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,\textsuperscript{1} and the knowledge that consumption patterns and beverage preference are moderated by gender,\textsuperscript{2} 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:

\[
\]

**AND**

\[
\]

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 activity25,27,28 or walking at least 1hr/day24, to any exercise in the last two weeks32, 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 reported24,30,34,36,37—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\textsuperscript{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.\textsuperscript{24,28,30,32,39,42,43} Convincingly, six of six studies concluded heavier drinkers had higher BMIs.\textsuperscript{24-26,39-42}

In longitudinal studies where increased alcohol intake was positively associated with overall weight change at follow-up,\textsuperscript{29,31} this correlation was affected towards the null when results were adjusted for drinking frequency.\textsuperscript{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).\textsuperscript{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.\textsuperscript{25,28,42,44} Where studies adjusted for confounders (ie, age, energy intake, expenditure, and smoking), this association held for WC.\textsuperscript{25,26,28,34} A minority of studies finding no correlation with central obesity markers were less accurate, with wide confidence intervals\textsuperscript{35} or standard of error.\textsuperscript{37} Importantly, effect sizes were modest with one-drink per day increases correlating with ~1cm increase in WC.\textsuperscript{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;\textsuperscript{26,43,45} however, these associations were particularly weak in men.\textsuperscript{43} This relationship held for wine but not beer or spirits.\textsuperscript{45} At follow-up, no association was found between baseline drinking frequency and 5-year change in WC.\textsuperscript{29} However, when considering changes in drinking patterns over 5 years, Wannamethee et al.\textsuperscript{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\textsuperscript{24,27,28,37} and only positively associated when analyses were unadjusted for important confounders such as energy intake, expenditure, and smoking.\textsuperscript{46} Beer intake was associated with change in weight\textsuperscript{30,31} but not WC over long-term follow-up.\textsuperscript{30,36} The magnitude of weight change was invariably modest.\textsuperscript{31} No association with weight gain was found in a randomised, longitudinal cross-over trial.\textsuperscript{47}
Wine
Overall, wine consumption was not associated with obesity. Any correlations with positive changes in weight or WC were weak and more pronounced for heavier drinkers. 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.

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

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, and many did not adjust for non-alcoholic calories. Where appropriate adjustments for confounders were made, either no or modest associations were observed. 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, 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, and concurs that the results for BMI in men are modest. The fact that men generally accumulate weight in the android region (so it may be years before central adiposity impacts BMI) may explain this. Given the associations of abdominal adiposity with poor health outcomes, the notion that alcohol may influence central obesity remains relevant.

Our finding that heavy drinking was associated with high BMI is corroborated by others. The SUN study found heavier drinkers to have 0.9–1.2 kg/m² higher BMIs than teetotallers. Interestingly, heavy drinkers consumed more non-alcohol calories than any other intake category.
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. Consequently, results had wider confidence intervals, which compromised the ability to accurately detect significant differences between alcohol intake categories.

Similar to others, 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—that mitigate against weight gain.

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. Beer only contributed to central obesity when consumed in high quantities or in studies where the proportion of beer drinkers differed significantly among the countries examined. The latter skewed confidence intervals, impacting the validity of the association shown.

Our findings regarding wine were corroborated by others who concluded either inverse or no association between wine intake and obesity. Though one 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. Where no association was found, 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, and that certain drinking patterns may be associated with varied dietary and exercise behaviours, 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 to Caucasian and Asian 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 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. 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

ACKNOWLEDGEMENTS
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PEER REVIEW
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CONFLICTS OF INTEREST
The authors declare that they have no competing interests.

FUNDING
None

ETHICS COMMITTEE APPROVAL
None
Figure 1: PRISMA Flowchart demonstrating the process of identifying papers for inclusion in the review (adapted from Moher et al.)

- Records identified through database searching (n=3,518)
- Additional records identified through reference lists (n=5)
- Records after duplicates removed (n=2,948)
- Records excluded (n=575)
- Primary Screening (n=179)
- Records excluded (n=2,769)
- Full-text articles assessed for eligibility (n=118)
- Full-text articles excluded, with reasons (n=90)
  1. Do not report on age group specified (n=55)
  2. Do not stratify by gender (n=24)
  3. Do not quantify alcohol consumption (n=6)
  4. Not specified study type (n=2)
  5. Irrelevant (n=2)
  6. Unavailable (n=1)
- Studies included in quantitative synthesis (n=28)
Figure 2: Commonly reported confounding factors influencing the relationship between alcohol and obesity

CONFOUNDING FACTORS

Physical Activity

Energy Intake

Smoking

Education

Age

Energy Intake

Smoking

Physical Activity

Education

Age

Energy Intake

Smoking

Physical Activity

Education

Age

Energy Intake

Smoking

Physical Activity

Education

Age

Energy Intake

Smoking

Physical Activity

Education

Age

Energy Intake

Smoking

Physical Activity

Education

Age

Energy Intake

Smoking
### Table 1: Summary of included cross-sectional studies

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Sample</th>
<th>Outcome Measure</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brandhagen et al., 2012</td>
<td>524 men 36–61 yrs</td>
<td>BMI, WC, SAD (sagittal abdominal diameter), % body fat</td>
<td>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</td>
</tr>
<tr>
<td>Da Rocha et al., 2017</td>
<td>514 men 35–64 yrs</td>
<td>BMI, Android Fat Mass:Gynoid Fat Mass ratio, Total Fat Mass</td>
<td>Low-moderate alcohol intake associated with increased adiposity (statistically insignificant)</td>
</tr>
<tr>
<td>Dumesnîl et al., 2013</td>
<td>7,106 men 50–59 yrs</td>
<td>BMI, WC</td>
<td>Alcohol consumption associated with increased risk of overweight and obesity; Drinking frequency inversely associated with mean BMI, except in heavy drinkers</td>
</tr>
<tr>
<td>Kim et al., 2011</td>
<td>141 men 40–59 yrs</td>
<td>BMI, WHR, % body fat</td>
<td>Light and heavy drinkers have higher BMI, WHR, and % body fat than moderate drinkers</td>
</tr>
<tr>
<td>Lee et al., 2008</td>
<td>61,582 men 40–75 yrs</td>
<td>BMI, WHR</td>
<td>Alcohol intake positively associated with WHR but not BMI; Ex-drinkers have higher prevalence of overweight and obesity</td>
</tr>
<tr>
<td>Leite et al., 2006</td>
<td>705 men 40–74 yrs</td>
<td>BMI, WC, HC (hip circumference), Skin-fold thickness</td>
<td>Alcohol intake not associated with BMI, WC, or HC; Light drinkers had lower peripheral subcutaneous fat</td>
</tr>
<tr>
<td>Lukasiewicz et al., 2005</td>
<td>1,210 men 45–60 yrs</td>
<td>BMI, WHR</td>
<td>J-shaped relationship: alcohol intake and WHR and BMI; wine consumption and WHR and BMI; Spirits intake linearly associated with WHR</td>
</tr>
<tr>
<td>Marques-Vidal et al., 2000</td>
<td>5,363 men 50–59 yrs</td>
<td>BMI (France &amp; Northern Ireland)</td>
<td>More alcoholic beverages consumed among obese than non-obese participants</td>
</tr>
<tr>
<td>Ning et al., 2014</td>
<td>1,032 men (1991); 865 men (2011)</td>
<td>BMI</td>
<td>Alcohol consumers had the greatest increase in obesity prevalence</td>
</tr>
<tr>
<td>Author(s)</td>
<td>Sample</td>
<td>Outcome Measure</td>
<td>Findings</td>
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<tr>
<td>Park et al., 2017&lt;sup&gt;15&lt;/sup&gt;</td>
<td>4,491 men</td>
<td>WC</td>
<td>Alcohol intake not associated with central obesity</td>
</tr>
<tr>
<td></td>
<td>40–69 yrs</td>
<td></td>
<td>Drinking frequency not associated with central obesity</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Binge drinking positively associated with abdominal obesity</td>
</tr>
<tr>
<td>Risérus et al., 2007&lt;sup&gt;2a&lt;/sup&gt;</td>
<td>807 men</td>
<td>BMI, WC, WHR</td>
<td>Alcohol intake positively associated with WC and WHR but not BMI</td>
</tr>
<tr>
<td></td>
<td>70 yrs</td>
<td></td>
<td>Neither beer nor wine intake associated with BMI, WC, or WHR</td>
</tr>
<tr>
<td>Rouillier et al., 2004&lt;sup&gt;4e&lt;/sup&gt;</td>
<td>2,126 men</td>
<td>BMI</td>
<td>Abstainers and light drinkers had the lowest BMI</td>
</tr>
<tr>
<td></td>
<td>45–60 yrs</td>
<td></td>
<td>Heavy drinkers and table wine drinkers had the highest BMI</td>
</tr>
<tr>
<td>Rouillier et al., 2005&lt;sup&gt;5i&lt;/sup&gt;</td>
<td>2,126 men</td>
<td>BMI, WC, WHR</td>
<td>Alcohol intake linearly associated with BMI, WC, and WHR</td>
</tr>
<tr>
<td>Rouillier et al., 2006&lt;sup&gt;7f&lt;/sup&gt;</td>
<td>2,126 men</td>
<td>BMI, WC, WHR</td>
<td>High quality wine consumers has greatest risk of overweight, high WC and WHR - association lost after adjusting for level of alcohol intake</td>
</tr>
<tr>
<td>Sieri et al., 2009&lt;sup&gt;6i&lt;/sup&gt;</td>
<td>13,025 men</td>
<td>BMI</td>
<td>Heavy drinkers had higher BMI than abstainers in many countries</td>
</tr>
<tr>
<td>Tolstrup et al., 2005&lt;sup&gt;8e&lt;/sup&gt;</td>
<td>25,325 men</td>
<td>BMI, WC, HC</td>
<td>Alcohol intake positively associated with odds of large WC</td>
</tr>
<tr>
<td></td>
<td>50–65 yrs</td>
<td></td>
<td>Alcohol intake not associated with BMI up to 20 drinks/wk</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Drinking frequency inversely associated with BMI and WC but not HC</td>
</tr>
<tr>
<td>Wilkinson et al., 2017&lt;sup&gt;5s&lt;/sup&gt;</td>
<td>1,729 men</td>
<td>BMI</td>
<td>Alcohol intake significantly higher in underweight males compared to all other BMI categories</td>
</tr>
<tr>
<td>Wills et al., 2017&lt;sup&gt;4f&lt;/sup&gt;</td>
<td>53,794 men</td>
<td>BMI</td>
<td>Alcohol intake inversely associated with BMI</td>
</tr>
<tr>
<td></td>
<td>40–69 yrs</td>
<td></td>
<td>Drinking frequency inversely associated with BMI</td>
</tr>
<tr>
<td>Yamada et al., 2003&lt;sup&gt;9e&lt;/sup&gt;</td>
<td>2,399 men</td>
<td>UBO (BMI≥25 and WC ≥95cm)</td>
<td>Alcohol intake not associated with UBO</td>
</tr>
</tbody>
</table>
### Table 2: Summary of Included Longitudinal Studies

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Sample</th>
<th>Outcome Measure</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downer et al., 2017</td>
<td>14,971 men 40–64yrs</td>
<td>Weight (Δ pounds)</td>
<td>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</td>
</tr>
</tbody>
</table>
| Halkjær et al., 2006    | 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 | 16,587 men 40–75yrs   | WC (Δ cm)       | Total alcohol intake not correlated with 9-year waist gain                                                                                                                                              |
| Lofley et al., 2017     | 4,890 men 45–64yrs     | WC              | Alcohol intake positively associated with WC but not HC                                                                                                                                               |
| Mozaffarian et al., 2011 | 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    | 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   | 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 | 7,608 men 40–59yrs     | BMI             | Alcohol intake positively associated with BMI  
Stable and new heavy drinkers had the highest weight gain                                                                                                                                             |

### Table 3: Summary of Included Randomised Controlled Trials

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Sample</th>
<th>Outcome Measure</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Padro et al., 2018</td>
<td>21 men 40–60yrs</td>
<td>Weight</td>
<td>Neither traditional nor alcohol-free beer was associated with increases in weight, BMI or WC</td>
</tr>
</tbody>
</table>
### Table 4: Classifications for alcohol intake across studies

<table>
<thead>
<tr>
<th>Classification</th>
<th>Amount per day</th>
<th>Amount per week</th>
<th>Amount per month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>250–500ml&lt;sup&gt;20&lt;/sup&gt; 0–12g&lt;sup&gt;24,41&lt;/sup&gt; &lt;6.7g&lt;sup&gt;25&lt;/sup&gt; &lt;3.2g&lt;sup&gt;28&lt;/sup&gt;</td>
<td>&lt;1 unit&lt;sup&gt;39&lt;/sup&gt; &lt;7 drinks&lt;sup&gt;26,29,35&lt;/sup&gt;</td>
<td>1–12 drinks&lt;sup&gt;42&lt;/sup&gt;</td>
</tr>
<tr>
<td>Moderate</td>
<td>500–&lt;1000ml&lt;sup&gt;20&lt;/sup&gt; 12–24g&lt;sup&gt;24,41&lt;/sup&gt; 3.2–&lt;8.8g&lt;sup&gt;28&lt;/sup&gt; 6.7–24.4g&lt;sup&gt;25&lt;/sup&gt;</td>
<td>1–20 units&lt;sup&gt;39&lt;/sup&gt; 7–20 drinks&lt;sup&gt;26,29&lt;/sup&gt; 7–13 drinks&lt;sup&gt;35&lt;/sup&gt; 0–140g&lt;sup&gt;45&lt;/sup&gt;</td>
<td>13–52 drinks&lt;sup&gt;42&lt;/sup&gt;</td>
</tr>
<tr>
<td>Intermediate</td>
<td>24.4–37.3g&lt;sup&gt;25&lt;/sup&gt;</td>
<td>21–27 drinks&lt;sup&gt;26,29&lt;/sup&gt; 14–20 drinks&lt;sup&gt;35&lt;/sup&gt; 141–280g&lt;sup&gt;45&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Heavy drinking</td>
<td>≥1000ml&lt;sup&gt;20&lt;/sup&gt; ≥37.3g&lt;sup&gt;25&lt;/sup&gt; ≥24g&lt;sup&gt;24,41&lt;/sup&gt; ≥8.8g&lt;sup&gt;28&lt;/sup&gt;</td>
<td>21–42 units&lt;sup&gt;39&lt;/sup&gt; ≥28 drinks&lt;sup&gt;26,29&lt;/sup&gt; ≥21 drinks&lt;sup&gt;35&lt;/sup&gt; ≥280g&lt;sup&gt;45&lt;/sup&gt;</td>
<td>≥53 drinks&lt;sup&gt;42&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

### Table 5: Variations in reporting results across studies

<table>
<thead>
<tr>
<th>No. of Studies</th>
<th>Reporting of Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Linear trends between levels of alcohol intake and BMI, WC, or WHR&lt;sup&gt;25,29,31,33,36,37&lt;/sup&gt;</td>
</tr>
<tr>
<td>7</td>
<td>Odds ratios for BMI, WC, or WHR in relation to drinking categories&lt;sup&gt;26,27,30,35,39,44,45&lt;/sup&gt;</td>
</tr>
<tr>
<td>4</td>
<td>Multivariate regression analysis for baseline and/or follow-up adiposity outcomes&lt;sup&gt;24,28,32,34&lt;/sup&gt;</td>
</tr>
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</table>