrais S, Daudin JJ, et al. Drinking patterns are associated with variations in atherosclerotic risk factors in French men. *Eur J Nutr*. 2006 Mar;45(2):79–87. Doi: 10.1007/s00394-005-0567-6
28. Risérus U, Ingelsson E. Alcohol intake, insulin resistance, and abdominal obesity in elderly men. *Obesity (Silver Spring)*. 2007 Jul;15(7):1766–73. Doi: 10.1038/oby.2007.210
29. Tolstrup JS, Halkjær J, Heitmann BL, et al. Alcohol drinking frequency in relation to subsequent changes in waist circumference. *Am J Clin Nutr*. 2008 Apr;87(4):957–63. Doi: 10.1093/ajcn/87.4.957

30. Schütze M, Schulz M, Steffen, A et al. Beer consumption and the 'beer belly': scientific basis or common belief? *Eur J Clin Nutr*. 2009 Sep;63(9):1143–9. Doi: 10.1038/ejcn.2009.39
31. Mozaffarian D, Hao T, Rimm EB, et al. Changes in diet and lifestyle and long - term weight gain in women and Men. *N Engl J Med*. 2011 Jun;364(25):2392–404. Doi: 10.1056/NEJMoa1014296
32. da Rocha TF, Hasselmann MH, Curioni CC, et al. Alcohol consumption is associated with DXA measurement of adiposity: the Pró-Saúde Study. *Brazil. Eur J Nutr*. 2017 Aug;56(5):1983–91. Doi: 10.1007/s00394-016-1240-y
33. Downer MK, Bertoia ML, Mukamal KJ, et al. Change in alcohol intake in relation to weight change in a cohort of United States men with 24 years of follow-up. *Obesity (Silver Spring).* 2017 Nov;25(11):1988–96. Doi: 10.1002/oby.21979
34. Lofley AC, Root MM. Macronutrients association with change in waist and hip circumference over 9 years. *J Am Coll Nutr*. 2017 Jan;36(1):57–63. Doi: 10.1080/07315724.2016.1183241
35. Park K. Park H, Hwang H. Relationship between abdominal obesity and alcohol drinking pattern in normal-weight, middle-aged adults: the Korea national health and nutrition examination survey 2008–2013. *Public Health Nutr*. 2017 Aug;20(12):2192–200. Doi: 10.1017/S1368980017001045
36. Halkjær J, Tjønneland A, Thomsen BL, et al. Intake of macronutrients as predictors of 5-y changes in waist circumference. *Am J Clin Nutr*. 2006 Oct;84(4):789–97. Doi: 10.1093/ajcn/84.4.789
37. Brandhagen M, Forslund HB, Lissner L, et al. Alcohol and macronutrient intake patterns are related to general and central adiposity. *Eur J Clin Nutr*. 2012 Mar;66(3):305–13. Doi: 10.1038/ejcn.2011.189
38. Koh-Banerjee P, Chu N, Spiegelman D, et al. 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*. 2003 Oct;78(4):719–27. Doi: 10.1093/ajcn/78.4.719
39. Wannamethee SG, Shaper AG. Alcohol, body weight, and weight gain in middle-aged men. *Am J Clin Nutr*. 2003 May;77(5):1312–7. Doi: 10.1093/ajcn/77.5.1312
40. Leite, MLC, Nicolosi, A. Lifestyle correlates of anthropometric estimates of body adiposity in an Italian middle-aged and elderly population: a covariance analysis. *Int J Obes (Lond).* 2006 Jun;30(6):926–34. Doi: 10.1038/sj.ijo.0803239
41. Sieri S, Krogh V, Saieva C, et al. Alcohol consumption patterns, diet and body weight in 10 European countries. *Eur J Clin Nutr*. 2009 Nov;63(Suppl 4):S81–100. Doi: 10.1038/ejcn.2009.76
42. Kim O, Jeon HO. Relationship between obesity, alcohol consumption, and physical activity of male office workers in South Korea. *Nurs Health Sci*. 2011 Dec;13:457–62. Doi: 10.1111/j.1442-2018.2011.00639.x
43. Wills AG, Evans LM, Hopfer C. Phenotypic and genetic relationship between BMI and drinking in a sample of UK adults. *Behav Genet.* 2017 May;47(3):290–7. Doi: 10.1007/s10519-017-9838-2

44. Lee S, Wen W, Xu WH et al. Prevalence of obesity and correlations with lifestyle and dietary factors in Chinese men. *Obesity (Silver Spring).* 2008 Mar;16(6):1440–7. Doi: 10.1038/oby.2008.58
45. Dumesnil C, Dauchet L, Ruidavets JB, et al. Alcohol consumption patterns and body weight. *Ann Nutr Metab.* 2013 Mar;62(2):91–7. Doi: 10.1159/00034283
46. Marques-Vidal P, Arveiler D, Evans A, et al. Patterns of alcohol consumption in middle-aged men from France and Northern Ireland. The PRIME Study. *Eur J Clin Nutr*. 2000 Apr;54(4):321–328. Doi: 10.1038/sj.ejcn.1600954
47. Padro T, Muñoz-García N, Vilahur G, et al. Moderate beer intake and cardiovascular health in overweight individuals. *Nutrients*. 2018 Sep;10(9):1237. Doi: 10.3390/nu10091237
48. Wakabayashi I. Cross-sectional relationship between alcohol consumption and prevalence of metabolic syndrome in Japanese men and women. *J Atheroscler Thromb*. 2010 Jul;17(7):695–704. Doi: 10.5551/jat.3517
49. Alcácera MA, Marques-Lopes I, Fajó-Pascual M, et al. Lifestyle factors associated with BMI in a Spanish graduate population: the SUN Study. *Obes Facts*. 2008 May;1(2):80–7. Doi: 10.1159/000124237
50. Butler L, Popkin BM, Poti JM. Associations of Alcoholic Beverage Consumption with Dietary Intake, Waist Circumference, and Body Mass Index in US Adults: National Health and Nutrition Examination Survey 2003–2012. *J Acad Nutr Diet*. 2018 Mar;118(3):409–20. Doi: 10.1016/j.jand.2017.09.030
51. French MT, Popovici I, Maclean JC. Do alcohol consumers exercise more? Findings from a national survey. *Am J Health Promot*. 2009 Sep-Oct;24(1):2–10. Doi: 10.4278/ajhp.0801104
52. Wannamethee SG, Shaper AG, Whincup PH. Alcohol and adiposity: effects of quantity and type of drink and time relation with meals. *Int J Obes (Lond).* 2005 Dec;29(12):1436–44. DOI: 10.1038/sj.ijo.0803034
53. Lean MEJ, Vlachou P, Govan L, et al. Different associations between body composition and alcohol when assessed by exposure frequency or by quantitative estimates of consumption. *J Hum Nutr Diet*. 2018 Dec;31(6):747–57. Doi: 10.1111/jhn.12583
54. Rouillier P, Boutron-Ruault M, Bertrais S, et al. Drinking patterns in French adult men—a cluster analysis of alcoholic beverages and relationship with lifestyle. *Eur J Nutr*. 2004 Apr;43(2):69–76. DOI:10.1007/s00394-004-0442-x
55. Wilkinson K, Bryant ES, Heal K. Obesity and cardiovascular risk factors: results of a unique approach to NHS health checks. *Practice Nursing.* 2017 Sep;28(9):390–7. Doi: 10.12968/pnur.2017.28.9.390
56. Yamada Y, Noborisaka Y, Suzuki H, et al. Alcohol consumption, serum gamma-glutamyl transferase levels, and coronary risk factors in a middle-aged occupational population. *J Occup Health*. 2003 Sep;45(5):293–9. Doi: 10.1539/joh.45.293
57. Moher D, Liberati DG, The PRISMA Group. Preferred reporting items for systematic reviews and meta analyses: The PRISMA statement. *PLoS Med*. 2009 Jul;6(7):e1000097. Doi: 10.1371/journal.pmed1000097

58. Ning X, Zhan C, Yang Y, et al. Secular Trends in Prevalence of Overweight and Obesity among Adults in Rural Tianjin, China from 1991 to 2011: A Population-Based Study. *PLoS One*. 2014 Dec;9(12):e116019. Doi: 10.1371/journal.pone.0116019

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CONFLICTS OF INTEREST

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Figure 1: PRISMA Flowchart demonstrating the process of identifying papers for inclusion in the review (adapted from Moher et al.)[57]

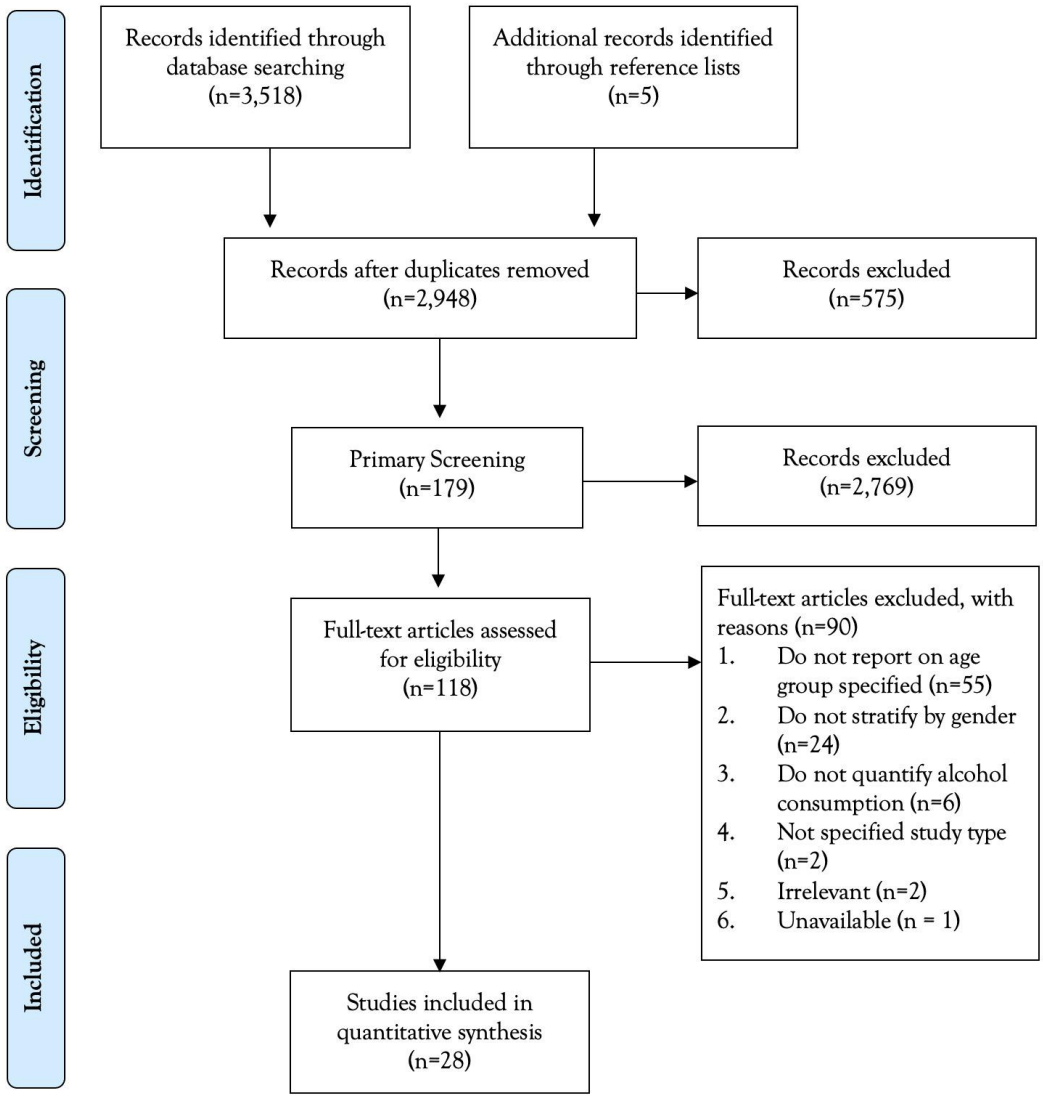

Figure 2: Commonly reported confounding factors influencing the relationship between alcohol and obesity

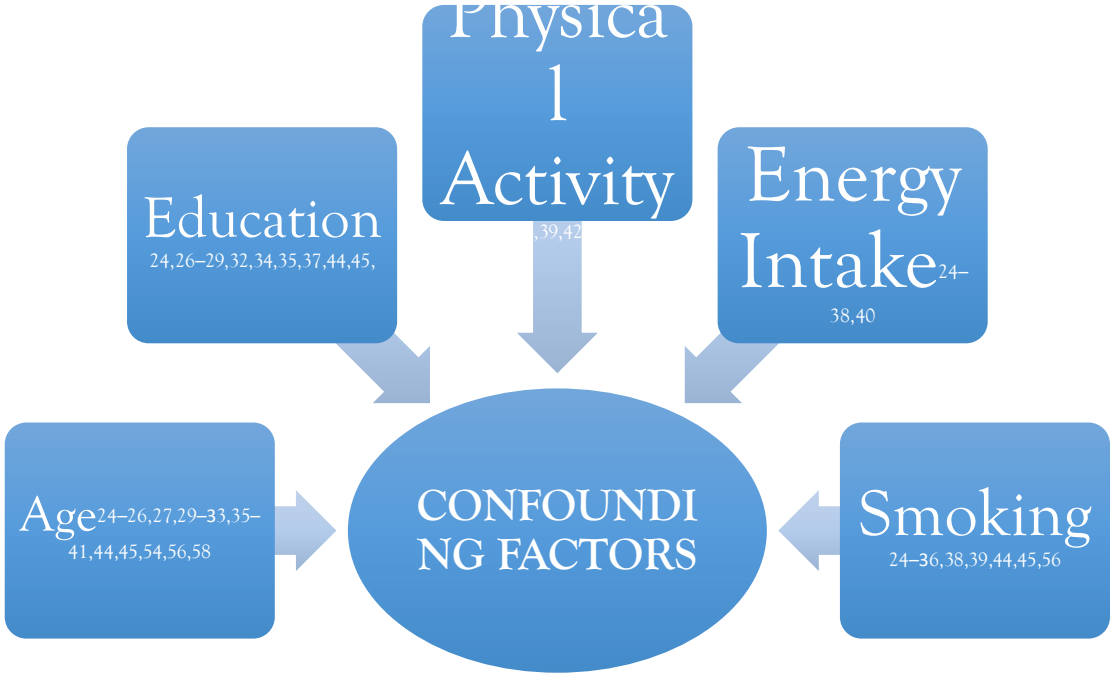

Table 1: Summary of included cross-sectional studies

Author(s)	Sample	Outcome Measure	Findings
Brandhagen et al., 2012[37]	524 men 36–61 yrs	BMI WC SAD (sagittal abdominal diameter) % body fat	Alcohol intake positively correlated with central but not general obesity Beer not associated with any anthropometric measure Wine negatively associated with BMI but not WC Spirits positively associated with WC but not BMI
Da Rocha et al., 2017[32]	514 men 35–64 yrs	BMI Android Fat Mass:Gynoid Fat Mass ratio Total Fat Mass	Low-moderate alcohol intake associated with increased adiposity (statistically insignificant)
Dumesnil et al., 2013[45]	7,106 men 50–59 yrs	BMI WC	Alcohol consumption associated with increased risk of overweight and obesity Drinking frequency inversely associated with mean BMI, except in heavy drinkers
Kim et al., 2011[42]	141 men 40–59 yrs	BMI WHR % body fat	Light and heavy drinkers have higher BMI, WHR, and % body fat than moderate drinkers
Lee et al., 2008[44]	61,582 men 40–75yrs	BMI WHR	Alcohol intake positively associated with WHR but not BMI Ex-drinkers have higher prevalence of overweight and obesity
Leite et al., 2006[40]	705 men 40–74 yrs	BMI WC HC (hip circumference) Skin-fold thickness	Alcohol intake not associated with BMI, WC, or HC Light drinkers had lower peripheral subcutaneous fat
Lukasiewicz et al., 2005[24]	1,210 men 45–60 yrs	BMI WHR	J-shaped relationship -alcohol intake and WHR and BMI; wine consumption and WHR and BMI Spirits intake linearly associated with WHR
Marques-Vidal et al., 2000[46]	5,363 men 50–59 yrs	BMI (France & Northern Ireland)	More alcoholic beverages consumed among obese than non-obese participants
Ning et al., 2014[58]	1,032 men (1991); 865 men (2011)	BMI	Alcohol consumers had the greatest increase in obesity prevalence

Author(s)	Sample	Outcome Measure	Findings
	35–74 yrs		
Park et al., 2017[35]	4,491 men 40–69 yrs	WC	Alcohol intake not associated with central obesity Drinking frequency not associated with central obesity Binge drinking positively associated with abdominal obesity
Risérus et al., 2007[28]	807 men 70 yrs	BMI WC WHR	Alcohol intake positively associated with WC and WHR but not BMI Neither beer nor wine intake associated with BMI, WC, or WHR
Rouillier et al., 2004[54]	2,126 men 45–60yrs	BMI	Abstainers and light drinkers had the lowest BMI Heavy drinkers and table wine drinkers had the highest BMI
Rouillier et al., 2005[25]	2,126 men 46–60yrs	BMI WC WHR	Alcohol intake linearly associated with BMI, WC, and WHR
Rouillier et al., 2006[27]	2,126 men 45–60yrs	BMI WC WHR	High quality wine consumers has greatest risk of overweight, high WC and WHR - association lost after adjusting for level of alcohol intake
Sieri et al., 2009[41]	13,025 men 35–74yrs	BMI	Heavy drinkers had higher BMI than abstainers in many countries
Tolstrup et al., 2005[26]	25,325 men 50–65yrs	BMI WC HC	Alcohol intake positively associated with odds of large WC Alcohol intake not associated with BMI up to 20 drinks/wk Drinking frequency inversely associated with BMI and WC but not HC
Wilkinson et al., 2017[55]	1,729 men 40–74yrs	BMI	Alcohol intake significantly higher in underweight males compared to all other BMI categories
Wills et al., 2017[43]	53,794 men 40–69yrs	BMI	Alcohol intake inversely associated with BMI Drinking frequency inversely associated with BMI
Yamada et al., 2003[56]	2,399 men 35–64yrs	UBO (BMI≥25 and WC ≥95cm)	Alcohol intake not associated with UBO

Table 2: Summary of Included Longitudinal Studies

Author(s)	Sample	Outcome Measure	Findings
Downer et al., 2017[33]	14,971 men 40–64yrs	Weight (Δ pounds)	One drink increases of total alcohol, total beer, liquor or regular beer but not wine associated with small but statistically significant weight gain over 4-year periods
Halkjær et al., 2006[36]	20,126 men 50–64yrs	WC (Δ cm)	Total alcohol intake not associated with WC change Beer and spirits not associated with WC change Wine showed a U-shaped association with WC
Koh-Banerjee et al., 2003[38]	16,587 men 40–75yrs	WC (Δ cm)	Total alcohol intake not correlated with 9-year waist gain
Lofley et al., 2017[34]	4,890 men 45–64yrs	WC HC	Alcohol intake positively associated with WC but not HC
Mozaffarian et al., 2011[31]	22,557 men 40–65yrs	Δ Weight (lb)	Alcohol intake positively associated with weight change Liquor, beer and wine (in decreasing order of magnitude of change) positively associated with weight change
Schütze et al., 2009[30]	7,614 men 35–65yrs	Δ Weight (kg/8.5y) Δ WC (cm/8.5y) Δ WHR (units/8.5y)	Beer positively associated with baseline WC Beer intake showed a U-shaped relationship with change in weight and WC
Tolstrup et al., 2008[29]	20,472 men 50–64yrs	WC (Δ cm/5yr)	Alcohol intake not significantly associated with waist loss Drinking frequency inversely associated with major waist gain
Wannamethee et al., 2003[39]	7,608 men 40–59yrs	BMI Δ Weight	Alcohol intake positively associated with BMI Stable and new heavy drinkers had the highest weight gain

Table 3: Summary of Included Randomised Controlled Trials

Author(s)	Sample	Outcome Measure	Findings
Padro et al., 2018[47]	21 men 40–60yrs	Weight BMI WC	Neither traditional nor alcohol-free beer was associated with increases in weight, BMI or WC

Table 4: Classifications for alcohol intake across studies

Classification	Amount per day	Amount per week	Amount per month
Light	250–500ml[30] 0–12g[24,41] <6.7g[25] <3.2g[28]	<1 unit[39] <7 drinks[26,29,35]	1–12 drinks[42]
Moderate	500–<1000ml[30] 12–24g[24,41] 3.2–<8.8g[28] 6.7–24.4g[25]	1–20 units[39] 7–20 drinks[26,29] 7–13 drinks[35] 0–140g[45]	13–52 drinks[42]
Intermediate	24.4–37.3g[25]	21–27 drinks[26,29] 14–20 drinks[35] 141–280g[45]	
Heavy drinking	≥1000ml[30] >37.3g[25] >24g[24,41] ≥8.8g[28]	21–42 units[39] ≥28 drinks[26,29] ≥21 drinks[35] >280g[45]	≥53 drinks[42]

Table 5: Variations in reporting results across studies

No. of Studies	Reporting of Results
6	Linear trends between levels of alcohol intake and BMI, WC, or WHR[25,29,31,33,36,37]
7	Odds ratios for BMI, WC, or WHR in relation to drinking categories[26,27,30,35,39,44,45]
4	Multivariate regression analysis for baseline and/or follow-up adiposity outcomes[24,28,32,34]