Alcohol consumption and risk of developing type 2 diabetes

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A review of the epidemiological evidence in population studies on the influence of alcohol on risk of type 2 diabetes suggest that heavy alcohol consumption and binge drinking increase the risk of developing type 2 diabetes, but moderate drinking may reduce the risk of this condition. While earlier reviews and meta-analyses have suggested that moderate drinking is associated with a 30–40% reduction in risk of type 2 diabetes in men and women, with optimal benefit seen around two drinks daily, more recent evidence suggests a much smaller reduction in risk associated with moderate drinking in men of 10–13%. However, there is no justification to encourage drinking for health purposes; keeping weight under control, exercising, eating a healthy diet and not smoking are more effective preventive measures for type 2 diabetes. Public health messages should emphasise the potential harm of drinking in excess of recommended guidelines and of binge drinking, which is particularly prevalent in the UK, on risk of developing type 2 diabetes.

Diabetes mellitus is a common chronic condition that affects an estimated 2.6 million adults in the UK, and approximately 145 000 adults are diagnosed with diabetes each year (Diabetes UK, 2010). Type 2 diabetes is a major cause of premature mortality and cardiovascular morbidity; lifestyle factors play an important aetiologic role, and there is increasing evidence that most cases of type 2 diabetes can be prevented through lifestyle modification (Hu, 2011). In recent years, increasing attention has been turned to the role of alcohol in the aetiology of type 2 diabetes.

Alcohol consumption is highly prevalent in the UK; 71% of men and 56% of women (aged 16 and over) reported drinking an alcoholic drink on at least one day in the week (The Health and Social Care Information Centre, 2011). The Department of Health (2012) recommends that men should not regularly drink more than 3–4 units of alcohol a day and women not more than 2–3 units a day, with a recommended maximum weekly total intake of 21 units for men and 14 units for women; despite this, 26% of men and 18% of women report drinking more than the recommended guidelines

(The Health and Social Care Information Centre, 2011). Binge drinking, defined as drinking over 8 units on at least one day in the week for men and over 6 units for women, is common, with 22% of men and 15% of women reporting binge drinking (The Health and Social Care Information Centre, 2011).

Type 2 diabetes is recognised clinically as a complication of alcoholism (Kim and Kim, 2012), and while chronic abuse of alcohol is considered to be a potential risk factor for the development of type 2 diabetes, several large studies have demonstrated its moderate use can decrease the risk of this condition (Howard et al, 2004; Pietraszek et al, 2010). There have been conflicting reports on the importance of type of drink and unequivocal reports on the association between heavy or binge drinking and type 2 diabetes (Pietraszek et al, 2010).

This review assesses the epidemiological evidence on the association between alcohol drinking and risk of incident type 2 diabetes; the influence of type of alcohol, patterns of drinking, including binge drinking, and the use of non-drinkers as a reference group are also discussed.

Light-to-moderate drinking and risk of diabetes

Several epidemiological studies have suggested a "U-shaped" or "J-shaped" relationship between alcohol intake and the risk of developing type 2 diabetes, although the strength of the associations has varied between studies (Howard et al, 2004; Carlsson et al, 2005; Koppes et al, 2005; Pietraszek et al, 2010). Two quantitative meta-analyses (Carlsson et al, 2005; Koppes et al, 2005) indicate that moderate alcohol intake is associated with about a 30–40% reduction in risk of type 2 diabetes compared with non-drinkers.

The first meta-analysis on the effects of alcohol consumption and risk for type 2 diabetes conducted by Koppes and colleagues in 2005 involved 15 cohort studies (*n*=369 862) and nearly 12 000 incident cases of type 2 diabetes. A U-shaped relationship was reported, with individuals consuming <48 g alcohol/day (6 units a day) showing a significant 30% risk reduction in type 2 diabetes compared with heavier consumers or abstainers. Heavy drinkers (>48 g alcohol/day) showed similar risk to non-consumers. The relative risk of type 2 diabetes for those who consumed 6–12, 12–24, 24–48 and ≥48 g alcohol daily were 0.70 (95% confidence interval [CI], 0.61–0.79), 0.69 (95% CI, 0.58–0.81), 0.72 (95% CI, 0.62–0.84) and 1.04 (95% CI, 0.84–1.29), respectively. When examined separately in men and women, the lower risk of type 2 diabetes compared with abstainers was seen for women consuming up to 24 g alcohol/day; for men the reduction was seen for all those consuming 6–48 g alcohol/day.

The subsequent meta-analysis conducted by Carlsson et al (2005) involved 13 cohorts and showed similar results, with moderate drinkers, defined as drinking 5–30 g alcohol/day, showing a 30% reduction in risk of type 2 diabetes among men (relative risk [RR], 0.72; 95% CI, 0.67–0.77) and women (RR, 0.68; 95% CI, 0.61–0.75).

However, both these meta-analyses have been criticised for the use of current abstainers or low consumers as the reference group (Baliunas et al, 2009), which included former drinkers who may have abstained because of health reasons – known as the "sick quitter effect" (Shaper et al, 1988).

A more recent meta-analysis of 20 prospective cohort studies (*n*=477 200, 12 556 incident cases of type 2 diabetes; Baliunas et al, 2009), which evaluated the dose–response relationship between alcohol consumption and type 2 diabetes using lifetime abstainers as the reference group, confirmed a U-shaped relationship between alcohol consumption and type 2 diabetes in men and women; in men, the lowest risk was seen in those consuming 22 g

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alcohol/day. However, the magnitude of risk reduction in men was only 13% (RR, 0.87; 95% CI, 0.76–1.00), compared with around a 30% reduction in previous meta-analyses (Carlsson et al, 2005; Koppes et al, 2005). For women, the reduction was greatest in those who consumed 24 g alcohol/day (RR, 0.60; 95% CI, 0.52–0.69). Risk of type 2 diabetes increased at levels of 60 g alcohol/day for men and 50 g alcohol/day for women.

The smaller reduction effect associated with moderate drinking was confirmed by the team of European researchers from eight countries participating in the EPIC (European Prospective Investigation into Cancer and Nutrition) study (Beulens et al, 2012). This nested case–control study included over 26 000 participants (11 559 people with type 2 diabetes and 14 529 controls). A similar but non-significant 10% reduction in risk was observed in men who drank 12.1–24 g alcohol/day after taking into account BMI (RR, 0.90; 95% CI, 0.79–1.03) compared with low consumers (0.1–6 g alcohol/day); the lower risk of type 2 diabetes associated with

moderate drinking was stronger in women (RR, 0.82; 95% CI, 0.72–0.92).

These more recent studies strongly suggest that the benefit of moderate drinking on risk of type 2 diabetes is considerably smaller than previously suggested.

The reason for a consistently stronger reduction in risk of type 2 diabetes in women compared with men in most studies is unclear, but it may to some degree reflect the differences in the association between alcohol intake and body weight between men and women (Pietraszek et al, 2010). The associations reported between alcohol and BMI in men have been positive or non-existent (Suter et al, 1997; Wannamethee and Shaper, 2003), but in women most cross-sectional studies report an inverse association, with higher obesity rates in non-drinkers (Suter et al, 1997; Wannamethee et al, 2004). The higher BMI levels commonly seen in female non-drinkers may in part be because of self-selection bias; women who are overweight may abstain from drinking because of their belief that alcohol contributes to weight

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gain. As obesity is the strongest lifestyle determinant of type 2 diabetes, this may contribute to the stronger reduction seen in women, rather than the greater effect of alcohol *per se* when comparing moderate drinkers with non-drinkers.

Heavy drinking and risk of diabetes

Heavy drinking has been implicated as a risk factor for type 2 diabetes (Holbrook et al, 1990; Wei et al, 2000). Although meta-analyses show heavier drinkers to have about a 40% increase in risk of type 2 diabetes compared with moderate drinkers, whether they have increased risk compared with non-drinkers or low consumers is less clear (Carlsson et al, 2005; Koppes et al, 2005; Baliunas et al, 2009). Meta-analyses on the association between alcohol and type 2 diabetes have all shown heavy drinkers to have similar risk to non-drinkers (Carlsson et al, 2005; Koppes et al, 2005; Baliunas et al, 2009). In the meta-analysis by Koppes et al (2005), those drinking >48 g alcohol/day showed similar risk to non-drinkers (RR, 1.04; 95% CI, 0.84–1.29). The meta-analysis by Baliunas et al (2009) showed that heavy drinkers (>50 g alcohol/day in women and >60 g alcohol/day in men) have significantly higher risk than light or moderate drinkers, but their risk is similar to lifelong abstainers (RR, 1.01, 95% CI, 0.71–1.44 for men and RR, 1.02, 95% CI, 0.82–1.26 for women).

On the basis of findings from these meta-analyses, no clear conclusion has been drawn on the effects of heavy drinking (Koppes et al, 2005; Baliunas et al, 2009; Pietraszek et al, 2010). However, even lifelong abstainers may not be a suitable group for comparative purposes in studies of the effects of alcohol on health, particularly in populations where drinking is the norm (Shaper and Wannamethee, 1998); lifelong teetotallers have characteristics other than the lack of drinking that may affect their morbidity. Thus comparisons with lifelong abstainers

may exaggerate the benefits of moderate drinking and underestimate the true adverse impact of heavy drinking.

Although a few studies have shown heavy drinkers (variously defined) to have higher risk of type 2 diabetes than non-drinkers (Holbrook et al, 1990; Wei et al, 2000; Wandell et al, 2007), occasional drinkers who consume very low amounts of alcohol may be a more appropriate group for comparative purposes. Strong evidence that heavy drinkers increase risk of type 2 diabetes tend to come from Western populations, which have used occasional drinkers (less than one drink a week) as the reference group or from non-Western populations.

In the British Regional Heart Study of middle-aged men (Wannamethee et al, 2002), heavy drinkers (more than six drinks a day) showed a 30% increase in risk of type 2 diabetes compared with occasional drinkers. In the ARIC (Atherosclerosis Risk in Communities) study (Kao et al, 2001), those who drank more than 21 drinks a week showed a 50% increase in risk of type 2 diabetes (RR, 1.50; 95% CI, 1.02–2.20) compared with those who drank less than one drink a week. In the EPIC-InterACT Study (Beulens et al, 2012), men who drank >96 g alcohol/day showed a 40% increased risk of type 2 diabetes compared with low consumers (<6 g alcohol/day). In the most recent report from Sweden (Cullmann et al, 2012), men drinking >22 g alcohol/day showed a 40% increase in risk of developing pre-type 2 diabetes or type 2 diabetes compared with occasional drinkers. In a study of middle-aged and older adults in China in whom abstinence was common (Lu et al, 2010), heavy drinking (>40 g alcohol/day) was associated with a 50% increase in developing impaired fasting glucose or type 2 diabetes in men compared with abstainers. In a study of middle-aged Japanese men (Sakai et al, 2006), men drinking >60 ml (48g) alcohol/day showed over a three-fold increase

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in risk of developing type 2 diabetes compared with lifelong abstainers. These studies provide strong evidence that heavy drinking is a risk factor for type 2 diabetes.

In most of the studies that have reported an increased risk of type 2 diabetes in heavy drinkers and compared men and women, the association is only seen in men; few studies have reported increased risk in heavy drinkers among women (Carlsson et al, 2003). This may partly be because of the lack of reporting of heavy drinking and the limited number of women who drink at higher levels in population studies. Alternatively, it may be a result of self-selection bias and the strong inverse association seen between alcohol and body weight in women.

Does type of drink matter?

A factor that may explain the differences in findings between studies and the differences between men and women may be differences in beverage type (Pietraszek et al, 2010). In the few studies that have compared men and women, women were more likely to drink wine than other beverages (Beulens et al, 2012), while in men beer tends to be the predominant drink (Wannamethee et al, 2002; Beulens et al, 2012). Studies that have examined beverage-specific intake have reported inconsistent results on the importance of type of drink, and have not consistently shown any type of beverage to be more strongly associated (favourably or unfavourably) with risk of type 2 diabetes.

Although some studies have shown greater reduction associated with wine drinking (Rasouli et al, 2012), this is likely to be associated with the multiple healthy lifestyle characteristics of wine drinkers, as they have socio-economic, behavioural, dietary and physical characteristics that are advantageous to health. In some but not all studies, the risk reduction associated with light or moderate drinking is not seen with spirit drinking (Kao et al, 2001; Wannamethee et al, 2003; Rasouli et al,

2012), and heavy consumption of spirits tends to have a more deleterious effect than heavy wine or beer drinking (Kao et al, 2001; Wannamethee et al, 2003); this may be because people who drink spirits have a higher total ethanol consumption compared with beer or wine drinkers (Wannamethee et al, 2003). Overall there is no clear evidence that wine provides specific health benefits for type 2 diabetes.

Binge drinking

A few studies have attempted to examine drinking patterns and in particular binge drinking and risk of type 2 diabetes, with the suggestion that binge drinking may increase risk of type 2 diabetes. In the Melbourne Collaborative Cohort Study of over 30 000 adults (Hodge et al, 2006), consumption of >210 g alcohol in 1–3 days increases the risk of type 2 diabetes five-fold, while consuming the same amount of alcohol over a week did not increase risk. In a study of Swedish men (Cullmann et al, 2012), binge drinkers (those who reported drinking one bottle of wine on any one occasion at least once monthly) showed a significant 50% increase in risk of pre-type 2 diabetes and type 2 diabetes compared with occasional drinkers (RR, 1.52; 95% CI, 1.05–2.19); this rose to a near 70% increase in risk among those who reported drinking at least two bottles of alcohol on any one occasion (RR, 1.67; 95% CI, 1.11–2.50). In the Finnish Twin Cohort Study (Carlsson et al, 2003), binge drinking defined as consuming more than one bottle of wine on the same occasion at least once a month was associated with a two-fold increase in risk of diabetes in women but not in men (RR, 2.1; 95% CI, 1.0–4.4).

Possible mechanisms

There are several possible biological mechanisms that could explain the lower risk of type 2 diabetes associated with light-to-moderate drinking. It is well established that insulin resistance is a key factor in the pathogenesis of

type 2 diabetes and that light-to-moderate drinking may be associated with enhanced insulin sensitivity. Observational studies as well as randomised controlled trials have shown increased insulin sensitivity after moderate alcohol consumption (Davies et al, 2002; Hendriks, 2007). Alternatively, ethanol oxidation produces measurable downstream metabolites such as acetaldehyde and acetate that may reduce the risk of type 2 diabetes (Koppes et al, 2005). Moderate alcohol consumption may also reduce risk of diabetes through increases in high-density lipoprotein cholesterol concentrations or through the anti-inflammatory effect of alcohol (Koppes et al, 2005).

Conversely, heavy drinking can contribute to the conditions that cause diabetes; there is evidence to suggest that heavy drinking can reduce the body's sensitivity to insulin, which can trigger type 2 diabetes (Holbrook et al, 1990; Wei et al, 2000). Large amounts of alcohol (as a result of alcohol abuse) can cause damage to the pancreas through chronic pancreatitis, which can damage the beta-cells that produce insulin and ultimately lead to diabetes (Holbrook et al, 1990). Heavy drinking can also increase body weight, in particular central adiposity (Suter et al, 1997), as well as increasing triglyceride concentration, blood pressure and impaired liver function – all established risk factors for diabetes (Wannamethee et al, 2011).

Conclusion

Despite the consistent association between light-to-moderate drinking and lower risk of type 2 diabetes, the potential harmful effects of moderate drinking on other aspects of health outcome (such as breast cancer in women) and the harmful effects of heavy drinking need to be considered in discussions on health policy. Furthermore, recent studies strongly suggest that the reported benefits of moderate drinking may be much smaller than previously suggested.

For those who already drink alcohol, consumption should be kept within the recommended guidelines as higher amounts of alcohol increase risk of type 2 diabetes; for those who do not drink alcohol, there seems no convincing justification to encourage them to drink for health benefits.

Greater benefit for reducing the risk of type 2 diabetes can be achieved by weight control, exercising, eating a healthy diet and not smoking. The modifiable factors involved in the development of type 2 diabetes, such as being overweight or obese, physical inactivity and cigarette smoking, should be the key components of any public health programme for the prevention of this condition. Public health messages on alcohol and type 2 diabetes should emphasise the potential harm associated with drinking in excess of national guidelines and with binge drinking, which is particularly prevalent in the UK. ■

Baliunas DO, Patra J, Taylor BJ et al (2009) Alcohol as a risk factor for type 2 diabetes: A systematic review and meta-analysis. *Diabetes Care* **32**: 2123–32

Beulens JW, van der Schouw YT, Bergmann MM et al (2012) Alcohol consumption and risk of type 2 diabetes in European men and women: Influence of beverage type and body size. The EPIC-InterAct Study. *J Intern Med* **272**: 358–70

Carlsson S, Hammar N, Grill V (2005) Alcohol consumption and type 2 diabetes. *Diabetologia* **48**: 1051–4

Carlsson S, Hammar N, Grill V et al (2003) Alcohol consumption and the incidence of type 2 diabetes: A 20-year follow-up of the Finnish twin cohort study. *Diabetes Care* **26**: 2785–90

Cullmann M, Hilding A, Ostenson CG (2012) Alcohol consumption and risk of pre-diabetes and type 2 diabetes development in a Swedish population. *Diabet Med* **29**: 441–52

Page points

1. It is well established that insulin resistance is a key factor in the pathogenesis of type 2 diabetes and that light to moderate drinking may be associated with enhanced insulin sensitivity.

2. Conversely, heavy drinking can contribute to the conditions that cause diabetes; there is evidence to suggest that heavy drinking can reduce the body's sensitivity to insulin, which can trigger type 2 diabetes.

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Davies MJ, Baer DJ, Judd JT et al (2002) Effects of moderate alcohol intake on fasting insulin and glucose concentrations and insulin sensitivity in postmenopausal women: A randomized controlled trial. *JAMA* **287**: 2559–62

Department of Health (2012) *Alcohol Advice.* Available at: http://bit.ly/TxoifU (accessed 07.11.12)

Diabetes UK (2010) *Diabetes in the UK 2010: Key Statistics on Diabetes.* Available at: http://bit.ly/TxnF6f (accessed 07.11.12)

Hendriks HF (2007) Moderate alcohol consumption and insulin sensitivity: Observations and possible mechanisms. *Ann Epidemiol* **17**: S40–42

Hodge AM, English DR, O'Dea K, Giles GG (2006) Alcohol intake, consumption pattern and beverage type and the risk of type 2 diabetes. *Diabet Med* **23**: 690–7

Holbrook TL, Barrett-Connor E, Wingard DL (1990) A prospective population-based study of alcohol use and non-insulin-dependent diabetes mellitus. *Am J Epidemiol* **132**: 902–9

Howard AA, Arnsten JH, Gourevitch MN (2004) Effect of alcohol consumption on diabetes mellitus: A systematic review. *Ann Intern Med* **140**: 211–9

Hu FB (2011) Globalization of diabetes. The role of diet, lifestyle and genes. *Diabetes Care* **34**: 1249–57

Kao WH, Puddey IB, Boland LL et al (2001) Alcohol consumption and the risk of type 2 diabetes mellitus: Atherosclerosis Risk in Communities Study. *Am J Epidemiol* **154**: 748–57

Kim SJ, Kim DJ (2012) Alcoholism and diabetes mellitus. *Diabetes Metab J* **36**: 108–15

Koppes LL, Dekker JM, Hendriks HF et al (2005) Moderate alcohol consumption lowers the risk of type 2 diabetes: A meta-analysis of prospective observational studies. *Diabetes Care* **28**: 719–25

Lu C, Yu Z, Li H et al (2010) Associations of alcohol consumption with diabetes mellitus and impaired fasting glycaemia among middle-aged and elderly Chinese. *BMC Public Health* **10**: 713

Pietraszek A, Gregersen S, Hermansen K (2010) Alcohol and type 2 diabetes. *Nutr Metab Cardiovasc Dis* **20**: 366–75

Rasouli B, Ahlbom A, Andersson T et al (2012) Alcohol consumption is associated with reduced risk of type 2 diabetes and autoimmune diabetes in adults: Results from the Nord-Trondelag Health Study. *Diabet Med.* Available at: http://www.ncbi.nlm.nih.gov/m/pubmed/22612671 (accessed 07.11.12)

Sakai Y, Yamaji T, Tabata S et al (2006) Relation of alcohol use and smoking to glucose tolerance status in Japanese men. *Diab Res Clin Pract* **73**: 83–8

Shaper AG, Wannamethee SG (1998) The J-shaped curve and changes in drinking habit. In: Chadwick DJ, Goode JA, eds. *Alcohol and Cardiovascular Diseases.* Norvartis Foundation Symposium 216. Wiley and Sons, Chichester: 172–92

Shaper AG, Wannamethee G, Walker M (1988) Alcohol and mortality in British men: Explaining the U-shaped curve. *Lancet* **ii**: 1268–73

Suter PM, Hasler E, Vetter W (1997) Effects of alcohol on energy metabolism and body weight regulation: Is alcohol a risk factor for obesity? *Nutr Rev* **55**: 157–71

The Health and Social Care Information Centre (2011) *Statistics on Alcohol: England, 2011 [NS].* Available at: http://www.ic.nhs.uk/pubs/alcohol11 (accessed 07.11.12)

Wandell PE, de Faire U, Hellenus ML (2007) High intake of alcohol is associated with newly diagnosed diabetes in 60 year-old men and women. *Nutr Metab Cardiovasc Dis* **17**: 598–608

Wannamethee SG, Camargo CA Jr, Manson JE et al (2003) Alcohol drinking patterns and risk of type 2 diabetes mellitus among younger women. *Arch Intern Med* **163**: 1329–36

Wannamethee SG, Field AE, Colditz GA, Rimm EB (2004) Alcohol intake and 8-year weight gain in women: A prospective study. *Obesity Res* **12**: 1386–96

Wannamethee SG, Papacosta O, Whincup PH et al (2011) The potential for a two-stage diabetes risk algorithm combining non-laboratory-based scores with subsequent routine non-fasting blood tests: Results from prospective studies in older men and women. *Diabet Med* **28**: 23–30

Wannamethee SG, Shaper AG (2003) Alcohol, body weight and weight gain in middle-aged men. *Am J Clin Nutr* **77**: 1312–7

Wannamethee SG, Shaper AG, Perry IJ, Alberti KG (2002) Alcohol consumption and the incidence of type 2 diabetes. *J Epidemiol Comm Health* **56**: 542–8

Wei M, Gibbons LW, Mitchell TL et al (2000) Alcohol intake and incidence of type 2 diabetes in men. *Diabetes Care* **23**: 18–22