

Oct. 2009 (Vol. 2, Issue 2, pages 15-18)



SUGAR-SWEETENED SOFT DRINK CONSUMPTION AND RISK OF TYPE 2 DIABETES AND CARDIOVASCULAR RISK

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In parallel with the increasing prevalence of obesity and type 2 diabetes, the consumption of sugar-sweetened soft drinks in the US has increased dramatically in the past several decades. There is substantial evidence that higher intake of soft drinks is associated with increased risk of obesity in children and adults [1]. Sugar-sweetened soft drinks may contribute to weight gain because of the low satiety of liquid calories. In experimental studies, intake of sugar-sweetened beverages is not fully compensated by reductions in energy intake in subsequent meals, resulting in increased energy intake and positive energy balance.

Key Points

- Sugar-sweetened soft drinks are a major source of excess calories and glycemic load in the diet.
- Epidemiologic studies have provided substantial evidence that regular consumption of soft drinks not only contributes to weight gain and obesity, but also increases risk of type 2 diabetes and the metabolic syndrome.
- The deleterious effects of soft drinks on diabetes are not entirely explained by body weight.
- Emerging evidence suggests that soft drink consumption is also associated with increased risk of coronary heart disease.

Emerging evidence also suggests that higher consumption of sugar-sweetened soft drinks may raise the risk of developing type 2 diabetes and the metabolic syndrome. Soft drinks contain large amounts of simple sugars, which can induce higher glycemic and insulinemic responses. Soft drinks are an important source of glycemic load in the diet, which has been associated with the risk of developing type 2 diabetes and cardiovascular disease.

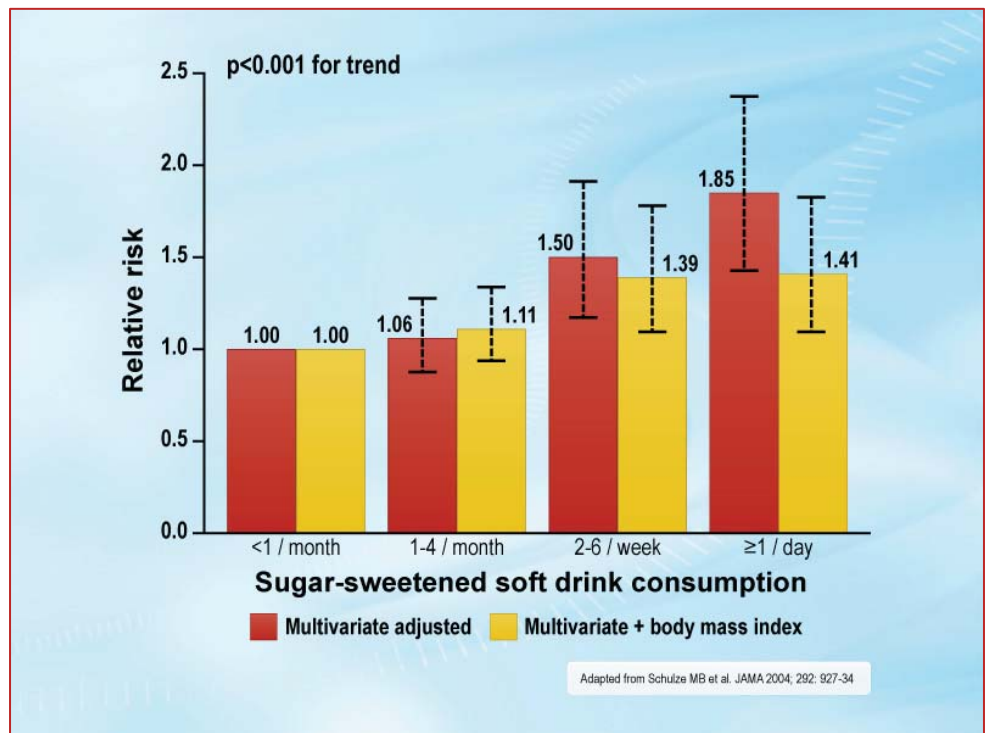
Several epidemiologic studies have examined the relationship between soft drink consumption and risk of type 2 diabetes. Schulze et al. [2] conducted a prospective analysis of soft drink consumption and risk of weight gain and diabetes among 91,249 women who were followed from 1991 to 1999 in the Nurses' Health Study II. During the follow-up, 741 incident cases of type 2 diabetes were confirmed. After adjustment for potential confounders, women consuming 1 or more sugar-sweetened soft drinks per day had a relative risk (RR) of type 2 diabetes of 1.83 (95% CI: 1.42-2.36; $p < 0.001$ for trend) compared with those who consumed less than 1 of these beverages per month (see Figure). The

RR for extreme categories, after further controlling for body mass index (BMI), was 1.41 (95% CI: 1.09-1.83; $p=0.008$ for trend). This finding suggests that BMI accounted for about half of the excess risk. The results for sugar-sweetened cola alone were similar to those for all sugar-sweetened soft drinks (multivariate-adjusted RR of diabetes for consumption ≥ 1 /day compared with <1 /month: 1.88, 95% CI: 1.43-2.46, $p<0.001$ for trend). This association was also attenuated after additional adjustment for BMI (RR: 1.46, 95% CI: 1.12-1.92, $p=0.004$ for trend). In addition, consumption of fruit punch was associated with increased diabetes risk (RR for ≥ 1 drink/day compared with <1 drink/month, 2.00; 95% CI: 1.33-3.03; $p=0.001$).

In the Black Women’s Health Study, Palmer et al. [3] examined the association between sugar-sweetened beverage consumption and risk of type 2 diabetes among 43,960 African American women who were followed from 1995 to 2001. During the follow-up, 2,713 incident cases of type 2 diabetes were identified. After adjustment for confounding variables, the RR for ≥ 2 soft drinks/day was 1.24 (95% CI: 1.06-1.45). For fruit drinks, the corresponding RR was 1.31 (95% CI: 1.13-1.52). The association of diabetes with soft drink consumption was primarily mediated by BMI, whereas the association with fruit drink consumption appeared to be independent of body weight.

Figure:

Multivariate relative risks of type 2 diabetes according to sugar-sweetened soft drink consumption in the Nurses’ Health Study II 1991-1999. Multivariate relative risks were adjusted for age, alcohol (0, 0.1-4.9, 5.0-9.9, 10+ g/day), physical activity (quintiles), family history of diabetes, smoking (never, past, current), postmenopausal hormone use (never, ever), oral contraceptive use (never, past, current), intake (quintiles) of cereal fibre,



magnesium, trans fat, polyunsaturated fat, saturated fat, and consumption of sugar-sweetened soft drinks, diet soft drinks, fruit juice, and fruit punch (other than the main exposure, depending on model). The data was based on reference 2.

Dhingra and colleagues [4] examined soft drink consumption and risk of developing the metabolic syndrome in the Framingham Heart Study. In cross-sectional analysis, individuals consuming ≥ 1 soft drink/day had a 50% greater prevalence of the metabolic syndrome [odds ratio (OR): 1.48; 95% CI: 1.30-1.69] than those consuming < 1 drink/day. In prospective analysis with 4-year follow-up, consumption of ≥ 1 soft drink/day was associated with increased risk of developing the metabolic syndrome (RR: 1.44, 95% CI: 1.20-1.74). Regular consumption of soft drinks was also associated with individual components of the metabolic syndrome, including increased waist circumference (RR: 1.30, 95% CI: 1.09-1.56), impaired fasting glucose (RR: 1.25; 95% CI: 1.05-1.48), higher blood pressure (RR: 1.18; 95% CI: 0.96-1.44), hypertriglyceridemia (RR: 1.25; 95% CI: 1.04-1.51), and low HDL cholesterol (RR: 1.32, 95% CI: 1.06-1.64).

In a recent analysis, Fung and colleagues [5] examined the relationship between sugar-sweetened beverages and risk of coronary heart disease (CHD) among 88,520 subjects from the Nurses' Health Study. During 24 years of follow-up, 3,105 incident cases of CHD (nonfatal myocardial infarction and fatal CHD) were documented. After adjusting for cardiovascular risk factors, the RRs (and 95% CIs) of CHD according to categories of cumulative average of sugar-sweetened beverage consumption (< 1 /month, 1-4/months, 2-6/weeks, 1/day, and ≥ 2 servings/day) were 1.0, 0.96 (0.87-1.06), 1.04 (0.95-1.14), 1.23 (1.06-1.43), and 1.35 (1.07-1.69) ($p < 0.001$ for trend). Additional adjustment for BMI, energy intake, and incident diabetes attenuated the associations, but they remained significant. Artificially-sweetened beverages were not significantly associated with CHD.

This data provides mounting evidence that sugar-sweetened beverages not only contribute to positive energy balance and obesity, but also to type 2 diabetes and cardiovascular risk. It appears that the deleterious effects of soft drinks are not entirely mediated through BMI. One potential explanation is that the high glycemic load of soft drinks increases insulin demand and in the long-run, may lead to beta-cell failure. Because high-fructose corn syrups contained in soft drinks contain roughly 45% glucose and 55% fructose, the overall glycemic index of soft drinks is only moderate due to the low glycemic index of fructose. However, overall blood glucose response is not only determined by the glycemic index value of a food, but also by its amount of carbohydrate. Thus, the concept of glycemic load, which is the product of the glycemic index value of a food and its carbohydrate content, has been used to represent the quality and quantity of carbohydrates consumed. Because of their high sugar content, soft drinks are an important source of glycemic load in the US diet. Several large population-based studies have documented an inverse association between dietary glycemic load values and HDL levels and a positive association with triglycerides [6]. Epidemiologic studies report that a higher dietary glycemic load, especially combined with low intake of cereal fibre, significantly elevates long-term risk of type 2 diabetes and CHD (6). Therefore, the detrimental effects of sugar-sweetened beverages stem from both increased caloric intake and high glycemic load values.

References

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