Tea Expert Newsletter

Issue six

Scientific update on sugar, sweeteners and weight management

Scientific Update on Sugar, Sweeteners and Weight Management

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"From the editor"

Over the past five issues we have considered the emerging scientific evidence relating to tea and its role in hydration, the evidence surrounding its proposed cardiovascular and blood pressure lowering effects and the science on tea and attention. We also reported on a symposium conducted at the International Conference on Polyphenols and Health in 2011. In addition to being consumed as a leaf tea beverage, tea is often incorporated into other beverage formats to include Ready to Drink iced tea and Iced tea powder mixes. These additional formats maybe sweetened with sugar or non-caloric sweeteners. In this issue we have therefore chosen to review new scientific findings associated with sugars and sweeteners in the context of weight management.

Contents

1. Introduction

Relationships of sweetness and sugars with obesity are embedded in everyday beliefs and anecdote, and have provided the starting point for a long history of scientific study. Yet, despite the media headlines, the evidence base is far from straightforward. Wrapped up in the topic are questions related to effects of sweetness itself, liquid versus solid sources of energy, specific sugars or non-caloric alternatives, and the influence of each of these on appetite control and energy metabolism. Unfortunately, the answers to these can be wildly different, depending on the methods and interpretations applied by different research groups, and have led to questions about the role of bias and overall quality of evidence evaluation and reporting in nutrition[1,2].

While debates about the science and public policy options continue, there is a clear consensus for reductions in consumption of added sugars, coming from wide range of global and national public health bodies. Professional organizations such as the Academy of Nutrition & Dietetics, the Canadian Diabetes Association, the American Diabetes Association and American Heart Association are furthermore supportive of the use of non-caloric sweeteners as part of dietary strategies to help in reducing sugar and energy intakes[3-5]. In Unilever, this guidance has been applied in deriving standards for assessing and improving the nutritional quality of our products[6], setting targets for the reduction of energy and added sugars in the Unilever Sustainable Living Plan (www.unilever.com/ sustainable-living/ nutrition-health/making-our-products-healthier/ reducing-sugar-and-calories), and evaluating approaches to achieve these.

To provide readers of this newsletter with a flavour of the current scientific issues in this area, we present and discuss 5 recent papers relating to the impacts of sugars and non-caloric sweeteners on body weight and metabolism, including recent systematic reviews and meta-analyses.

2. Sugars, sweeteners and weight management: Recent developments

2.1 CALORIC SWEETENED BEVERAGES AND BODY WEIGHT

Mattes RD, Shikany JM, Kaiser KA, Allison DB.
Nutritively sweetened beverage consumption and body weight: a systematic review and meta-analysis of randomized experiments. Obes Rev 2011;12(5):346-65.

ABSTRACT

Nutritively sweetened beverages (NSBs) may play a role in the obesity epidemic. We abstracted data from randomized controlled trials (RCTs) and evidence-based reviews through January 2009 concerning effects of consumption of NSBs on changes in body weight and adiposity. Studies included were those (i) conducted in humans; (ii) lasting at least 3 weeks; (iii) incorporating random assignment of subjects to conditions that differed only in the consumption of NSBs and (iv) including an adiposity indicator as an outcome. Twelve studies met the inclusion criteria. Meta-analysis of six studies that added NSBs to persons' diets showed dose-dependent increases in weight. Contrarily, meta-analysis of studies that attempted to reduce NSB consumption consistently showed no effect on body mass index (BMI) when all subjects were considered. Meta-analysis of studies providing access to results separately for subjects overweight at baseline showed a significant effect of a roughly 0.35 standard deviations lesser BMI change (i.e. more weight loss or less weight gain) relative to controls. The current evidence does not demonstrate conclusively that NSB consumption has uniquely contributed to obesity or that reducing NSB consumption will reduce BMI levels in general. We recommend an adequately powered RCT with overweight persons, for whom there is suggestive evidence of an effect.

SUMMARY:

In this systematic review and meta-analysis, Mattes *et al.*[7] attempt to quantify the evidence for 2 key propositions: (i) the consumption of nutritively sweetened beverages (NSBs) contributes significantly to the development and maintenance of overweight and obesity and (ii) reducing the consumption of NSBs will lead to weight loss or less weight gain'. Their definition of NSBs included beverages with (added) caloric sweeteners, thus for example regular soft drinks, fruit punches (squashes) and chocolate milks, but excluding diet soft drinks, pure fruit juice, regular milk, etc. Key differences from previous meta-analyses were use of data only from controlled intervention trials (no observational studies), and a clear split in analyses between designs testing the 2 different propositions (effect of inclusion versus reduction in NSBs). From over 400 eligible studies, 10 were suitable for use in meta-analyses, and the authors provide a clear explanation for the exclusion of other studies.

In the meta-analysis for testing the effect of a required inclusion of NSBs in the diet, data from 5 cohorts (4 studies) generated a clear dose-response relationship: each additional intake of 250 kcal/day from NSBs was associated with an estimated mean 0.2 kg weight gain over 3-12 weeks. In contrast, data from 6 cohorts (5 studies) testing effects of reductions in NSB intakes, are consistent in indicating minimal or no effect on weight change overall, though a possible beneficial effect on weight from analyses of 3 overweight/obese cohort subgroups is observed.

The authors conclude that the data suggest (but do not confirm) that reductions in NSB consumption may be effective for weight reduction, especially for overweight individuals. However, they also point out that very few studies have been designed in a way that would provide unambiguous answers, because they do not allow for separation of effects of sweetness, energy source and format (liquid versus solid). Furthermore, the literature does not always provide for a clear distinction and interpretation on efficacy (impact attainable from a rigidly prescribed and adhered intervention) versus effectiveness (impact observed in realistic settings).

Lastly, the authors suggest that further observational studies on this topic would be of little value, and that the causal impact of NSB reduction and related mechanisms should be studied in well-designed efficacy trials.

INTERPRETATION:

Mattes *et al.*[7] conclude that the evidence for a unique contribution of nutritively sweetened beverage consumption or its reduction to weight change is inconclusive. Systematic reviews and meta-analyses such as this are increasingly seen as providing the best quality and most objective representation of evidence. Yet this paper closely followed 2 other meta-analyses on the same topic, which came to opposing conclusions: Vartanian *et al.*[8] reported that soft drink intake was positively associated with energy intake and body weight, whilst Forshee *et al.*[9] concluded associations with body mass index (BMI, kg/m^2) were near zero. There are also other examples of systematic reviews of a similar topic and timeframe drawing conflicting conclusions[10]. Thus, the interpretation of such analyses is highly dependent on the specificity and relevance of the hypotheses, appropriateness of the study inclusion criteria, and validity of measures of exposures and outcomes.

Given the very large number of reviews on the topic, why does the Mattes *et al.* paper merit attention and credibility? It is the methodology that makes this paper stand out. Shortly after its publication, Weed *et al.*[2] assessed several recent reviews on this topic and were highly critical of much of this literature. They concluded that, without clear *a priori* methodology for the selection and evaluation of the evidence, such reviews "may be little more than personal subjective opinions…". By their criteria, Mattes *et al.* is one of the reviews judged to be of the highest relative quality.

Mattes *et al.* applied a very logical set of criteria to the selection of studies, and carefully explain why other potentially important data sets were excluded. A key difference from previous meta-analyses is that they restricted themselves to intervention trials, and split analyses between effects of added versus reduced consumption. Furthermore, they used a method that allows for differing outcome measures to be entered into the same analyses. Nevertheless, in most systematic reviews, the choices for study inclusion criteria are ultimately subjective[11], and often very conservatively and rigidly applied. Thus, studies which others might see as highly relevant and informative are not considered. Lastly, especially where the analysis is based on a very limited number or size of studies, there is a greater chance that large new studies could substantially change the picture.

This and other reviews illustrate how drawing conclusions about this widely-discussed diet-health relationship may be more complex than expected, and highly dependent on detailed aspects of the approach taken to select and evaluate the evidence base.

2.2

2.2 INTENSE SWEETENERS, ACUTE SATIETY AND ENERGY INTAKE

Anton SD, Martin CK, Han H, Coulon S, Cefalu WT, Geiselman P, Williamson DA. Effects of stevia, aspartame, and sucrose on food intake, satiety, and postprandial glucose and insulin levels. Appetite 2010;55(1):37-43.

ABSTRACT

Consumption of sugar-sweetened beverages may be one of the dietary causes of metabolic disorders, such as obesity. Therefore, substituting sugar with low calorie sweeteners may be an efficacious weight management strategy. We tested the effect of preloads containing stevia, aspartame, or sucrose on food intake, satiety, and postprandial glucose and insulin levels. Design: 19 healthy lean (BMI=20.0-24.9) and 12 obese (BMI=30.0-39.9) individuals 18-50 years old completed three separate food test days during which they received preloads containing stevia (290kcal), aspartame (290kcal), or sucrose (493kcal) before the lunch and dinner meal. The preload order was balanced, and food intake (kcal) was directly calculated. Hunger and satiety levels were reported before and after meals, and every hour throughout the afternoon. Participants provided blood samples immediately before and 20min after the lunch preload. Despite the caloric difference in preloads (290kcal vs. 493kcal), participants did not compensate by eating more at their lunch and dinner meals when they consumed stevia and aspartame versus sucrose in preloads (mean differences in food intake over entire day between sucrose and stevia=301kcal, p<.01; aspartame=330kcal, p<.01). Self-reported hunger and satiety levels did not differ by condition. Stevia preloads significantly reduced postprandial glucose levels compared to sucrose preloads (p<.01), and postprandial insulin levels compared to both aspartame and sucrose preloads (p<.05). When consuming stevia and aspartame preloads, participants did not compensate by eating more at either their lunch or dinner meal and reported similar levels of satiety compared to when they consumed the higher calorie sucrose preload.

SUMMARY:

This paper focuses on a comparison of the short-term behavioural and physiological impacts of sucrose and 2 intense sweeteners (stevia and aspartame) within pre-meal 'preloads', consumed 20 min prior to self-selected *ad libitum* buffet lunch and dinner meals. The results with regard to voluntary food intake are clear and consistent: energy intakes at the test meals were similar in all conditions, so total energy intakes over the day differed by amounts equal to the differences in energy contents of the sucrose and intense sweetener preloads. In other words, there was no evidence of compensation within meals, for the lower energy content of the intensely-sweetened preloads. Furthermore, there were no differences in self-reported satiety, despite these differences in energy intakes. Plasma glucose and insulin responses showed (as would be expected) a greater immediate rise from the sucrose preload, whereas post-lunch values for glucose and insulin were fairly similar and stable for all conditions. However, both insulin and glucose responses were lowest for the stevia preloads.

Overall, the results are consistent with an acute reduction in energy intake and a smaller glycaemic impact of intense sweeteners relative to sucrose.

INTERPRETATION

Although stevia has long been known as an intense (non-caloric), nature-derived sweetener, it has only recently gained widespread regulatory approval and commercialization. Stevia has attractive technical and consumer attributes, and its use in manufactured food and tabletop applications is rapidly increasing. While it has a smaller record of use in human studies than other established sweeteners (e.g. saccharin, aspartame), there is little reason to expect that it would have differing effects on eating behaviour or metabolic responses, and this is largely confirmed in the work of Anton *et al.*[12].

There is an immense literature of human studies on the effects of non-caloric sweeteners versus sucrose or other caloric sweeteners on satiety, energy intake and energy balance. Recent position statements and expert reviews and meta-analyses of the human clinical data[3-5,13-17] typically conclude that use of intense sweeteners, particularly in beverages, can be used to reduce the risk of excessive energy intake. However, they also indicate that the supporting evidence base is imperfect, and effects are likely to be dependent on how consumers use these products. Furthermore, epidemiological and animal data have generated hypotheses that use of non-caloric sweeteners could cause weight gain[18]. Nevertheless, in every longer-term intervention trial, in both children and adults, the use of non-caloric in place of caloric sweeteners has consistently led to either no change or a reduction in energy intake and body weight[19-21].

The immediate impact of using non-caloric in place of caloric sweeteners has been tested many times in studies of acute effects on eating motivations (hunger, satiety, etc) and food intake under controlled conditions. The design used by Anton *et al.* for assessing these is a form of preload-test meal paradigm commonly used in appetite research[22]. Notable features of this particular study were the high energy content of the preloads, and the very short time (20 min) between the preload and test meals.

In common with many other studies, Anton *et al.* found that preloads of similar weights or volumes produced similar changes in immediate self-reported satiety, despite differences in energy content. In general, eating motivations such as self-reported hunger and satiety are most immediately responsive to sensory (visual, flavour, etc) and volume differences (size, weight) of test foods. Effects of preload energy contents or sustained bulking effects tend affect eating motivations somewhat later, e.g. around 1-4 hours after eating.

However, in contrast to the results of Anton *et al.*, most acute studies of food intake report partial or complete compensation for energy differences between effects of non-caloric and calorically-sweetened preloads. This has been repeatedly shown in different food and beverage formats, with different intense sweeteners, and in children and adults[23-32]. Futhermore, differences in preload energy content tend to have the clearest impact on food intake when (as in Anton *et al.*) consumed shortly before or with a meal[33-35]. It is possible that the unusually high energy content of the preloads used by Anton *et al.* obscured accurate sensing of energy differences between treatments, suggesting that energy reduction may be more effective (less likely to be compensated) in the context of higher- rather than lower-energy foods and beverages.

Anton *et al.* also report a greatly reduced impact of a preload containing non-nutritive sweeteners versus sucrose on glucose and insulin responses. There has been substantial recent *in vitro* and animal research related to possible physiological effects of gut sensing of nutrients and gustatory (mainly sweet or bitter) stimuli; yet intense sweeteners appear to be generally weak stimuli for gut sensing in humans[36-38]. This conclusion is supported by the large number of studies reporting only limited effects of various non-caloric sweeteners on glycaemic and insulinaemic (and gut hormone) responses[27,30-32,39-41].

Overall this study indicates that behavioural and metabolic responses to stevia are largely in line with other well-known sweeteners. The lack of any caloric compensation at all for the lower energy content of the non-calorically sweetened preloads in this study is unusual, but may relate to the specific nature of the study design and product compositions.

2.3

2.3 SUGAR-FREE AND SUGAR-SWEETENED BEVERAGES AND CHILDREN

de Ruyter JC, Olthof MR, Seidell JC, Katan MB.
A trial of sugar-free or sugar-sweetened beverages and body weight in children.
N Engl J Med 2012;367(15):1397-1406.

ABSTRACT

BACKGROUND The consumption of beverages that contain sugar is associated with overweight, possibly because liquid sugars do not lead to a sense of satiety, so the consumption of other foods is not reduced. However, data are lacking to show that the replacement of sugar-containing beverages with noncaloric beverages diminishes weight gain.

METHODS We conducted an 18-month trial involving 641 primarily normal-weight children from 4 years 10 months to 11 years 11 months of age. Participants were randomly assigned to receive 250 ml (8 oz) per day of a sugar-free, artificially sweetened beverage (sugar-free group) or a similar sugar-containing beverage that provided 104 kcal (sugar group). Beverages were distributed through schools. At 18 months, 26% of the children had stopped consuming the beverages; the data from children who did not complete the study were imputed.

RESULTS The z score for the body-mass index (BMI, the weight in kilograms divided by the square of the height in meters) increased on average by 0.02 SD units in the sugarfree group and by 0.15 SD units in the sugar group; the 95% confidence interval (CI) of the difference was −0.21 to −0.05. Weight increased by 6.35 kg in the sugar-free group as compared with 7.37 kg in the sugar group (95% CI for the difference, −1.54 to −0.48). The skinfold-thickness measurements, waist-to-height ratio, and fat mass also increased significantly less in the sugar-free group. Adverse events were minor. When we combined measurements at 18 months in 136 children who had discontinued the study with those in 477 children who completed the study, the BMI z score increased by 0.06 SD units in the sugar-free group and by 0.12 SD units in the sugar group (P = 0.06).

CONCLUSIONS Masked replacement of sugar-containing beverages with noncaloric beverages reduced weight gain and fat accumulation in normal-weight children.

SUMMARY

de Ruyter *et al*. have carried out a large and fairly realistic 18-month intervention trial, giving either a sugar-sweetened beverage (SSB, 104 kcal) or a non-caloric alternative to habitual SSB-consuming children aged 4-11. Extensive efforts were made to ensure the unmarked 250 ml portions of drinks were matched for sensory attributes and acceptability, and not recognized as caloric or non-caloric by the recipients. Compliance and completion rates were additionally very well-documented and high.

The key results of this relatively simple but well-executed invervention were consistent on all the primary and secondary endpoints related to weight and body composition. These clearly indicate relatively greater increases in body weight, BMI and fatness in the SSB group, with about a 1 kg greater body weight gain over the 18 months.

The authors interpret their results as indicative of excess weight gain being caused by SSBs, which was prevented by the use of non-caloric sweetened alternatives (rather than a direct effect of the latter causing slowing of normal weight gain). They speculate on the possible reasons why SSB use might cause excess weight and fat gains, and suggest that water or other non-caloric beverages (e.g., unsweetened tea) would likely be as effective as the sweetened alternative used here.

INTERPRETATION

The method, exposure and outcome measures used by de Ruyter *et al.*[21] were straightforward, and have similarities with many other interventions using non-caloric in place of caloric sweetened beverages. However, the study size, duration and quality, the use of a 'vulnerable' group, and clarity of the outcomes make this stand out, as a particularly important and convincing contribution to the literature.

At the same time as this study was published, data from a similar trial were also reported. Ebbeling *et al.*[20] followed a smaller population of SSB-consuming teenagers (mean age 15 years) for 2 years: A 1-year intervention in which the experimental group was counselled to consume home-delivered water or non-caloric sweetened beverages in place of SSB, and then a 1-year non-intervention follow-up. Consistent with de Ruyter *et al.*, the experimental group had significantly lower gains of BMI at the end of the 1 year intervention period. However, after 2 years (the primary endpoint) there were no statistically significant differences bwetween the groups. Unlike de Ruyter *et al.*, subjects were not blinded to the beverage alternatives, and were especially encouraged to consume water rather than non-calorically sweetened drinks. In a pilot to that study, Ebbeling *et al.*[42] reported that providing teenagers with non-caloric alternatives to SSB over 25 weeks had no effect on mean (total group) BMI, but a benefit was apparent in subjects with a higher BMI at baseline.

de Ruyter *et al.* note that their data do not support various hypotheses suggesting intense sweeteners might induce weight gain. They cite as an example observational data showing that consumption of 'diet' drinks has been associated with weight gain[43]. However, there are also other epidemiological data showing that increased (versus decreased) use of these products is associated with lower weight gain over time[44].

Lastly, the authors acknowledge that their results (in Dutch children) may be different in other populations, due to both genetic variation and differing baseline levels of SSB consumption. Nevertheless, as suggested by other papers reviewed and cited in this newsletter, the results from de Ruyter *et al.* are consistent with data from many short-, medium- and long-term human intervention studies where caloric sweetened beverages have been compared with or replaced by non-caloric alternatives.

2.4

2.4 FRUCTOSE METABOLISM

Sun SZ, Empie MW.
Fructose metabolism in humans -- what isotopic tracer studies tell us.
Nutr Metab 2012;9(1):89. doi:10.1186/1743-7075-9-89.

ABSTRACT

Fructose consumption and its implications on public health are currently under study. This work reviewed the metabolic fate of dietary fructose based on isotope tracer studies in humans. The mean oxidation rate of dietary fructose was 45.0% ± 10.7 (mean ± SD) in nonexercising subjects within 3–6 hours and 45.8% ± 7.3 in exercising subjects within 2–3 hours. When fructose was ingested together with glucose, the mean oxidation rate of the mixed sugars increased to 66.0% ± 8.2 in exercising subjects. The mean conversion rate from fructose to glucose was 41% ± 10.5 (mean ± SD) in 3–6 hours after ingestion. The conversion amount from fructose to glycogen remains to be further clarified. A small percentage of ingested fructose (<1%) appears to be directly converted to plasma TG. However, hyperlipidemic effects of larger amounts of fructose consumption are observed in studies using infused labeled acetate to quantify longer term de novo lipogenesis. While the mechanisms for the hyperlipidemic effect remain controversial, energy source shifting and lipid sparing may play a role in the effect, in addition to de novo lipogenesis. Finally, approximately a quarter of ingested fructose can be converted into lactate within a few of hours. The reviewed data provides a profile of how dietary fructose is utilized in humans.

SUMMARY:

This systematic review brings together data from 34 isotopic tracer studies of unbound (free) or bound (e.g. as part of sucrose) fructose in human adults, to quantify the metabolic fates of this sugar. Most of the studies were small (10 or fewer subjects), and they varied in relation to subject fasting status, route of fructose administration, exercise regimens, co-ingestion with glucose or with other nutrient infusions, as well as dose levels and administration method (single or multiple).

Although studies yield substantial variability in estimates, taken together these data indicate that within 3-6 hours of intake, around 25 and 50% of fructose is initially converted to lactate and glucose respectively, and (via these and other routes) about 50% or more is oxidized. The amount oxidized appears to be somewhat higher (50-70%) when fructose is co-ingested with glucose. While evidence suggests that significant amounts of fructose may be converted to glycogen, no tracer studies have quantified this in humans. Lastly, there are very limited data on conversion of fructose to lipids, and the authors emphasize that evaluating the impact of fructose metabolism on *de novo* lipogenesis is difficult in terms of both methodology and interpretation. Although it appears that <1% of fructose may be converted to lipids, fructose metabolism may also promote lipogenesis from other substrates, and this could potentially contribute toward increased hepatic lipid storage or very low density lipoprotein production.

INTERPRETATION:

This review by Sun & Empie[45] comes in the midst of a furore over fructose, fueled by a diversity of opinions. Depending on the intepretation of the evidence, either "…policies to eliminate or limit fructose in the diet should be considered premature"[46] or fructose has '…metabolic, hedonic and societal parallels with ethanol'[47]. It is therefore useful to take a step back and consider what happens to the fructose we ingest, and the factors that may affect this and assessments of its risks.

2.4

The estimates for metabolic disposal pathways of fructose reported by Sun & Empie are consistent with estimates from other sources. Tappy & Lê[48] furthermore refer to evidence that fructose stimulates hepatic glycogenesis more than glucose, and (based on data from glucose) presume that >15% of consumed fructose would usually appear as glycogen in the post-prandial period.

Regardless of the analysis, however, the greatest amount of attention tends to be focused on the quantitatively smallest route of fructose diposal: lipogenesis. It is generally stated that at most perhaps 1-3% of fructose is used as a substrate for lipid synthesis[45,48,49]. Yet, putative lipid-related effects are the main health issues mentioned in relation to fructose: obesity, dyslipidemia, and ectopic fat deposition including hepatic steatosis leading to insulin resistance[47,49-52].

There are several reasons why fructose might be implicated in lipid-related pathologies, despite very low estimates of transformation into lipid. Stanhope[51] and Lustig[47] for example argue that test conditions and duration of measurements may tend to underestimate the actual level of *de novo* lipogenesis in humans, particularly in some sub-groups such as obese individuals with insulin resistance. Furthermore, these authors and others[50] note that – even if absolute levels of lipid formation are low – there is evidence and proposed mechanisms implicating fructose specifically in deposition of fat in sensitive ectopic (hepatic and intramuscular) and abdominal sites, that are linked to the development of metabolic risk.

A key point of debate centres on the amounts of fructose that might trigger these effects. There seems to be general agreement that detrimental effects of fructose are only likely at intakes exceeding 50 g/d, and perhaps 80-100 g/d for some outcomes. This is supported by systematic reviews and meta-analyses that have specifically considered dose-relevance[53-55]. Several authors have argued that deleterious effects are not likely at all under normal conditions and levels of consumption[48,53,56,57]. Dolan *et al.*[54], for example, concluded there was no evidence that fructose causes biologically relevant changes in lipids or body weight at levels <95th percentile intakes (≈135 g/d in USA). Indeed, Rizkalla[56] and Sievenpiper *et al.*[58] even propose metabolic benefits of low and moderate fructose intakes. Against this, however, it is argued that many population subgroups may be regularly exposed to fructose at levels well above 50 g/d and/or may be particularly susceptible to its effects[47,59].

A final point to consider is the actual way fructose appears in the diet. Sun & Empie note that post-prandial rates of fructose oxidation appears to be higher when it is co-ingested with glucose (as sucrose or separate monsaccharides). The fructose moiety itself typically accounts for about 40% of total sugars intakes, and is overwhelming found and consumed in foods together with glucose at ratio around 1:1[60-62]. Therefore, a somewhat distorted view of fructose metabolism and its impacts may be derived from study conditions that do not reflect this reality (ie where high amounts of fructose alone have been given). In addition, most interventions and a large part of the epidemiological (and intake) data relate to fructose consumed in simple beverage form. A different picture may emerge for other, more complex food formats, where the interactions with other dietary constituents and rates of uptake would be different.

2.5

2.5 WATER INTAKE

Daniels MC, Popkin BM.
Impact of water intake on energy intake and weight status: a systematic review.
Nutr Rev 2010;68(9):505-21.

ABSTRACT

The effects of consuming water with meals rather than drinking no beverage or various other beverages remain under-studied. This systematic review of studies reported in the English-language literature was performed to compare the effects of drinking water and various beverage alternatives on energy intake and/or weight status. Relevant clinical trials, epidemiologic studies, and intervention studies were identified and findings across the literature were summarized. From the clinical trials, average differences were calculated in total energy intake at test meals (DeltaTEI) for each of several beverage categories in comparison with water. The available literature for these comparisons is sparse and somewhat inconclusive. However, one of the most consistent sets of findings was related to adults drinking sugar-sweetened beverages (SSBs) versus water before a single meal. In these comparisons, total energy intakes were 7.8% higher (DeltaTEI range, -7.5 to 18.9) when SSBs were consumed. Studies comparing non-nutritive sweeteners with water were also relatively consistent and found no impact on energy intake among adults (DeltaTEI, -1.3; range, -9 to 13.8). Much less conclusive evidence was found in studies replacing water with milk and juice, with estimated increases in TEI of 14.9% (range, 10.9 to 23.9%). These findings from clinical trials, along with those from epidemiologic and intervention studies, suggest water has a potentially important role to play in reducing energy intake, and consequently in obesity prevention. A need for randomized-controlled trials to confirm this role exists.

SUMMARY:

Although the title of this paper emphasizes effects of water intake on food intake, this systematic review and meta-analysis specifically considers the effects not only of water alone but also water relative to other beverages: (added) sugar-sweetened, non-nutritively sweetened, and milk or juices. The meta-analyses are comprised of a large number of short-term intervention studies in which water or alternative beverages have been consumed as a 'preload', and subsquent food intake measured in test meals or over some prescribed time period. To allow contrast with other conditions, for the analysis of water alone, results are reported as the effect of water removal. The meta-analyses of these intervention trials indicates:

- Absence of water slightly reduced energy intake (-3.1%) in young and middle-aged adults (4 studies, 9 comparisons), but increased energy intake by an average of 8.7% in older adults (3 studies, 4 comparisons)
- Replacement of water by beverages with added sugars (sucrose or high fructose corn syrup) increased mean intakes by 3.1% in children (1 study, 6 comparisons) and 7.8% in adults (11 studies, 19 comparisons).
- Replacement of water by non-caloric sweetened beverages (11 studies, 15 conditions) led to essentially no change (-1.3%) in average energy intakes in adults (10 studies, 19 conditions) and a 6.7% reduction in children (1 study, 6 conditions).
- Lastly, replacement of water by milk (3 studies, 4 comparisons) or juice (2 studies, 4 comparisons) produced an average 14.9% increase in energy intake.

The authors also reviewed 4 epidemiological studies of water and energy intake. These had differing populations and designs, and yielded variable results. In general, consumption of water versus other caloric beverages was associated with reduced energy intakes. An additional 2 studies that considered water and weight status in adults indicated associations of water intake with successful weight maintenance and loss; however, no associations were observed in children.

Lastly, they reviewed 4 longer-term intervention studies of water and weight status. In 2 studies with adults, advice to drink water before meals within weight loss programmes led to modestly increased loss of weight or fat, though effects were not consistently significant for all measures. In a further 2 studies with children, multi-component interventions that included increased water intake were associated with reduced risk of weight gain.

The authors conclude that there are many gaps in the literature. Nevertheless, the available evidence tends to converge on a view that drinking water versus caloric beverages would contribute toward a lower energy intake. Differences between water and non-caloric sweetened beverages were negligible. While the data are seen as favourable for promoting water consumption as an aid to controlling energy intake, it is recognized that the putative benefits would need to be confirmed in stronger, longer interventions.

INTERPRETATION

This analysis from Daniels & Popkin[63] highlights the remarkable paucity of studies that have explicitly considered how water consumption might affect energy intake and weight status. The epidemiology is particlarly limited, in part because - unlike other beverages - consumption of plain water simply is not captured in many assessments of dietary intake. Although health and weight control guidance very often stress the importance for a sustained high daily water intake, the need and empirical basis for such recommendations is surprisingly limited[64].

The analyses also strongly suggest that non-caloric sweetened ('diet') drinks differ little from water in their impact on energy intakes. Although this seems hardly surprising, one might also interpret from this that there is little effect of the sweetness *per se* in beverages on (subsequent) energy intakes, a point which has often been debated but is supported by another comprehensive review[19]. A further question, not addressed in the paper, is whether water as a beverage affects appetite differently from water incorporated into food. This seems to be very clearly true, at least in acute (single meal) situations[65,66]. In these studies, water addded into food significantly reduced appetite motivations and food intake relative to the same water taken as a beverage with the meal.

Subsequent to the publication of this analysis, Tate *et al.*[67] reported that 6 months substitution of water or non-caloric sweetened ('diet') beverages for caloric beverages, as a single dietary strategy, led to similarly modest weight losses. However, they also observed better adherence and achievement of a 5% weight loss with 'diet' beverages, leading the authors to suggest that it may be easier for some consumers of sweetened caloric beverages to switch to 'diet' alternatives than to water.

Daniels & Popkin generally provide a compelling argument that use of non-caloric in place of caloric beverages is generally likely to be beneficial in weight management. This view has widespread support in the weight management expert community, and there is no evidence of this guidance leading to poorer weight outcomes. Nevertheless, most of the data are from short-term studies. Longer-term trials are also supportive, but it is not possible to state with certainty the conditions and timeframes where evidence of this benefit is reliably found and sustained. Consistent with this, the European Food Safety Authority (EFSA) has issued a negative opinion on claims for weight management being based on food products only being low or reduced in energy, referring to a lack of direct, long-term evidence for defined compositions and usage patterns[68].

Overall, the Daniels & Popkin paper presents a good example of a research question that seems like it should deliver an 'obvious' and unambiguous answer. Yet, by strict standards of evidence, further confirmatory data are needed to narrow down the generally-observed results to specific consumer and usage situations where weight management benefits of consuming water or other non-caloric beverages are reliably assured.

3. Concluding remarks

FROM THIS OVERVIEW OF THE RECENT SCIENCE, SEVERAL KEY MESSAGES EMERGE:

- Whilst consumption of sugar-sweetened beverages is often suggested to have a unique contributory role in weight gain and obesity, there is not fully conclusive evidence of this, nor that reduced consumption will reduce overweight.
- Use of non-caloric in place of caloric sweeteners leads to either no change or relative reductions in energy intake and body weight in human interventions. This evidence is consistent across short-, medium- and long-term trials, using different sweeteners, different foods and beverages, and in children and adults.
- There is a high level of debate about the role of fructose consumption (in all forms, including as part of sucrose) as a cause of metabolic diseases. There is general agreement that negative effects are likely at very high intake levels (at least 50 and perhaps >80-100 g/d). The conditions of controlled clinical trials may exaggerate the negative effects of fructose relative to realistic consumption conditions; however, these studies are also methodologically challenging in terms of both design and outcomes.
- There is limited evidence for an impact of water consumption on weight management. The effect of drinking water as an alternative to caloric beverages appears to be similar to the effects of 'diet' (non-calorically sweetened) beverages.

Overall, the literature is consistent with a view that, at least as precautionary step, replacement or reduction in energy from added sugars is prudent dietary advice. The use of intense sweeteners as an alternative may help reduce risks of excessive energy intake, and produces relatively small metabolic and hormonal responses.

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6. Notes

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