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Research report

Effects of sucrose drinks on macronutrient intake, body weight, and mood state in overweight women over 4 weeks☆

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ABSTRACT

The long-term effects of sucrose on appetite and mood remain unclear. Normal weight subjects compensate for sucrose added blind to the diet (Reid et al., 2007). Overweight subjects, however, may differ. In a single-blind, between-subjects design, soft drinks (4 × 25cl per day; 1800 kJ sucrose sweetened versus 67 kJ aspartame sweetened) were added to the diet of overweight women (n = 53, BMI 25–30, age 20–55) for 4 weeks. A 7-day food diary gave measures of total energy, carbohydrate, protein, fat, and micronutrients. Mood and hunger were measured by ten single Likert scales rated daily at 11.00, 14.00, 16.00, and 20.00. Activity levels were measured by diary and pedometer. Baseline energy intake did not differ between groups. During the first week of the intervention energy intake increased slightly in the sucrose group, but not in the aspartame group, then decreased again, so by the final week intake again did not differ from the aspartame group. Compensation was not large enough to produce significant changes in the composition of the voluntary diet. There were no effects on hunger or mood. It is concluded that overweight women do not respond adversely to sucrose added blind to the diet, but compensate for it by reducing voluntary energy intake. Alternative explanations for the correlation between sugary soft drink intake and weight gain are discussed.

Introduction

Diets high in simple carbohydrate may be related to a positive energy balance and weight gain, particularly with carbohydrate in liquid form. Malik, Schulze and Hu (2006) systematically reviewed 30 studies relevant to the impact of sugar sweetened beverages on weight gain and concluded that the weight of evidence indicated an association. Their review included 15 cross-sectional studies, 10 observational prospective longitudinal studies, and the 5 experimental studies reviewed in detail below. Of the 15 cross-sectional studies, five found a significant association between sugary drink intake and weight of a magnitude equivalent to a correlation coefficient of at least 0.3. Five found a statistically significant association of some kind at $p < 0.05$, but in very large samples. Such associations are difficult to interpret because they involve correlations smaller than 0.2, which means that only 4% or less of the variance in one variable is shared with the other (Rummel, 1976). Another five studies found no significant relationship, although Malik et al. (2006) describe two of these as finding 'a positive non-significant association'. So cross-sectional studies offer five positive associations, five small, potentially accidental associations, and five non-significant findings. These were naturalistic studies where weight status was related to intake of sugar-sweetened beverages, as reported in food diaries or questionnaires.

A difficulty is that only one of the studies controlled for other aspects of nutrient intake in analysing the data. Without such control, it is not possible to tell whether reported sugar-sweetened beverage intake is a direct cause of weight increase, or whether reported intake is primarily an indirect marker of a less healthy diet, with weight gain mainly caused by other factors, such as fat intake, or inactivity.

Prospective longitudinal studies may be more capable of addressing the question of whether sugary drinks cause weight gain. Of the ten reviewed (Malik et al., 2006), four found sufficient mean weight gain to have clinical significance, three found smaller effects, and two found no significant differences. Again, there are difficulties with interpreting the findings because studies varied considerably in how they controlled for other aspects of diet and activity patterns. There is a risk that reported sugary drink intake is sometimes confounded with other variables that more strongly

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cause weight gain. If sugar intake were a strong, direct cause of weight gain, then one might expect findings to be more consistent.

As well as the studies reviewed by Malik et al. (2006), there are experiments on the effects of carbohydrate (CHO) over less than 24 h, often providing CHO in liquid, which also find inconsistent effects (Reid & Hammersley, 1999, 2001). Reid, Hammersley, Hill, and Skidmore (2007) suggest that studies shorter than 24 h may not allow sufficient time for adaptation to CHO added to the diet, or for compensation to occur elsewhere in the diet. Differences in findings may also be due to the interplay between uncontrolled cognitive factors and physiological factors, when CHO is not given under blind conditions. For instance, what subjects expect to happen can influence how they respond in some studies. It is feasible that over longer than 24 h, such expectancy effects would diminish and people would adjust to CHO added to the diet.

Indeed, fat and sugar intake are negatively correlated in some surveys (Raben, Macdonald, & Astrup, 1997). Three studies have added CHO blind to the diet of normal weight individuals, controlling sweetness by using aspartame placebos. One found that fructose increased energy intake (Tordoff & Alleva, 1990), while another found that sucrose did not increase energy intake or affect mood (Reid & Hammersley, 1998a, 1998b). A third, replicated here, found that over four weeks subjects partially compensated for added sucrose by reducing voluntary CHO, fat, and protein intake, and did not gain weight or increase voluntary carbohydrate intake (Reid et al., 2007).

James et al. (2004), successfully reduced schoolchildren's reported sugary soft drink intake in a controlled trial of an educational intervention. Receiving the intervention led also to significant weight loss, compared to children who received no intervention. Unfortunately, the absence of a control intervention and the high drop out rate (only 36% of children completed before and after drink diaries) make it impossible to be confident that reduced soft drink intake was the cause of weight loss. Perhaps families who judged that their children had 'succeeded' by reducing soft drink intake and weight were more likely to participate in the second stage. Di Meglio and Mattes (2000) explicitly compared isoenergetic liquid and solid carbohydrate in normal, unrestrained subjects, finding weight gain after the liquid, but not the solid, carbohydrate. However, the weight gain was only about 0.5 kg over 4 weeks (approximately 0.03 of a standard deviation of baseline weight), and insufficient details of the statistics are reported to ascertain how this small a difference could be significant with $n = 15$.

Five studies have manipulated the diet of overweight or obese individuals, with partial blinding. Three found that the CHO content made no difference to weight loss (Brinkworth et al., 2004; Poppitt et al., 2002; Surwitt et al., 1995). Two found that high-starch diets led to weight loss, but high-sucrose diets led to slight weight gain (Raben et al., 1997; Raben, Vasilaras, Moller, & Astrup, 2002).

To sum up, from previous research, it is not possible to be confident as to whether or not sugary soft drinks directly affect diet and weight gain. Not all studies find weight gain (or reduced weight loss) to be related to sugary soft drink intake. Few studies that find such effects are sufficiently controlled to rule out the existence of underlying confounding variables that cause both self-reported sugary soft drink intake and weight gain.

There are also unresolved questions about whether or not overweight or obese subjects respond differently. Most experimental studies use normal weight participants, partly for ethical reasons. Most studies using overweight or obese participations have involved dietary interventions aimed at weight loss.

There are theoretical reasons that suggest that sugary soft drinks may lead to different responses in overweight or obese people compared to normal weight people. These include (a) that their voluntary diets are different. For example, normal weight women in Reid et al. (2007) obtained only approximately 19% of their energy from fat, well below the national mean. (b) Overweight and obese people include those whose dietary intake and weight fluctuates and who may alternate bouts of dietary restraint with bouts of overeating (Brownell & Rodin, 1994). (c) Overweight and obese people may include people whose food intake is more influenced by cognitive and emotional factors than by physiological satiety mechanisms (Van Strein, Herman, & Verheijden, 2009). (d) Depending upon which findings one focuses upon, overweight and obese people may, or may not, tend to consume more non-intrinsic sugars than normal weight people.

Should this latter difference exist, then it could affect overweight or obese peoples' sensitivity to sugar deliberately added to the diet. Sensitivity could increase if sugar kindles craving for more sugar, as in carbohydrate craving obesity (Spring et al., 2008), or it could decrease, if the added sugar represents a trifling amount relative to their habitual intake and they exhibit some form of tolerance.

Thus, the aim of the present study was to determine the long-term effects of supplementary sucrose in overweight women (BMI 25–30) on dietary intake and mood, using a replication of Reid et al. (2007). One feature of that study was the use of an ecologically relevant amount of sucrose (1800 kJ in four drinks; approximately 23% of mean daily energy intake at baseline). Because that study did not find substantial adverse effects of this quantity of sucrose, it was deemed ethical to replicate it with overweight women, who may or may not respond differently. Reid et al. (2007) emphasise the importance of administering sucrose blind, with a between-subjects control group. Under those conditions, potential cognitive influences on food choice, such as expectancy effects, are substantially reduced. This should apply to overweight women as much as to normal weight women. Consequently, it was hypothesised that overweight women after four weeks of sucrose sweetened soft drinks added to the diet, compared to controls receiving artificially sweetened drinks will:

1. Not gain significant weight.
2. Compensate for the energy added to the diet by reducing voluntary energy intake, which will involve reductions in voluntary carbohydrate, fat, and protein intake.
3. Not selectively increase carbohydrate intake.
4. Not show significant changes in their rated mood that endure over the four weeks, but may possibly show changes in mood over the first week of the study.

Reid et al. (2007) included an expectancy manipulation in the experimental design by labelling drink bottles as containing sugar or artificial sweetener, counterbalanced with their true contents, and supplementing this with appropriate written and verbal instructions. This manipulation was repeated here, but, as in Reid et al. (2007), it had no effect on the results and is not shown in the design, or reported here.

Research design and methods

Design

This was a 5 week study including one week of baseline data (week 0) followed by 4 weeks of supplementary drinks containing either sucrose or aspartame (weeks 1–4). Data from weeks 0, 1 and 4 were compared. A target sample size of 60 (15 per cell) was chosen to produce a 90% chance of detecting an effect of 0.75 at $p < 0.001$, or of detecting an effect of 0.5 at $p < 0.05$.

The design was 2 between-subjects by 3 repeated measures design with 53 subjects (sucrose ($n = 24$) vs aspartame ($n = 29$) by week 0, 1 and 4), using as a covariate baseline mean percentage energy from starch (as the aspartame group tended to consume slightly more starch and less sugar than then sucrose group).