Association between adolescents' consumption of total and different types of sugar-sweetened beverages with oral health impacts and weight status

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Abstract

Objective: To examine the associations between adolescents' intake of sugar-sweetened beverages (SSBs) with oral health impacts (OHI) and weight status.

Methods: Cross-sectional health survey with anthropometry and self-report OHI (toothache and avoiding some foods because of oral problems) and SSB intake (fruit juice, flavoured water, soft, diet, sports and energy drinks) collected in 2015.

Results: A total of 3,671 adolescents participated (50% girls; mean age 13.2 years ±1.7). Drinking ≥1cup/day of SSBs was consistently associated with higher odds of OHI compared with drinking <1cup/day: diet soft drinks (AOR, 5.21 95%CI 2.67, 10.18); sports drinks (AOR 3.60 95%CI 1.93, 6.73); flavoured water (AOR 3.07 95%CI 1.55, 6.06); and energy drinks (AOR 2.14 95%CI 1.44, 3.19). Daily SSB intake was not consistently associated with weight status. The odds of overweight/obesity (AOR 1.27 95%CI 1.01, 1.59) and obesity (AOR 1.61 95%CI 1.01, 2.57) were higher for energy drink consumption, compared with not drinking energy drinks; and the odds of abdominal obesity were twice as high among adolescents who drank ≥1cup/day of sports drinks, compared with <1cup/day intake.

Conclusions: Daily consumption of SSBs is prevalent among adolescents and is consistently associated with higher odds of OHI. The most popular SSBs among adolescents were energy drinks. Different types of SSB were differentially associated with OHI and weight status.

Implications for public health: Different types of SSBs were differentially associated with OHI and weight status in adolescents. Diet soft drinks and new generation SSBs such as energy and sport drinks and flavoured water had a greater impact on adolescents' OHI compared with soft drinks and fruit juice.

Key words: adolescents, oral health impacts, obesity, sugar-sweetened beverages

Over-consumption of dietary sugar is a public health concern, with the World Health Organization (WHO) recently announcing revised guidelines for sugar intake.[1] The guideline for both adults and children recommends sugars from all sources, including sugars found naturally in foods, be reduced to less than 10% of total energy intake. The new guidelines are based on evidence which shows that intake of added sugars, particularly sugar-sweetened beverages (SSBs), increases overall energy intake and may reduce the intake of more nutritious foods, leading to a poor-quality diet and contributing to unhealthy weight gain and dental caries.[2,3]

The most recent systematic review of randomised control trials and cohort studies concluded that reduced intake of dietary sugars was associated with a decrease in body weight, and an increased sugar intake was associated with a weight increase.[3] The evidence on reducing sugar intakes in children is inconclusive, but longitudinal studies on children's SSB intake show drinking about one serve (240 mL or 8 fluid ounces) daily is associated with a 55% increased risk of being overweight or obese.[2] As well as contributing to weight gain, numerous studies[4] have concluded that dietary sugars contribute to the development of dental caries. The most recent review concluded there is evidence that restricting sugar intake to less than 10% of energy intake was associated with lower incidence of dental caries in adults and children.[2]

In Australia, national nutrition surveys indicate the intake of added sugars exceeds the dietary recommendation and that daily intakes of added sugars are highest among adolescents (aged 14–18 years) compared with other age groups.[5] Approximately 15% of Australian adolescents' energy intake comes from added sugars and more than three-quarters of adolescents exceed the WHO added-sugar intake recommendation.[5] One of the major food sources of added sugars in Australian adolescents' diets is SSBs.[6,7]

The purpose of this study is to examine the association between adolescents' SSB intake and the prevalence of frequent toothache and frequently avoiding food because of oral health issues, and the prevalence of overweight/obesity, obesity and abdominal obesity in a large representative sample of Australian adolescents.

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Methods

Data source

We used data from the most recent NSW Schools Physical Activity and Nutrition Survey (SPANS), conducted between February and April 2015, a cross-sectional representative survey of NSW primary and high school students' weight and weight-related behaviours. We included data from students in school years 6, 8 and 10 (ages 10–16 years). Trained field staff visited schools and administered the survey, where students completed a written questionnaire. Informed consent by students and their care providers was required for participation. The University of Sydney Human Research Ethics Committee, the NSW Department of Education and Training, and the NSW Catholic Education Commission approved the survey.

Outcome measures

Height (m) weight (kg) and waist circumference (cm) were measured, in private, to one decimal place by trained field staff and used to calculate body mass index (BMI: kg/m^2) and waist-to-height ratio (WtHR: cm/cm). Using international age-sex adjusted cut-points,[8] adolescents' BMI was classified as thin, healthy weight, overweight and obese. WtHR is an indicator of abdominal obesity and was dichotomised as <0.5 or ≥0.5 (higher ratio indicates increased cardiometabolic risk).[9]

Two questions from the National Dental Telephone Survey[10] were used to assess oral health impacts. The questions were selected because they were validated measures of the social impacts of oral health issues and correlate strongly with the presence of dental caries, the main oral disease affecting adolescents.[11] The questions asked adolescents' about how frequently during the past 12 months they had a toothache and avoided eating some foods because of problems with their teeth or mouth. Response options were rarely/never, hardly ever, and sometimes, and were categorised for the analyses as infrequent (rarely/never, hardly ever, and sometimes) or frequent (often and very often).

Measures of SSBs

Information on SSB consumption was collected using a validated short food frequency questionnaire developed for Australian population-based monitoring surveys.[12] The types of SSBs measured included: i) soft drinks (carbonated soda) or cordials; ii) diet soft drinks; iii) fruit juice; iv) sports drinks (i.e. flavoured beverages that often contain carbohydrates, minerals, electrolytes, vitamins or other nutrients[13]); v) flavoured water (response options: never/rarely, ≤1 cup/week, 2-4 cups/week, 5-6 cups/week, 1 cup/day, 1.5 cups/day and ≥2 cups/day; where 1 cup = 250mL); and vi) energy drinks (response options: never/rarely, ≤1 time/week, 2-4 times/week, 5-6 times/week, once a day, ≥2 times/day). For the multivariate analysis, consumption was categorised as <1 cup/day (includes adolescents who never/rarely drank SSBs) or ≥1 cup/day, as approximately 240mL/day is associated with higher risk of unhealthy weight gain.[3] For energy drinks (i.e. drinks that contain stimulants such as caffeine and guarana, with varying amounts of carbohydrate, protein, amino acids, vitamins, sodium and other minerals[13]) response options were <500mL or >500mL can/bottles and were dichotomised for the analysis as 'does drink' and 'does not drink'.

We also examined total SSB intake by recoding each SSB response into millilitres per week (i.e., never/rarely = 0mls, ≤1 cup/week= 250mL, 2–4 cups/week= 750mL, 5–6 cups/week = 1,375mL, 1 cup/day = 1,750mL, 1.5 cups/day = 2,625mL and ≥2 cups/day =3,500mL). This weekly volume was then divided by 250 (i.e. 1 cup) and by 7 (days) to estimate daily SSB intake. For the analysis, total SSB intake was categorised into: Does not drink SSB; <1cup/day; 1–2 cups/day; or ≥2 cups/day.

Covariates

Demographic information included each student's sex, date of birth, language spoken most at home and postcode of residence. Postcode was mapped to a ranking of the Australian Bureau of Statistics' Index of Relative Socioeconomic Disadvantage,[14] and categorised into socioeconomic tertiles (SES: low, medium, high). Postcode was also defined by urban or rural location, using the Accessibility/Remoteness Index of Australia.[15] Language spoken most at home was dichotomised as English-speaking and non-English-speaking.[16] A potential additional confounder for oral health impacts, frequency of teeth brushing, was also collected (<daily, once a day, ≥2 times/day).[10] Physical activity participation (based on the number of days per week spent in moderate-to-vigorous physical activity)[17] and weekday recreational screen-time[18] (mean minutes per day) are potential additional confounders of weight status and were also included in models evaluating unhealthy weight status.

Statistical analysis

All analyses were conducted using Complex Samples SPSS (version 22 for Windows, IBM Corporation, Chicago, IL, USA) to account for the cluster design of the study (school sector and school). Post-stratification weights were used to account for variations in response rates, along with cluster and stratification variables to account for the complex sampling design. Bivariate associations between demographic characteristics of boys and girls were assessed using Pearson's chi-square tests. We examined the associations between outcomes and SSB intake using logistic regression models, with potential covariates (age, sex, SES, residence, language background) included in each model. Frequency of teeth brushing was included in the models for oral health outcomes and physical activity (days per week spent in moderate-to-vigorous physical activity) and weekday screen-time (minutes/day) were included in the models for unhealthy weight status.

Results

In total 3,671 adolescents from 84 schools in years 6, 8 and 10 participated in the survey (response rate 56%). The sociodemographic characteristics of the sample in Table 1 show the majority of adolescents lived in urban areas and were from English-speaking backgrounds. There were no significant sociodemographic differences between boys and girls but, compared with boys, girls were more likely to meet the daily recommendation for brushing teeth twice a day (75.7% vs 64.6%, respectively; p<0.001). Most (66%) adolescents were in the healthy weight range, 6.8% were classified as thin, one in five adolescents (21.1%) were overweight, 5.9% were obese, and 13.2% had WtHR≥0.5. A significantly higher proportion of boys than girls had WtHR≥0.5 (17.1% vs 9.4%; p=<0.001). In total, 7.7% of adolescents reported an oral health impact; 4.1% had a frequent toothache; and 4.7% avoided eating some foods because of problems with their teeth or mouth in the past 12 months.

Table 2 shows the odds of adolescents' reporting a frequent toothache and avoiding some foods separately for each SSB and total

SSB intake, after controlling for potential confounders. Approximately one in 10 adolescents do not drink SSBs, one-quarter drink 1–2 cups of SSB daily (26.1%) and one in seven (15.6%) drink two or more cups of SSB daily. One in five adolescents reported drinking energy drinks (19.4%), one in seven (14.1%) drink ≥1cup/day of fruit juice and 8% drink ≥1cup of soft drink daily. With the exception of fruit juice, daily consumption of each SSB was significantly associated with oral health impacts, with the odds of oral health impacts highest among adolescents who drank diet soft drinks; AOR 5.21 (95%CIs 2.67, 10.18) for toothache and AOR 4.01 (95%CIs 2.09, 7.70) for avoiding some foods. There was a dose-response for total SSB intake with the odds of oral health impacts being two- to three-fold higher among adolescents who drink two or more cups daily of SSBs, compared with adolescents who do not drink SSBs.

Table 3 shows the odds of adolescents being categorised in an unhealthy weight status, separately for each SSB and total SSB intake, after controlling for potential confounders including physical activity and recreational screen-time. There were no consistent associations between adolescents' SSB intake and being overweight/obese, obese or having a WtHR≥0.5. The odds of being overweight/obese or obese were 27% and 61% higher, respectively, among adolescents who reported drinking energy drinks, compared with adolescents who do not drink energy drinks, and the odds of abdominal obesity were two-fold higher among adolescents drinking ≥1cup of sport drinks daily. We found no association between total SSB intake and no evidence of a dose–response association, although the odds for all outcomes were highest for adolescents who reported the highest consumption of total SSB.

Discussion

The findings of this study showed that adolescents' SSB intake was more consistently associated with negative oral health impacts than unhealthy weight status and that these associations differed according to the type of SSB consumed. SSB consumption was prevalent in this study with only one in ten adolescents reporting that they did not drink SSBs. While almost half of adolescents reported drinking less than one cup of SSBs daily, one-quarter consumed 1–2 cups a day and one in seven drank more than two cups of SSBs daily.

The most prevalent SSB consumed were energy drinks, with one in five adolescents drinking this category of beverage, followed by fruit juice (one in seven), soft drink (8%) and around 2–3% of adolescents drinking diet soft drink, sports drinks and flavoured water daily. Energy drinks are a relatively new class of beverage, with a marketing focus on their stimulant effects, crafted to appeal to young people.[19] The popularity of energy drinks among adolescents has been previously reported[20,21] despite health concerns that caffeine and other stimulant substances contained in energy drinks have no place in the diet of children and adolescents.[22]

There are some weaknesses in the interpretation of our findings. The data come from a population health survey and most data were self-reported, and thus susceptible to recall issues and bias due to socially desirable responses. Clinical dental examinations for oral health were not feasible; however, the oral health questions are a validated measure of the social impacts of oral health issues used in other dental surveys, and they correlate strongly with the presence of dental caries (the main oral disease affecting adolescents).[10,11,23] Similarly, while our questions on SSB intake were specifically developed for population-surveillance surveys and have been validated, they are appropriate only for ranking individuals rather than providing precise estimates of intake.[12,24] Difference in the measurement and presentation of SSB intake often make comparisons between studies

Table 1: Sociodemographic characteristics of the sample (%; n=3,671).[a]

Covariates	Study population	
	n	% (95%CI)
Sex – boys	1,837	50.0
Mean age (years; range)	3,671	13.2 (10-16 years)
School year		
Year 6	1,354	31.2 (29.7, 32.7)
Year 8	1,275	34.4 (32.9, 36.0)
Year 10	1,042	34.4 (32.4, 36.5)
Live in urban area	**2,781**	**73.9 (62.8, 82.6)**
Socioeconomic tertile		
Low	1,039	31.3 (23.3, 40.7)
Middle	1,298	33.2 (25.7, 41.7)
High	1,334	35.4 (26.8, 45.2)
Language background		
English-speaking	3,181	87.5 (82.9, 91.0)
Frequency of teeth brushing[a]		
<2 times/day	1,036	29.8 (27.3, 32.5)

a: weighted data

Table 2: Adjusted odds ratios (AOR)[a] for the association between adolescents' SSBs and oral health impacts in the past 12 months.

SSB intake	Frequency (%)	Oral health impacts	
		Toothache	Avoid some foods
		AOR	AOR
Soft drinks	(n=3,671)		
< 1 cup/day	91.6	1.0	1.0
≥ 1 cup/day	8.4	**1.95 (1.22–3.12)**	1.71 (0.93–23.15)
Diet soft drinks	(n=3,460)		
< 1 cup/day	97.6	1.0	1.0
≥ 1 cup/day	2.4	**5.21 (2.67–10.18)**	**4.01 (2.09–7.70)**
Fruit juice	(n=3,449)		
< 1 cup/day	85.9	1.0	1.0
≥ 1 cup/day	14.1	1.32 (0.76–2.31)	1.72 (0.99–2.97)
Sports drinks	(n=3,466)		
< 1 cup/day	97.0	1.0	1.0
≥ 1 cup/day	3.0	**3.60 (1.93–6.73)**	1.56 (0.68–3.54)
Flavoured water	(n=3,523)		
< 1 cup/day	97.2	1.0	1.0
≥ 1 cup/day	2.8	1.63 (0.74–3.59)	**3.07 (1.55–6.06)**
Energy drinks	(n=3,455)		
Does not drink	80.6	1.0	1.0
Does drink	19.4	**2.14 (1.44–3.19)**	**1.90 (1.36–2.65)**
Total SSB intake	(n=3,458)		
Does not drink SSB	11.1	1.0	1.0
<1 cup/day	47.2	0.82 (0.43–1.58)	0.95 (0.50–1.79)
1-2 cups/day	26.1	1.15 (0.58–2.27)	1.10 (0.60–2.04)
>2 cups day	15.6	**2.41 (1.11–5.26)**	**2.93 (1.48–5.79)**

AOR = adjusted odds ratio; Total SSB intake – daily intake of all SSBs - soft drink, diet soft drink, fruit juice, sports drinks and flavoured water.

a: Adjusted for age, sex, SES, language background, residence and brushing teeth;

difficult, highlighting the need for standard presentation of dietary data.

The cross-sectional survey design limits causal inferences allowing us to report only associations. Despite these limitations, there were a number of study strengths including large representative sample of adolescents, measured anthropometry and validated questions for SSB and oral health impacts. A strength and novel aspect of our study was the disaggregation of SSBs to examine whether different SSBs have differential associations with oral health impacts and unhealthy weight status. In addition, we included WtHR, a marker of abdominal obesity and cardiometabolic risk,[25] which has not been included in similar surveys.

SSB and oral health impacts

The majority of adolescents in this study reported good oral health, with only 7.7% reporting they experienced an oral health impact issue during the past 12 months. These reported prevalences are lower than national estimates[10] as we included only frequent impact, rather than frequent or occasional impact, as our outcome. The prevalence of oral health impacts was, however, higher among adolescents who drank ≥1 cup of SSB daily, ranging from 5% to 19%. The prevalence of oral health impacts was highest among drinkers of diet soft drink (17–19%) and lowest among fruit juice drinkers (5–8%). More than half (54%) of adolescents reported drinking a range of SSB, and we found that higher consumption of total SSB (i.e. >2cups/day) was associated with higher odds of negative oral health impacts.

With the exception of fruit juice, each SSB type was associated with one or both oral health impacts and the associations were strongest for diet soft drinks and flavoured water. While it was not clear why the odds of oral health impacts were four- to five-fold higher among adolescents drinking ≥1 cup daily of diet soft drinks, future research could explore whether adolescents who drink dietary drinks have prolonged exposure to other sugary foods, (e.g. sucking confectionary) and more research into the effect of artificial sweeteners (e.g. saccharin, aspartame) on adolescents' oral health is required. The clear and consistent associations between diet and new generation soft drinks (i.e. energy and sports drinks, flavoured water) and oral health impacts is of concern because these beverages are marketed and promoted as an alternative beverage choice for adolescents[26] and adolescents perceive these beverages as healthy.[27]

We did not find an association between oral health impacts and fruit juice. Although we did not ask about the fruit content in juice, another study showed that drinking 100% fruit juice was not associated with caries.[28] The carbohydrate source of 100% fruit juice are sucrose, fructose and glucose, which may have lower cariogenicity[29] or, alternatively, adolescents who drink 100% fruit juice may be more inclined to consume healthier foods overall. Additionally, the volume of fruit juice consumed (and therefore added sugar) may potentially be less than most serving sizes of other SSB.

Table 3: Adjusted odds ratios (AOR)[a] for the associations between adolescents' SSB intake and unhealthy weight status.

SSB intake	Prevalence (%)	Weight status		
		Overweight/obese	Obese	Waist-to-height ratio ≥0.5
		AOR	AOR	AOR
Soft drinks	(n=3,537)			
< 1 cup/day	91.9	1.0	1.0	1.0
≥ 1 cup/day	8.1	0.79 (0.55–1.12)	1.01 (0.52–1.97)	0.84 (0.52–1.36)
Diet soft drinks	(n=3,561)			
< 1 cup/day	97.6	1.0	1.0	1.0
≥ 1 cup/day	2.4	1.02 (0.65–1.62)	1.82 (0.72–4.62)	1.12 (0.54–2.32)
Fruit juice	(n=3,518)			
< 1 cup/day	86.3	1.0	1.0	1.0
≥ 1 cup/day	13.7	1.09 (0.86–1.37)	1.44 (0.93–2.24)	1.00 (0.72–1.37)
Sports drinks	(n=3,563)			
< 1 cup/day	97.1	1.0	1.0	1.0
≥ 1 cup/day	2.9	1.47 (0.86–2.51)	1.80 (0.66–4.90)	**2.03 (1.11–3.71)**
Flavoured water	(n=3,521)			
< 1 cup/day	97.3	1.0	1.0	1.0
≥ 1 cup/day	2.7	1.33 (0.79–2.23)	1.39 (0.56–3.47)	1.58 (0.82–3.04)
Energy drinks	(n=3,550)			
Does not drink	80.4	1.0	1.0	1.0
Does drink	19.6	**1.27 (1.01–1.59)**	**1.61 (1.01–2.57)**	1.24 (0.85–1.80)
Total SSB intake	(n=3,560)			
Does not drink SSB	11.2	1.0	1.0	1.0
<1 cup/day	47.1	0.83 (0.56–1.24)	1.00 (0.46–2.15)	0.86 (0.46–1.59)
1-2 cups/day	26.0	0.80 (0.51–1.27)	0.95 (0.42–2.19)	0.94 (0.48–1.87)
>2 cups/day	15.7	1.07 (0.71–1.63)	1.58 (0.68–3.68)	1.22 (0.64–2.33)

AOR = adjusted odds ratio; Total SSB intake – daily intake of all SSBs - soft drink, diet soft drink, fruit juice, sports drinks and flavoured water.

a: Adjusted for age, sex, SES, language background, residence, physical activity (days) and weekday screen-time (mins)

SSBs and unhealthy weight status

The majority of adolescents in this study were in the healthy BMI category; however, 27% were overweight/obese (5.9% obese), and 13.2% had a WtHR≥0.5, an indicator of increased risk for adverse cardiometabolic health outcomes. The high prevalence of overweight/obesity among Australian adolescents has been reported elsewhere,[30] emphasising the need to address factors associated with unhealthy weight gain in adolescents. SSBs are a source of additional calories with no nutritive value, and they may be replacing energy sources from food. Around 30% of adolescents in this study who drank ≥1 cup of SSB daily were overweight/obese; however, the prevalence was higher among adolescents drinking the newer generations of SSBs, specifically sport and energy drinks and flavoured water. The prevalence of abdominal obesity was also higher among adolescents consuming these newer generation SSBs compared with other SSBs.

In contrast to most systematic reviews,[31,32] which suggest higher intakes of SSBs among children are associated with a higher risk of being overweight or obese compared with those with lower intake, we did not find a consistent association between SSB intake and odds of unhealthy weight status. Cross-sectional study designs determine associations, not causality, and potentially overweight or obese adolescents in this study may have reduced their SSB consumption. In this study, only the consumption of energy drinks was associated with overweight/obesity and obesity in adolescents, and sports drinks with higher odds for abdominal

obesity. Further research is required, but potentially the marketing and advertising claims for energy and sport drinks may have greater appeal for adolescents in unhealthy weight categories because they are associated with physical activity and 'health'. For example, sports drinks contain electrolytes and are primarily marketed to provide hydration during physical activity, while energy drinks contain high quantities of caffeine with advertising claims promising increased energy, enhanced mental alertness, physical performance, and health from antioxidants and vitamins.[26,33]

The lack of consistent associations between individual types and total SSBs consumption and obesity in our study is, however, not unique.[34] It has been suggested that equivocal findings are due to including studies in reviews that were not designed to evaluate whether SSBs contribute to obesity[34] or are the result of methodical issues.[35,36] For example, many studies do not control for appropriate confounding factors that could be associated with SSB consumption.[34] In our analyses, we controlled for adolescents' screen time and physical activity, as these behaviours may influence both SSB intake and weight status, and this may have influenced our findings towards the null. However, we did not include questions on dietary intentions such as dieting or on body size perception, which may have influenced our findings.

Conclusions

Daily consumption of SSBs was prevalent among adolescents. Daily intakes of ≥1 cup daily were consistently associated with higher odds of oral health impacts, but the association was less clear with weight status. We found that different types of SSB were differentially associated with oral health impacts and weight status. A key finding was that the new generation SSBs, diet soft drinks, sports drinks and flavoured water showed higher associations than traditional soft drinks. Although only a small percentage of adolescents consumed these beverages, consumption was associated with oral health impacts. Reductions in the frequency and volume of these beverages could have significant impact on adolescents' oral health, and potentially influence weight status.

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