Do sugary drinks contribute to obesity in children?

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1 Executive Summary

1.1 Background

The issue of childhood obesity is receiving widespread attention both locally and overseas. Thirty percent of New Zealand children aged 5−14 years are considered overweight or obese[1], using the criteria of Cole et al[2], and these figures are broadly comparable to those of other Western nations[3,4]. The contribution that beverages high in sugar (whether natural or added) may play in promoting excessive weight gain in children is of considerable interest. The aim of this report is to evaluate the current scientific literature on the impact of sugar-containing beverages − including the effects of individual beverage types (eg, soft drinks versus fruit juices) − on body weight in children. The literature concerning the mechanisms of how sugary drinks may contribute to weight gain was also evaluated.

1.2 Methods

Databases of scientific publications and relevant websites from January 1998 to February 2005 were searched. Only English-language references and human studies were included in the review. Considerable attention was paid to study design, with longitudinal studies with appropriate sample sizes and adjustment for confounders considered “stronger” evidence than smaller studies or cross-sectional studies. A meta-analysis was not undertaken because the studies were not comparable (Appendix).

1.3 Studies reviewed

Intervention studies are considered to provide the strongest evidence of causation. However, only one intervention has directly investigated the potential of reducing soft-drink intake on weight gain in children[5]. A limited health education intervention resulted in a significant difference in obesity prevalence at the end of an intervention compared with control subjects.

Numerous studies have been published examining the potential contribution of sugar-sweetened beverages to weight gain in children. Out of 11 cross-sectional studies identified, seven reported a positive association between sugary drinks and obesity and four found no association, while there were no reports of a negative association. Data from the national Children’s Nutrition Survey show a positive association between the frequency of intake of sugary drinks and obesity in one[6], but not both[7], of the analyses. Out of five longitudinal studies identified, four (including the ground-breaking study of Ludwig et al[8]) found a positive association between sugary drinks and obesity, and one found no association. Overall, there is extensive evidence that sugary drinks contribute to weight gain in children. Both baseline intake and changes in the intakes of these drinks are associated with an increased risk of weight gain in both children and adolescents[8-11].

1.4 Studies investigating fruit juice

Whether fruit juices *per se* also play a role in promoting obesity in children is unclear and the evidence is somewhat conflicting: studies have reported no relationship[12-14], an increased risk of obesity[11], a decrease in risk[13], or both[15]. No reports specifically examined the potential for other beverages containing large amounts of sugar and thus energy (energy drinks, sports drinks and flavoured milk) to contribute to weight gain in children. Although these drinks are generally consumed less frequently by New

Zealand children compared with soft drinks, juices and fruit drinks[1], their high sugar content would suggest that excess consumption could be a risk factor for obesity. The bulk of the research in this area has concentrated on the potential impact of soft drinks in particular, followed by fruit juices and fruit drinks. With respect to other beverages high in sugar, the absence of evidence should not be confused with the evidence of absence (of an effect).

1.5 Possible mechanisms

It is unclear whether the mechanism of action concerns a decrease in the satiety induced by sugary beverages compared with solid foods or mixed nutrient beverages, or whether a high intake of sweetened beverages is simply a marker for a less healthy lifestyle that promotes inappropriate weight gain. It is possible that there is an age-related difference in the relationship between weight and beverage intake given the weaker (and more inconsistent) results in younger children. Several reasons for this potential difference have been put forward, including the observation that youngsters have better energy compensation than older children and adults[16-18]. Instead, adolescents may add a drink to their meal rather than consuming less of a meal if a sweet beverage is available[19]. Younger children also consume less sweet beverages and particularly soft drinks, than older children and more of it is fruit juice.

1.6 Recommendations

Given that the majority of studies report a positive association between sugary drinks and obesity, it is advisable to advocate limiting the intake of all high-sugar drinks, whether high in natural or added sugars. It may be that fruit juice is less obesogenic than other beverages with added sugars, although some caution should still be applied. The recent advent of flavoured waters has provided a lower sugar (and calorie) alternative in the marketplace. However, it is undesirable for children to develop a taste for always having their drinks flavoured (and thus sweet). Also, because many of the serving sizes of sugar-containing beverages sold today are large, it is feasible that even these lower-sugar flavoured-water alternatives (sold as 750–800 ml bottles) could still provide significant amounts of sugar if the total serving is consumed. Although the manufacturers suggest on nutrition labels that each bottle contains more than one serve, it is unlikely that this is how they are consumed.

It is important to encourage our children to consume plain water as the beverage of choice. Promotion towards not consuming sweetened beverages on a daily basis needs to be encouraged. The recent National Children’s Nutrition Survey highlighted that few children consume plain milk as a drink on a regular basis (34% consumed plain milk at least once a week)[1]. Heightened promotion of the benefits of milk (particularly low-fat milk for those over two years of age) and water, and the potential adverse effects of beverages high in sugar, is required.

2.1 Introduction

The widespread prevalence of obesity in children[3], the rapidity of recent increases[20-22] and concern that rates are not declining[4] forecast major problems for future healthcare. The prevention of obesity in children is of utmost importance given the health consequences of obesity during growth[23] and the intractable nature of obesity in adults[24]. Considerable attention is currently being paid to this issue in New Zealand by both the scientific and the media communities, particularly in light of the recent National Children's Nutrition Survey, which reported that almost one in three New Zealand children aged 5−14 years is overweight or obese[1].

Recognising environmental influences that impact on body-weight change in children is critical for developing appropriate preventive strategies[25]. One area receiving widespread attention is the potential contribution from soft drinks and other sugar-containing beverages, given their ubiquitous presence in the food supply. In the US, enough regular soda is produced to supply every single American with almost 400 ml on a daily basis[26].

Although food supply data tend to overestimate intake, national surveys confirm that American children are drinking considerably more carbonated beverages than ever before[26]. Children in the US consume a significantly greater proportion of their daily dietary energy from soft drinks, fruit juices and fruit drinks now than they did two decades ago[27]. It is difficult to comment on whether the same situation applies in New Zealand since our first national dietary survey in children was completed only recently[1]. In this survey, half of New Zealand children reported consuming soft drinks at least once per week, with similar numbers reporting regular (at least once per week) consumption of fruit juices and fruit drinks[1]. Moreover, intakes increase substantially with age: in New Zealand weekly consumption of cola drinks increases from about 30% in 5−6-year-olds up to over 50% in 11−14-year-olds[1]; while in the US, one in two preschoolers compared with four in five adolescents consume soft drink on any given day[28].

In total, beverages (including tea, coffee and substitutes, soft drinks, juices, cordials, powdered fruit drinks, sports drinks and energy drinks) contributed 6% of the energy in the diets of New Zealand children[1]. This is somewhat lower than the most recent estimates from the NHANES (National Health and Examination Nutrition Survey) surveys in the US (1999–2001), which reported that coffee, tea, soft drinks, fruit drinks and fruit juice made up 13.5% of energy consumed by children aged 2−18 years[27].

Portion sizes of Coca-Cola in the US have increased threefold, from less than 200 ml in the 1950s to almost 600 ml in 2000[29], and the 600 ml bottle is a popular serving sold in New Zealand. Soft drink consumption increased 45% in New Zealand over only a five-year period and New Zealanders are now the 11th highest consumers of soft drink per capita worldwide[30]. The marketing budgets for these drinks are huge: Coca-Cola and Pepsi spent a combined total of almost US$200 million in 1998 in the US alone[26].

Until recently the major issues surrounding sugar-sweetened drinks concerned their potential detrimental effects on dental health and body weight. More worrying is recent longitudinal evidence that directly links high intakes of sweetened drinks − particularly soft drinks and fruit punch − with an increased risk of diabetes in adult women[31]. Researchers followed participants from the Nurses Health Study and demonstrated that the eight-year risk of developing diabetes was 83% ($p < 0.01$) higher in women consuming at least one serving per day of sugar-sweetened soft drinks compared to those who drank less than one a month. Women who drank two to six serves per week had a 49% ($p < 0.01$) increased risk of diabetes after adjusting for a variety of confounders, including age, physical activity and family history of diabetes. Further analyses showed that body mass index (BMI) accounted for approximately half the excess risk, but results remained significant even after adjusting further for energy intake[31].

What drinks affect body weight, what levels of intake are detrimental and how they affect body weight are matters of considerable interest, particularly in children. Therefore, the aim of this report is to evaluate the current scientific literature on the impact of sugar-containing beverages on body weight in children. Although soft drinks have arguably received the most attention, it was the intention of this report to evaluate the literature with respect to all sugar-containing beverages, where possible, including carbonated beverages, fruit juices, fruit drinks and other sweetened beverages.

2.2 Mean (range) energy and nutrient content of beverages per 250 ml serve widely available in New Zealand

Table 1 highlights the energy and nutrient content of a variety of energy-containing beverages widely available in the New Zealand food supply. It is apparent from these data that regular soft drink, fruit drinks, fruit juices and energy drinks contain comparable amounts of sugar and thus energy. A considerable proportion of the public may be unaware just how high the sugar content of these drinks is. For example, most adults would not consume tea or coffee with six to seven teaspoons of sugar per cup, yet that is the amount of sugar found in each of these beverages. The energy content of flavoured milk is higher due to the presence of protein and fat as well as sugars. A number of flavoured waters are now on the market, which are considerably lower in sugar and energy than most of the alternatives described above.

The table presents nutrient content per 250 ml serve so that comparisons between individual drinks can be made. However, it is also important to account for the actual portions typically sold. For example, although the sugar concentration of flavoured waters is generally less than that of other beverages, they are typically sold in 750−800 ml bottles. Thus the actual sugar content per "portion" can be up to 30 g, not dissimilar to the amounts found in a can (355 ml) of soda (36 g of sugar). As a result, the actual sugar intake from the beverages listed in the table could conceivably be higher in many instances. Accounting for portion size in managing energy balance is important, given that studies clearly show that increasing portion size is associated with increasing intake, even in very young children[32,33].

2.2.1 Caffeine content of soft drinks and energy drinks

Regular soft drinks not only have high sugar and energy content, but they also contain high levels of caffeine. For example, a 600 ml bottle of Coca-Cola consumed by a child weighing 23 kg provides a similar amount of caffeine as that found in four cups of instant coffee in a 70 kg adult[34]. Soft drinks are the single biggest contributor to caffeine intake in children aged 5–15 years[35].

Energy drinks also contain high amounts of sugar and energy, and three times as much caffeine as Coco-Cola[34]. Thus a small 250 ml can consumed by a child would be equivalent to an adult drinking five cups of instant coffee. Although energy drinks are not generally a significant source of caffeine in the diets of New Zealand children[35], they have the potential to provide caffeine in large amounts to individual children.

2.2.2 Vitamin C from fruit drinks

Many manufacturers include vitamin C in the nutrition information panel, suggesting that these drinks are promoted as sources of vitamin C. Beverages in total contribute 37% of the vitamin C intake in New Zealand children. However, fruit drinks are high-sugar options and provide a significant proportion (16%) of sucrose to the diets of New Zealand children[1](W Parnell, personal communication). Given that the average vitamin C intake is 115 mg and only 0.1% of New Zealand children have an inadequate intake, it is *unlikely* that fruit drinks are a *necessary* contributor to vitamin C intake. However, further analyses need to be completed to describe the effect on vitamin C intake of removing fruit drinks as a source of vitamin C.

Table 1: Nutrient content of New Zealand drinks containing sugar: Mean (range)

Beverage	Energy (kJ/250 ml)	Sugar (g/250 ml)	Other nutrients (/250 ml)
Regular soft drink	452 (355–530)	26 (20–31)	
Diet soft drink	7 (5–8)	0	< 1 g protein
100% fruit juice	441 (423–455)	25 (23–26)	88–100 mg vitamin C
Fruit drinks	415 (283–570)	25 (16–35)	18–188 mg vitamin C; B vitamins
Flavoured milk	729 (665–803)	23 (22–23) (includes lactose)	4–5 g fat; 8.3 g protein; 288–438 mg calcium
Energy drinks	492 (475–520)	28 (27–29)	B vitamins
Sports drinks	338 (300–375)	18 (15–21)	
Flavoured waters	129 (105–173)	7 (6–10)	50 mg vitamin C; B vitamins

Notes

Regular soft drinks included Coca-Cola, Pepsi, Budget Cola, Sprite, Fanta, Budget Raspberry, L & P and Wests Ice Cream Soda.

Diet soft drinks included Diet Coca-Cola, Pepsi Max and Diet Sprite.

100% fruit juice included Fresh-Up, Just Juice, McCoy and Charlies varieties.

Fruit drinks included Raro and Vitafresh powders (made according to packet directions), (Ribena ready to drink), Ribena, Pams Blackcurrant and Barkers Blackcurrant syrups (made to recommended strength) and E2.

Flavoured milk included Natures Energy, Primo and CalciKids.

Energy drinks included V, Redbull and Lift Plus.

Sports drinks included Powerade and Replace.

Flavoured waters included Charlies, Mizone, H_2Go, Sparkling H_2Go and Aquashot.

2.3 How does drinking sugary drinks affect nutrient intake in children?

Several studies have now examined how beverage choice impacts on nutrient intake in children, using data collected from the Continuing Survey of Food Intakes by Individuals (CSFII) 1994–96[28,36,37]. Harnack et al[28] were the first to report reduced nutrient density in the diets of children drinking large amounts of soft drink. Others[36] have reported that milk consumption was positively ($p < 0.001$) associated with the likelihood of achieving recommended intakes of vitamin A, folate, vitamin B_{12} and calcium, whereas juice consumers had good vitamin C and folate intakes ($p < 0.01$). The data of Bowman [37] would suggest that the negative impact of soda is not from the soda *per se* but from the replacement of milk in the diet. Adolescent girls who drank soda *and* milk had less nutritious diets than milk-drinking girls who did not drink soda. However, their micronutrient intakes were significantly greater than girls who did not drink milk, regardless of their soda intake, which was attributed to greater consumption of fortified breakfast cereals.

2.4 Do overweight children drink more sugary drinks? Cross-sectional analyses

2.4.1 Children who drink soft drinks have higher energy intakes than children who do not

One of the earliest reports[28] showed that children who consumed high (> 270 ml/day in preschoolers and school-aged children and 780 ml in adolescents) quantities of soft-drink consumed considerably more energy than those who did not (1071 additional kJ in preschoolers, 787 additional kJ in school-aged children and 2594 additional kJ in adolescents). Obviously such large energy differences have the potential to lead to considerable weight gain if not compensated for by increased physical activity. For example, assuming that each kilogram of body fat contains 37,000 kJ, only 14–47 days of extra energy at this level would be required to gain 1 kg of body weight. Unfortunately, the corresponding weights of children in Harnack et al[28] were not presented, due to the self-reported nature of the data, despite other investigators doing so when using this CSFII data[38,39]. Moreover, data were not adjusted for physical activity or other contributing factors; only race, age and gender.

2.4.2 Cross-sectional studies examining whether sweetened beverage intake is related to body weight in children provide mixed evidence

Eleven cross-sectional studies including the New Zealand 2002 Children's Nutrition Survey[6,7] have now investigated whether intake of sugar-containing beverages is related to body weight in children (Table 2)[38-46]. Seven have reported higher intakes of sugary drinks (including soft drinks and fruit drinks) in heavier compared with lighter children, despite differing in study design, analysis and subject characteristics[6,41,42,44,46]. For example, risk of overweight was twice as high in preschool children in the highest third of percentage energy from fruit juice[45], and similar results were observed in adolescents drinking three or more soft drinks per day[43]. Three studies have reported null associations between weight status and sugary beverages[38-40]. Bandini et al[40] observed no difference in the proportion of energy contributed by soft drinks in obese versus non-obese adolescents.

Table 2: Cross-sectional studies investigating the association between regular intake of sugary drinks and obesity in children

First author (reference)	Study sample	Dietary method	Type of beverages investigated	Measure of Obesity	Confounders adjusted for	Association between beverages and BMI
Studies reporting a positive relationship ($p < 0.05$)						
Tanasescu (41)	53 Puerto Rican boys and girls aged 7–10 years from Connecticut	24-hour recall and food frequency questionnaire	Soft drinks (including soda), fruit juice (including fruit drinks)	BMI > 85th	Maternal BMI, TV, marital status and dairy product intake	Obese children had greater intakes of fruit juice but not soft drinks.
Troiano (42)	10,371 boys and girls aged 2–19 years from representative US sample (NHANES III)	24-hour recall	14 beverage groups including soft drink, fruit juices and fruit drinks	BMI > 95th	Age, sex, energy intake	Overweight children consume a greater % of energy from soft drinks and total beverages than non-overweight children
Giammattei (43)	319 boys and girls aged 11–13 years from 3 schools in Santa Barbara county	Short questionnaire	Soft drinks (regular and diet combined)	BMI Z-score	Age, sex, ethnicity and TV	Higher BMI Z-scores in those drinking 3 or more serves per day compared with those drinking fewer than 3 serves per day.
Gillis (44)	185 Canadian children aged 4–16 years	24-hour recall and 2 days of diet records	Regular soda and sugar-sweetened beverages	BMI > 95th	None	Overweight children had a higher intake of sugar-sweetened drinks than non-overweight children.
Ariza (46)	80 Mexican-American children aged 5–6 years from 2 Chicago schools	Short questionnaire (4 beverage items)	Sweetened beverages: regular soda, Kool-aid, fruit punch, Atole	BMI > 95th	TV and mother's perception of own weight	Children with daily intake of sugar-sweetened beverages were more likely to be overweight.

Melgar-Quinonez (45)	204 low-income Mexican children aged 3−5 years	Food frequency questionnaire	Fruit juices (may include fruit drinks)	BMI > 85^{th}	Age, maternal BMI, birth weight, income and several dietary variables	Overweight children consumed a significantly higher proportion of energy from fruit juices than non-overweight children
Scragg (6)	3048 multi-ethnic New Zealand children aged 5−14 years	Food frequency questionnaire	Carbonated soft drinks	BMI	Age, sex, ethnicity, physical activity, TV and several dietary variables	Children drinking soft drinks > 1 per day had higher mean BMI than those with intakes < 1 per week (19.7 cf. 18.8 kg/m^2)
Studies reporting no relationship (p > 0.05)						
Forshee (38)	3311 multi-ethnic boys & girls aged 6−19 years from representative US (CSFII 1994–96, 98)	2 x 24-hour recalls (non-consecutive days)	Regular carbonated soft drinks, diet soft drinks, fruit drinks, fruit juices	BMI (self-reported)	Age, income, ethnicity	A positive relationship was found with diet soda, but none with regular soda, fruit drinks, non-citrus or citrus fruit juices.
Lin (39)	1651 multi-ethnic boys & girls aged 6−11 years from representative US (CSFII 1994-96)	2 x 24-hour recalls (non-consecutive days)	Carbonated soft drinks, juice drinks	BMI (self-reported)	Age, gender, ethnicity, income, TV and several dietary variables	Soft drinks and juice drinks as % of total beverages were not related to BMI.
Bandini (40)	21 obese vs 22 non-obese adolescents	14-day food records	Consumption of calories from soft drinks	Doubly labelled water	Energy intake	Obese and non-obese children consumed a similar % of energy from soft drinks.
Wilson (7)	3049 multi-ethnic New Zealand children aged 5−14 years	24-hour recall	All drinks with sugar (soft drinks, fruit juices/drinks, milk-based & hot drinks)	BMI	Age, gender, ethnicity, energy intake	Sugary drinks as % kJ were not related to BMI.

Although their study was very small (n = 43), careful dietary measurements were obtained (14-day diet records and under-reporting was assessed using doubly labelled water. Lin et al[39] utilised CSFII data to demonstrate that BMI was not associated with the percentage of energy contributed by soft drinks and fruit juice in 6–19-year-old American children. Further analyses of the CSFII data analysed adiposity in relation to individual beverages and showed that neither soda, milk nor fruit juice intakes were related to weight, although a weak positive association was observed between BMI and diet soda in both boys and girls[38].

2.4.3 The New Zealand evidence

Two cross-sectional studies utilising data from the 2002 National Children's Nutrition Survey are available and are also listed in Table 2[6,7]. Scragg et al[6] analysed the food frequency questionnaire (FFQ) data and demonstrated that children drinking carbonated soft drinks more than once a day had a significantly higher mean BMI than children drinking carbonated soft drinks less than once a week (19.7 versus 18.8 kg/m^2) adjusted for age, sex, ethnicity and a variety of lifestyle factors including physical activity and diet. By contrast, Wilson and colleagues[7] used the 24-hour recall data to show that no significant relationship was observed between BMI and the percentage of energy obtained from sugary drinks in children (adjusted for age, sex and ethnicity).

It is perhaps not surprising that different results were obtained even though these studies were conducted on the same subjects. Firstly, each study used different inclusion criteria for what constituted "sugary drinks" (Table 2). As described in this report, the evidence for sugary drinks predisposing to weight gain in children is strongest for carbonated soft drinks, which was the only beverage included in the analysis by Scragg et al[6]. Moreover, FFQ instruments assess different information than that obtained in a 24-hour recall. In this instance, the FFQ was used to estimate the "typical" *number* of servings of beverage consumed[6], whereas the 24-hour recall data were used to estimate the percentage of energy obtained from *all* drinks containing sugar[38].

2.4.4 Limitations of these cross-sectional studies

The weight of evidence in Table 2 would support the notion that sugary drinks are related to body weight in children. Seven of 11 studies reported a positive finding, with the remainder observing a null relationship. No study reported a negative association between sugary drinks and body weight. However, there are a number of problems with these cross-sectional analyses. Many studies involved relatively few participants[40,41,44-46], which is a particular problem if sugary drink intake is assessed using crude frequency-based tools[41,43-45] typically designed for use with larger samples. Even studies based on large national samples[7,38,39,42] are limited in that typically only one to two days of dietary assessment were obtained for each individual. Conflicting findings are perhaps not surprising given the difficultly in relating body weight, which reflects relatively long-term lifestyle habits, to a "snapshot" of dietary intake based on a limited number of days of dietary recording at one point in time. Cross-sectional studies are also limited by their inability to determine causality and the potential for reverse causation. Thus, the observation that diet soda intake was positively related to BMI[38] is most likely attributable to overweight children and adolescents using low-energy soft drinks as a way of controlling their weight rather than diet drinks *per se* contributing to excess body weight, given their negligible energy content. Dietary under-reporting also complicates analyses given that adolescents who are obese under-report more than those of normal weight[47], and selective under-reporting of particular foods (eg, soft drinks) is both possible and probable[48].

2.5 Does intake of sugary drink predict weight gain in children? Longitudinal studies.

2.5.1 Studies in older children and adolescents confirm the link between sugary drinks and body weight in children

Five longitudinal studies examining the association between sugary drinks and body weight in children have been undertaken (Table 3). Ludwig et al[8] provided the ground-breaking longitudinal study demonstrating that intake of sugary drinks predicts weight gain in young adolescents. At follow-up (19 months) BMI was significantly higher (0.18 units) for every serve of sugar-sweetened drinks (soda, fruit drinks and iced tea) consumed at baseline. Moreover, each additional beverage serve increased the incidence of obesity by 60% ($p = 0.02$) after adjustment for age, sex, ethnicity, television viewing, physical activity and energy intake. Appropriate adjustment for confounders, reasonable retention of participants (usable data obtained on 70%) and the consistency of the findings highlight the strength of the evidence provided by this work[8].

Two further studies in young adolescents[9,10] supported the findings of Ludwig et al[8]. Phillips et al[10] followed 196 non-obese girls aged 8−12 years for six to seven years with annual measurements of weight and beverage intake (modified Willett FFQ). Girls in the highest two quartiles of soda intake (% energy) had BMI Z-scores 0.17 units higher than girls in the lowest quartile of intake. The limitation of small numbers in this study[10] is somewhat offset by high retention rates (91%) and the number of repeat measurements used in analyses with girls completing an average of six yearly visits. Berkey et al[9] demonstrated that intake of sugar-added beverages was associated with small BMI gains during the corresponding year in boys (BMI +0.028, $p = 0.038$), but not girls (BMI +0.021, $p = 0.096$). However, other models in girls were significant, showing that girls drinking one serve per day did gain more weight than girls drinking none (0.07 kg, $p = 0.02$). Adjusting for energy intake reduced the effects and significance for all models.

The magnitude of the differences observed by Berkey et al[9] were considerably smaller than that observed by Ludwig et al[8]. For instance, Berkey et al[9] would suggest that, all other factors being equal, boys drinking two serves per day for 10 years would have an increase in BMI only 0.6 units more than those drinking none, whereas the corresponding figure for Ludwig et al[8] over this time would be 2.2 BMI units. Regardless of which is more correct, these differences are important at the population level and may have arisen due to height and weight being self-reported[9], which could weaken associations. Alternatively, the much larger sample size of Berkey et al[9] may provide a more appropriate reflection of the strength of the relationship between sugary drinks and change in body weight.

Table 3: Cohort studies investigating the association between regular intake of sugary drinks and obesity in children

First author (reference)	Study sample	Dietary method	Type of beverages investigated	Confounders adjusted for	Association between beverages and BMI
Studies reporting a positive relationship ($p < 0.05$)					
Ludwig (8)	548 multi-ethnic boys & girls, mean age 11.7 years from 5 Boston schools followed for 19 months	Food frequency questionnaire	Sugar-sweetened drinks: soft drink, sweetened fruit drinks, iced tea	Baseline BMI, age, sex, ethnicity, physical activity, TV, energy intake and several dietary variables	Intake of sweet drinks at baseline and increase in intake over 19 months were both associated with higher BMI values at study end even after adjusting for physical activity, diet, energy intake and initial BMI.
Berkey (9)	>10,000 boys & girls aged 9–14 years, offspring of Nurses Health Study II participants, followed for 2 years	Food frequency questionnaire	Sugar-added beverages: soda, sweetened iced tea, non-carbonated fruit drinks	Baseline BMI, age, ethnicity, physical activity, change in height, puberty and milk type	In boys only, intake of sugar-added beverages and diet soft drinks were associated with changes in BMI over the same year. Only diet soft drinks remained significantly associated with BMI once adjusted for energy intake.
Phillips (10)	192 girls, aged 8–12 years, from public schools & summer camps, followed until 4 years after menarche	Food frequency questionnaire	Soft drinks	Age at menarche, parental overweight and fruit and vegetable intake	Girls with the lowest soft-drink intake (lowest 25%) had significantly lower BMI values than girls with higher intakes of soft drinks, even after adjusting for physical activity and diet.
Welsh (11)	10,904 boys & girls aged 2–3 years from low-income Missouri families enrolled in public health nutrition programme followed for 1 year	Food frequency questionnaire	Sugar-sweetened and naturally sweet drinks: fruit juice, fruit drinks, soft drinks	Age, sex, ethnicity, birth weight, energy intake and several dietary variables	Only overweight children who drank at least 1 serve of soft drink, fruit juice/drink per day had twice the risk of overweight at follow-up compared with those who drank < 1 serve per day.

Studies reporting no relationship (p > 0.05)					
Newby (14)	1345 boys & girls aged 2−5 years from low-income North Dakota families enrolled in public health nutrition programme followed for 6−12 months	Food frequency questionnaire	Soft drinks diet soft drinks, fruit juice, fruit drinks	Age, sex, ethnicity, birth weight, energy intake, and demographic variables	No significant relationships between fruit juice, fruit drinks, milk, soda, or diet soda and annual weight or BMI change were observed, whether beverages were considered individually or as a group.

Note: All studies used change in BMI or BMI Z-score as the measurement of obesity except for Welsh et al, who used the prevalence of overweight (BMI ≥ 95^{th}) at study end.

2.5.2 Studies in preschool-aged children provide mixed evidence

Both studies in this age group utilised data from the Special Supplemental Nutrition Program for Women, Infants and Children (WIC), a federally funded assistance programme for low-income populations[11,14]. Newby et al[14] did not find any associations between beverage intake (fruit juice, fruit drinks, soda, diet soda or milk) and change in BMI after 6−12 months in participants in the North Dakota WIC programme. By contrast, Welsh et al[11] found that overweight children who drank at least one serving of soda, fruit juice/drinks per day had approximately twice the risk of overweight at follow-up compared with overweight children who consumed less than one serving per day (Missouri WIC participants).

The contrast in results is surprising given the similar methodology. Each appeared to use the same adapted FFQ to ascertain intake of a variety of beverages over the past month, and individual beverages appeared to be collated into similar categories. Moreover, the children were of similar age and the follow-up was comparable (6−12 months). The Missouri study[11] was considerably larger, though, and interestingly these authors analysed the relationships separately in children of differing weight status. Although the direction of the relationships was positive for all groups, it was only significant in children with high BMI values at baseline (BMI $\geq$ 85th percentile)[49].

2.5.3 Is fruit juice alone a significant predictor of weight gain in children?

The above studies would suggest that soda drinks and other beverages with added sugar play some role in increasing weight gain in children, whether it is due to a direct effect of the additional energy they provide or as a marker of other behavioural variables that might influence weight. Of considerable interest in this debate is the potential of fruit juice to promote weight gain in children, given that fruit juice in general contains amounts of sugar not dissimilar to carbonated beverages.

Initial *cross-sectional* data suggested that high fruit juice consumers were at greater risk of both short stature and obesity[50,51]. Given the limitations of cross-sectional studies as discussed previously, five *longitudinal* studies have now specifically addressed whether fruit juice is a significant predictor of weight gain in young children[11-15]. An additional two studies in older children included analyses of fruit juice separately from other beverages[9,52] and are discussed in section 2.5.4. Inconsistency in the longitudinal findings is clearly apparent: two found no relationship between longitudinal juice intake (average intake from successive dietary assessments) and BMI[12,14]; one found a negative relationship with ponderal index (kg/m^3)[13]; another found no effect in normal-weight children, but did observe that overweight children drinking more than one glass of fruit juice per day had a 20−50% greater risk of obesity at follow-up than their counterparts who drank less fruit juice[11]; and the last one[15] reported that children who developed obesity between the ages of three and six and those whose obesity reduced in this time drank less juice than children who were classified as normal weight at both time points.

Table 4: Studies investigating the intake of fruit juice in relation to body weight in children

First author (reference)	Study sample	Dietary method	Measurement of obesity	Confounders adjusted for	Association between fruit juice and BMI
Cross-sectional studies reporting a positive relationship ($p < 0.05$)					
Dennison (51)	223 boys and girls aged 2 and 5 years from upstate New York health care centre	7 days diet recalls and 7-day diet record	BMI	Age, sex, maternal height, energy intake (excluding juice)	Only apple juice was related to BMI (increase of 100 g/day associated with BMI difference of 0.29 units)
Cross-sectional studies reporting no relationship ($p > 0.05$)					
Forshee (38) (also in Table 2)	3311 multi-ethnic boys & girls aged 6–19 years from representative US (CSFII 1994–96, 98)	Two 24-hour recalls (non-consecutive days)	BMI (self-reported)	Age, income, ethnicity	No relationship with non-citrus or citrus fruit juices
Prospective studies reporting a positive relationship ($p < 0.05$)					
Field (52)	>14,000 boys & girls aged 9–14 years, offspring of Nurses Health Study II participants, followed for 2 years	Food frequency questionnaire	Annual change in BMI Z-score (self-reported)	Age, baseline weight, puberty, height change activity, inactivity, energy intake	Weak but significant relationship seen between juice intake and annual change in BMI Z-score once adjusted for energy intake.
Prospective studies reporting no relationship ($p > 0.05$)					
Alexy (12)	205 boys & girls aged 3 years from Germany followed for 2 years	3-day weighed diet records	BMI	None	No relationship was observed between weight gain and fruit juice intake.
Newby (14) (also in Table 3)	1345 boys & girls aged 2–5 years from low-income North Dakota families in nutrition programme followed for 6–12 months	Food frequency questionnaire	Change in BMI from baseline	Age, sex, ethnicity, birth weight, energy intake, and demographic variables	No relationship was observed between fruit juice intake and annual change in BMI.

Berkey (9) (also in Table 3)	>10,000 boys & girls aged 9–14 years, offspring of Nurses Health Study II participants, followed for 2 years	Food frequency questionnaire	Change in BMI (self-reported) from baseline	Baseline BMI, age, ethnicity, physical activity, change in height, puberty and milk type	No relationship was observed between fruit juice intake and annual change in BMI
Prospective studies reporting conflicting data					
Skinner (13)	72 white boys & girls aged 2 years from southern USA followed for 4 years	2-day diet record plus 1-day diet recall	Change in BMI from baseline	Baseline BMI, parental BMI, gender, energy intake	Longitudinal juice intake (average intake from repeated measures over time) was not associated with BMI at age 6 but was negatively associated with ponderal index (kg/m^3)
Sugimori (15)	8170 boys & girls aged 3 years from Japan followed for 3 years	Short questionnaire	Shifting from normal to overweight and vice versa from 3–6 years	Sex and baseline BMI	Both children who became obese and those whose obesity regressed drank less juice than children who were classified as normal weight at both time points.
Welsh (11) (also in Table 3)	10,904 boys & girls aged 2–3 years from low-income Missouri families enrolled in public health nutrition programme followed for 1 year	Food frequency questionnaire	Prevalence of overweight (BMI > 95^{th}) at study end	Age, sex, ethnicity, birth weight, energy intake and several dietary variables	Only children who were overweight at baseline and who drank 1–3 serves of fruit juice per day had a higher risk of being overweight at follow-up compared with those who drank < 1 serve per day, but results were not significant for those who drank 3 or more serves per day.

2.5.4 *Is fruit juice a predictor of weight gain in older children and adolescents?*

Two studies have examined the role of fruit juice in older children and adolescents[9,52] (Table 4). Field et al[52] concluded that the intake of fruit juice was not related to subsequent change in BMI Z-score in more than 14,000 adolescents from the Growing Up Today study (children of Nurses Health Study participants). However, closer examination of their data shows that a significant positive, albeit very weak, association was observed between the intake of juice and annual BMI Z-score change (0.003 in girls and 0.002 in boys), once adjusted for energy intake. However, further analysis by the same group[9] did not report any relationship between juice intake and weight gain in adolescent children.

2.6 Is a high intake of fruit juice less of a risk factor for weight gain than soda and other beverages containing large amounts of sugar?

Based on the evidence above, it is unclear what role fruit juice alone plays in promoting excessive weight gain in children. Consistency in results was more apparent in analyses of carbonated beverages and other sweetened drinks than for studies where the contribution of fruit juice alone was studied. However, it should be noted that each study included different types and/or combinations of beverages, rather than analysing the contribution from all beverage types, making it difficult to judge the potential of each type of beverage to promote (or otherwise) weight gain in children. In particular, several studies included measurement of the intake of a variety of beverages but only published data related to specific ones[12,13,15]. Only Berkey et al[9] and Welsh et al[11] analysed the contribution of individual types of drinks as well as sweet drinks in total. In both studies, the relationships between weight gain and beverage intake were in the same positive direction for all beverages, although, as mentioned, only some reached statistical significance.

However, it does appear that if any relationship between fruit juice and weight gain in children exists, it is weaker than that of soft drinks and sweetened drinks in general. It should be remembered that carbonated beverages and fruit juices contain similar amounts of sugar and energy and therefore theoretically have the same potential to promote weight gain if consumed inappropriately. It is feasible, however, that children drinking large amounts of fruit juice have different dietary and/or lifestyle patterns from children who consume soda regularly. Regardless of the mechanism, intakes of all sugar (natural or added) -sweetened drinks should be kept to a minimum for all children given their potential to contribute unnecessary energy to the diet. What that minimum intake should be is, of course, a matter of considerable debate.

2.7 Why does the relationship between sugary drinks and body weight appear stronger in older compared with younger children?

There are several reasons for why an age-related difference in the relationship between weight and beverage intake is possible given the weaker (and more inconsistent) results in younger children. Firstly, it appears that youngsters have better compensation (eat less in same or subsequent meals) for energy provided in drinks than older children and adults[16-18]. Secondly, beverages do not contribute as much energy to the diets of younger children. In particular, soft drink consumption is considerably less[28] and both juice and other sweetened beverages contribute only small amounts of energy to the diet in preschoolers (5% and < 2% respectively)[12]. In addition, the major sweet drink consumed by preschoolers tends to be fruit juice[11,12,14], which may not have as strong a relationship with BMI as do carbonated beverages, as discussed above.

It could simply be that adolescents add a drink to their meal rather than consume less of the meal if a sugar-containing drink is available[19]. In youngsters, juice intake was negatively correlated with the intake of energy from both food and other beverages, suggesting substitution occurs. In contrast, Berkey et al[9] showed that both sugar-added beverage and fruit juice intakes contributed more energy to the diet than the actual energy contained within each drink in their adolescents. In other words, intake of these drinks was associated with consuming additional energy from other sources in this age group, supporting the notion that these drinks may be a marker for less nutritious dietary habits.

Alternatively, differences in other factors or study methodology could be contributing to the age effect. The prevalence of obesity tends to be lower in younger children[4], and Welsh et al[11] clearly showed that detrimental effects of beverage intake were only observed in children who were overweight. Also, some[11,14] but not all[12,13], studies in younger children tended to have shorter follow-up periods than those typically observed in older children[8-10]. All these factors contribute to lowering the heterogeneity of response, which may limit the ability to detect significant relationships.

2.8 Do interventions that have targeted reducing the intake of sugary drinks impact on obesity in children?

Unfortunately, only one intervention has specifically targeted whether reducing the intake of sugar-containing beverages can prevent obesity in children (Table 5). James et al[5] completed a brief school-based educational programme designed to reduce the intake of carbonated beverages in more than 600 UK children aged 7−11 years at baseline. Soda consumption was obtained from three-day diet records and anthropometry was completed at baseline, 6 and 12 months. The intervention consisted of one lesson per term (four in total) taught by school staff over one school year, and included aspects of dental and general health. Six schools were chosen to participate in the study, and intervention and control children were chosen by random allocation of clusters (classes), although because of the nature of the intervention concealment of allocation was not possible.

At study end, consumption of carbonated beverages over three days was reduced by 0.6 glasses in intervention children and increased by 0.2 glasses in control children (group difference $p < 0.05$). There was no difference in mean BMI or mean BMI Z-score between control and intervention children, and no change in the prevalence of overweight (≥ 91st percentile of the British 1990 growth charts) in the intervention participants. However, a 7.5% increase in prevalence in control children resulted in a significant difference in post-study prevalence.

These results appear exciting and encouraging at first glance, if a simple educational programme can reduce the intake of soda drinks in children and, perhaps more importantly, impact on the prevalence of obesity.

Table 5: Intervention studies targeting sugary drink intake and the effect on weight gain in children

First author (reference)	Study sample	Intervention	Outcome	Confounders adjusted for	Intervention effective?
James (5)	644 boys and girls, aged 7–11 years, from 6 schools in southwest England, followed for 1 year	Nutrition education programme at school aimed at reducing carbonated drinks: 1 hour per term for each class	BMI Z-score	None	Intervention group (compared with control) had a decrease in consumption of carbonated drinks, along with decreased obesity prevalence.

However, there are lingering concerns regarding this paper[53]. Most surprising, perhaps, was the impact on obesity prevalence despite what may be termed a fairly "lightweight" intervention, given that many more intensive[54,55] and some similar education-based[56] studies, although not specifically targeting sugary drinks, have had limited success. Also, current consensus suggests that simple education is generally ineffective at changing long-term behaviour, at least in the context of weight management[3]. Although good retention of participants was observed (89%), the number of children completing adequate diet records was poor (56%)[5]. The authors did try to address this by showing that BMI did not differ between responders and non-responders. In addition, no adjustments were made for potential confounders in analyses. This is particularly important given that no change in BMI was observed in intervention children despite decreasing their intake of carbonated beverages. By contrast, control children did not increase their intake, yet substantial increases in the prevalence of overweight (from approximately 20 to 27%) were observed). No explanation is provided for such a rapid increase in the prevalence of obesity over only one year.

Data from US children showed that the prevalence of overweight (≥ 95th Centers for Disease Control 2000 Growth Charts) only increased by four-five percentage points in 6−19-year-olds between 1988−1994 and 1999/2000[21]. Although direct comparison is difficult given the cross-sectional nature of the US data[21] compared with the longitudinal study of James et al[5] and the potential differences in ethnic and age distribution of the samples, an increase of 7.5 percentage points only over one school year is very high in comparison. The lack of difference in mean BMI or BMI Z-score would suggest that many control children were just below the overweight cut-off at baseline, meaning that only small changes in weight were sufficient for them to "become" overweight.

2.9 What role might "diet" beverages play?

Few studies have evaluated the potential role that low-calorie or "diet" beverages may play in managing body weight during growth. This is perhaps not surprising considering that the consumption of diet drinks is much lower than that of high-sugar alternatives[28,57], perhaps as low as 4% of total carbonated beverages[58]. However, the increasing focus on sugary drinks as promoters of weight gain coupled with the controversial view that artificial sweeteners are detrimental to health necessitates a closer look at this class of beverages.

Much of the debate, at least in the US, has centred around the widespread presence of soft-drink vending machines, particularly in schools[26,30]. However, even in the recent American Academy of Pediatrics Policy Statement on Soft Drinks in Schools[59], diet soft drinks are mentioned only briefly in that schools should "preferentially vend drinks that are sugar-free or low in sugar to lessen the risk of overweight". In 2002 the Los Angeles District School Board voted to remove all soft drinks from vending machines in schools. Interestingly, this also included diet options but allowed fruit drinks (which had to be at least 50% fruit juice) and sports drinks with less than 42 g of sugar per 600 ml bottle. No analyses have been published which examine the effect of this initiative.

The single cross-sectional study (section 2.4) that evaluated the relationship between diet carbonated soft drinks and weight in children[38] reported that higher intakes of diet carbonated beverages were associated with higher body weight in boys but not girls. Given the limitations of cross-sectional studies, as previously discussed, this finding is probably due to overweight children and adolescents using low-energy drinks in an effort to control weight, rather than diet drinks actually promoting weight gain, given their negligible energy content.

To sum up, three prospective studies have evaluated the contribution of diet drinks to weight gain in children of different ages[8,9,14]. Two reported no relationship[8,14] and one a positive relationship (boys only)[9] between baseline or change in intake and BMI[8,14]. However, Ludwig et al[8] showed that increasing the intake of diet drinks was associated with a decrease in the *incidence* of obesity ($p = 0.03$).

Thus more attention needs to be paid to how much (if any) diet beverages should be recommended to children and adolescents. The strongest predictor of soft drink consumption in children is taste[57], and at the very least, diet drinks do allow the taste for a fraction of the calories[30].

2.10 How might sugary drinks contribute to excess weight gain?

Sugar-sweetened drinks could contribute to weight gain either by directly increasing energy intake due to lower satiety value or by simply being a marker of poor diet.

2.10.1 Do sugary drinks provide less satiety than other drinks or solid foods?

Whether sugar-containing drinks provide the same satiety or degree of energy compensation as solids or other liquids is a matter of considerable debate[60-62]. Unfortunately, little work (especially recently) has been conducted in children, and the following studies were all completed in adults. Raben et al[63] demonstrated that adults given sucrose-containing beverages gained weight over a 10-week period whereas those consuming artificially sweetened beverages did not (+1.6 kg vs –1.0kg, $p < 0.05$). Studies have shown that satiety and hunger ratings vary for different drinks post-ingestion[64]. However, whether these rating differences translate into differences in actual food intake is uncertain, at least in single-meal experiments[65].

Longer-term work[17] has demonstrated that energy compensation was complete when adults were given 1.8 MJ/day of jellybeans for a four-week period, but not when the same amount of energy was provided as soft drink (subjects gained weight). Others[61] have criticised this study because the subjects consumed the preloads at different times of the day: it is possible that the timing of consumption may be more important than the physical form of energy consumed. Energy intakes at lunch were lower when the preload was consumed closer to the test meal (20 minutes compared with two hours) but were not affected by physical form (regular cola versus cookies; ie, liquid vs solid)[65]. Which is to say, large amounts of beverages consumed with or close to a meal may reduce subsequent energy intake whereas drinks consumed as snacks may not[61].

Of interest currently is the potential contribution that high-fructose corn syrup (HFCS) may play in the obesity epidemic. HFCS is the sole caloric sweetener in soft drinks produced in the United States[62,66]. Because fructose is metabolised differently to glucose and does not stimulate leptin or insulin production, it is possible that HFCS may contribute to weight gain[62]. Unfortunately, little is known about the intakes of HFCS in countries other than the United States.

Despite the controversy, it is apparent that energy compensation is very variable, even in children[18], and is affected by a variety of factors including age, behavioural influences, hormonal factors, nutritional components such as macronutrient composition and energy density[61], and (perhaps) exercise habits[67].

2.10.2 Is a high intake of sugary drinks simply a marker of poor diet/lifestyle habits?

Alternatively, sugary drinks may contribute to adiposity by simply being a marker of other dietary or lifestyle habits that promote weight gain. Longitudinal data in adult women have shown that women with higher intakes of sugar-sweetened drinks consume more energy, smoke more and exercise less[31,68]. At the ecological level, secular changes show dramatic increases in the consumption of carbonated beverages at the same time as purported declining rates of participation in physical activity by children[25,42,69]. Data from the CSFII survey showed that children who consumed fast food had greater energy intakes and poorer diet quality, including a greater intake of sugar-sweetened beverages (228 g, $p < 0.05$), less fibre (−1.1 g, $p < 0.05$) and less fruit and vegetables (−45 g, $p < 0.05$) than children who did not eat fast food. Moreover, similar results were observed in a within-subjects analysis when children acted as their own controls[70].

If sugary drinks simply add energy to the diet, then adjusting for energy should negate any relationships with body weight. On the other hand, if sugary drinks are more of a marker for poor diets, the adjusting for energy should still provide some residual relationship with adiposity. However, as described above, conflicting results have been obtained. Some[8,10,11] but not all[9,14] studies have shown that sugary drink intake predicted weight gain in children and adolescents even when adjusted for energy.

3.1 Conclusions

There is extensive evidence that sugary drinks play a role in promoting weight gain in children. Ideally, multiple intervention trials demonstrating a similar outcome would provide convincing evidence that a nutritional factor is involved in obesity[71]. However, in the absence of numerous trials targeting the reduction of sugary drink intake, other types of evidence and expert opinion prevail[71], such as cohort studies and a plausible hypothesis. Both these types of evidence are clear with respect to sugary drinks. Four of five prospective studies consistently demonstrated that sugary drink intake predicts weight gain in children, even after adjusting for a multitude of confounding factors. The one study that did not observe a relationship[14] was conducted in preschoolers, who, for a variety of reasons outlined in this report, may be less susceptible to the obesity-promoting effects of sugary drinks. In addition, despite some limitations, the one intervention that has been conducted reported a significant benefit from a reducing soft drinks promotion. Although the level of evidence provided from cross-sectional data is not a reliable predictor of causation, as discussed, 7 of 11 studies report a positive association between sugary drink intake and weight in children.

Moreover, as others[72] have highlighted, delaying suitable intervention trials because the causes of *disease* are not conclusively identified is actually delaying potential benefits for population health. Given the level of existing evidence for several environmental factors, including soft drinks, we must move towards designing studies that identify the causes of *improved health* [72].

The actual mechanisms whereby sugary drinks promote inappropriate weight gain in children remain to be elucidated. That soft drinks and fruit drinks are detrimental appears feasible from the evidence. It is unclear what potential role fruit juices may play in excessive weight gain in children, although this may be complicated by age. It is possible that they contribute to the obesity equation given their similar energy content, but if any causal relationship exists it is likely to be smaller in degree than the weight gain effects noted for carbonated beverages and fruit drinks.

The potential of newer sugar-containing drinks (energy drinks, sports drinks and flavoured milk) to contribute to weight gain in children has not been evaluated. Although these drinks are generally consumed less frequently than soft drinks, juices and fruit drinks by New Zealand children[1], their high sugar content would suggest that excess consumption could be a risk factor for obesity. Thus, in terms of these beverages, the absence of evidence should not be confused with the evidence of absence (of an effect).

It is therefore advisable to advocate limiting the intake of all sugary drinks, whether high in natural or added sugars. Although lower sugar alternatives are now available (such as flavoured waters), it is also important that children develop a taste (and hopefully a preference) for water. Although only small differences in actual sugar content per 100 ml are apparent for most sugar-containing drinks, the portion size in which they are sold must also be considered. Heightened promotion of the benefits of water and milk (particularly low-fat milk for those over two years of age) consumption and the potential adverse effects of beverages high in sugar is urgently required.

3.2 Recommendations from the Scientific Committee

In light of the evidence reviewed, the Scientific Committee provides the following recommendations with respect to reducing the intake of sugary drinks in New Zealand children. Further to these recommendations, strategies need to be developed in consultation with a variety of stakeholders which address *how* we might tackle the problem. The Scientific Committee was not asked to provide strategies, but to review the evidence as to whether sugary drinks promote inappropriate weight gain in children.

Beverage	**Additional information**	
Encourage as much as possible		
Plain water	Keep a source of cold water in the fridge – most drinks are more enjoyable when cold. Add slices of lemon, lime or orange to impart some flavour, if required. Make ice cubes with small mint leaves to add interest, if required. Buy younger children their own special water bottle or provide straws to encourage consumption**.**	
Trim milk	Children over the age of two years can have low- and reduced-fat milk and dairy products. Introduce gradually into the diet from two years of age and upwards.	**Encourage the regular consumption of trim milk as a drink**
Do not consume, or at most limit consumption to 0–1 serving (250 ml) per day, drinks (when combined) in this category		
100% fruit juices	Although 100% fruit juices are not yet implicated in obesity development like the beverages described below, they still contain large amounts of sugar and energy. About 2–3 fresh oranges provide the same energy as found in only one 250 ml glass of orange juice. Choosing the fresh fruit option in conjunction with a glass of water would provide more fibre (more than 4 g compared with less than 0.5 g) and be more filling, with comparable amounts of other nutrients.	**Water juice down by at least 1 in 4 in young children and up to 1 in 3 in older children.**

Flavoured milk	Although flavoured milk will provide some additional protein and calcium, flavoured milk is not a major source of either of these nutrients to the diets of NZ children[1]. Using half flavoured milk and half trim milk will lower the energy (535 vs 729 kJ), sugar (18 vs 23 g) and fat (4.5 vs 2.9 g) contents and slightly increase the calcium content (358 vs 339 mg per serving).	**Use half flavoured milk thinned down with half trim milk.**
Flavoured waters	While these drinks do contain considerably less sugar, they are sold in large servings, which may encourage increased consumption. In addition, it is important not to encourage a taste for always having a flavoured drink.	
Diet drinks	Although diet drinks only contain small amounts of energy, regular consumption is not encouraged due to other health issues not considered in this document.	
Do not consume, or at most limit consumption to treats only (less than once a week), all drinks (when combined) in this category		
Regular soft drinks	Soft drinks have high sugar and energy contents and some contain significant amounts of caffeine.	
Energy drinks	These drinks also contain high amounts of sugar, energy and caffeine.	
Sports drinks	Advice should be sought from a registered sports nutritionist or sports dietitian regarding the usefulness of these drinks in children for certain sports and certain situations.	
Fruit drinks	Fruit drinks contain large amounts of sugar and energy. While they do contribute to the vitamin C intake of New Zealand children, vitamin C is not a nutrient of concern in NZ[1]. In addition, the evidence would suggest they promote inappropriate weight gain in children and therefore should be limited.	

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Appendix: Methodology

Goal of the Scientific Committee

The goal of the Scientific Committee is to provide New Zealand nutrition and physical activity practitioners with practical evidence summaries about issues of interest to Agencies for Nutrition Action (ANA) member organisations.

Topic identification

Three initial topics were proposed by the Scientific Committee, in consultation with the Chair and the Executive Officer of ANA. The proposed topics are of relevance to ANA and its member organisations, and reflect the professional expertise of members of the Scientific Committee. The proposed topics were submitted to the Board of ANA for discussion and approval.

Literature identification

One member of the Scientific Committee with expertise in the area of sugary drinks and body weight in children produced an initial scan of the topic area, providing many of the key papers. These initial notes provided the basis for discussion by the Scientific Committee and the Executive Officer as to the questions and issues that should be incorporated into this report.

A precise and specific search of the literature was then conducted using the following key words: “obesity or overweight”, “drink or beverage”, and “sugar or carbonated”. Searches were conducted using the following electronic databases and websites: (i) Medline, (ii) Cochrane Library, (iii) DARE database (includes a database of abstracts of reviews of effects, an NHS economic evaluation database and the Health Technology Assessment database), (iv) HDA evidence base, (v) Ministry of Health website, (vi) NHMRC website, (vii) NICE website, (viii) Research Findings Register and (ix) the Campbell Collaboration. All databases and websites were searched from January 1998 to February 2005, an arbitrary starting point to make the analyses manageable. Only English-language references and human studies were included.

The literature searched yielded the following number of articles for each database: (i) 277 from Medline (of which 82 were kept after a rapid scan of their potential relevance), (ii) three from the Cochrane Library, (iii) 34 from the DARE database, (iv) 28 from the HDA evidence base, (v) five links from the Ministry of Health website (vi) one link from the NHMRC website (vii) none from the NICE website, (viii) three from the Research Findings Register and (ix) one from the Campbell Collaboration. In many instances, the same article featured in several of the databases (data not shown).

Data handling process

Each member of the Scientific Committee then reviewed the title and abstract of each identified reference for relevance. Abstracts were rejected if the intervention included surgical or pharmacological components, as these interventions are not included within the remit of ANA. Similarly, systematic reviews of interventions promoting healthy eating and physical activity in the general population were excluded if they did not explicitly have prevention of obesity and overweight as a stated objective, or reduction of sugary drinks as a component.

Of the 157 articles listed above, 111 were found not to be relevant by all members of the Scientific Committee. In many instances the same research article was identified on several databases, as discussed above. Of the remaining 46 documents, agreement on relevance was obtained on 22 documents by at least two members of the scientific committee. Further discussion was held on the 24 documents that only one member of the Scientific Committee had chosen as relevant and a final decision for inclusion/exclusion was made by the group (four were accepted).

Assessment of papers
The final 26 papers were each critically appraised in terms of relevance and quality by two Scientific Committee members. There was no blinding of authorship of retrieved documents. A critical appraisal form was developed after thorough discussion, and was based on the NHMRC tools for assessing individual studies and the Health Development Agency tool for assessing reviews and systematic reviews. The appraisal form included questions relating to the type of study, power and statistical analyses performed, adjustment for confounders, bias and consistency of findings. A joint decision was made about whether a document should inform the report and be placed on the literature database, or used in the report to inform discussion only, or discarded. Any disagreements were to be resolved through discussion, or, if necessary, by recourse to the third Scientific Committee member. For all papers, agreement for inclusion or exclusion was obtained. A meta-analysis was not conducted because the studies were not comparable.

Writing of the report
Once the writing of the report commenced it was clear that the search terms utilised (see above) were not finding papers that had concentrated on measuring the impact of fruit juice. The first author completed a literature search on Medline using the same timeframe but including the term “juice” rather than “drink or beverage”. This search yielded an additional four references, which were reviewed by the first author only. Similarly, only one reference was found in the initial search suitable for inclusion in section 2.10. The first author completed another literature search in this area but did not restrict the studies to those conducted in children. Only the first author reviewed these additional papers.

An initial draft of the report was produced by the first author and subsequent amendments raised by the Scientific Committee at teleconferences were incorporated into the second, third and fourth drafts. The report was then sent for external review.

All authors contributed to the review process and writing of the report, and all members of the Scientific Committee have final responsibility for the report.

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