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Sugar-sweetened Beverage and Water Intake in Relation to Diet Quality in U.S. Children

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Introduction: Sugar-sweetened beverages (SSBs) are a major contributor to children's added sugar consumption. This study examines whether children's SSB and water intake are associated with diet quality and total energy intake.

Methods: Using data on children ages 2–18 years from the 2009–2014 National Health and Nutrition Examination Survey, linear regression models were used to analyze SSB and water intake in relation to Healthy Eating Index (HEI-2010) scores and total energy intake. Generalized linear models were used to analyze SSB and water intake in relation to the HEI-2010 scores. Analyses were conducted including and excluding caloric contributions from SSBs, and were conducted in 2016–2017.

Results: SSB intake was inversely associated with the HEI-2010 total scores (9.5-point lower score comparing more than two servings/day with zero servings/day, p-trend<0.0001) and positively associated with total energy intake (394 kcal higher comparing more than two servings/day with zero servings/day, p-trend<0.0001). The associations between SSB and HEI-2010 total scores were similar when SSBs were excluded from HEI-2010 calculations. Water intake was positively associated with HEI-2010 total scores, but not associated with total energy intake. SSB intake was inversely associated with several HEI-2010 component scores, notably vegetables, total fruit, whole fruit, greens and beans, whole grains, dairy, seafood and plant proteins, and empty calories. Water intake was positively associated with most of the same HEI-2010 component scores.

Conclusions: Children who consume SSBs have poorer diet quality and higher total energy intake than children who do not consume SSBs. Interventions for obesity and chronic disease should focus on replacing SSBs with water and improving other aspects of diet quality that correlate with SSB consumption.

INTRODUCTION

Sugar-sweetened beverages (SSBs) are the main source of added sugar in U.S. children's diets.[1–4] Although WHO recommends that children consume no more than 10% of total calories from sugar, data from the 2009–2010 National Health and Nutrition Examination Survey (NHANES), found that children consumed 8.0% of total calories from SSBs alone.[5,6] Water in its plain form contains no sugar or calories. According to the 2009–2012 NHANES, more than 60% of children and adolescents drink less than 2 cups of water daily, and 13% drink no water on a given day.[7] Given the low levels of water consumption, more attention to water intake is needed.

SSB intake has been associated with increased energy intake[8,9] and higher risks of obesity, metabolic syndrome, type 2 diabetes, and heart disease.[10–14] Experimental studies have shown that interventions can be effective in reducing SSB consumption in children, translating into favorable impacts on BMI,[15,16] weight gain and fat accumulation,[17] and lean body mass.[18] However, SSB reduction may not be the only factor in childhood obesity prevention as several observational studies have shown that SSBs are correlated with other unhealthy dietary behaviors. One national study found that higher consumption of SSBs in children was associated with lower intakes of calcium, folate, iron, and fiber, and higher intakes of saturated fat and added sugars.[19] Other studies have shown that children who consume SSBs also have higher intakes of fast food, savory snacks, and desserts.[8,20] These findings suggest that SSB reduction alone may not be enough to improve overall diet quality.

This study investigated water and SSB consumption in relation to overall diet quality and individual dietary components (e.g., total vegetables, total fruit), using the Healthy Eating Index-

2010 (HEI-2010), as well as total energy intake (TEI) in a representative sample of U.S. children (aged 2–18 years). Associations were further examined by specific age groups: 2–5 years, 6–11 years, and 12–18 years, as beverage consumption and diet quality can vary across stages of childhood. It is hypothesized that SSB intake is inversely correlated with diet quality and positively correlated with energy intake, whereas water intake is positively correlated with indices of diet quality and not associated with energy intake. As SSB reduction has been increasingly promoted as public health policy, this study aims to understand if interventions should focus on SSB reduction alone or whether SSB reduction combined with additional dietary guidance is warranted.

METHODS

Study Population

NHANES uses a multistaged probability design to derive a sample of participants that is representative of the U.S. civilian, non-institutionalized population. The cross-sectional data are collected continuously. This study combined three waves (2009–2010, 2011–2012, and 2013–2014).

For this study, the data were limited to children aged 2 to 18 years. Participants were excluded if they had incomplete or missing dietary recall (only those with complete 2 days included), or had implausible energy intake (>2 SDs of reported energy intake from age- and sex-specific predicted energy requirements).[21] The resulting sample size was 7,757 children. The sample was further stratified into the following age groups: children aged 2–5 years (*n*=1,972), 6–11 years (*n*=2,890), and 12–18 years (*n*=2,895).

Measures

Dietary intake data were derived from the mean of two 24-hour dietary recalls per participant. Recalls for children aged <6 years were completed by a proxy (i.e., usually a parent). Recalls for children aged 6–8 years were done with a proxy and the child present, children aged 9–11 years conducted the recalls with the assistance of an adult familiar with the child's diet, and children aged 12–18 years completed the recalls without adult assistance.[22]

SSBs included soft drinks, fruit drinks with added sugar, sweetened coffee and tea drinks, sports drinks, and sweetened bottled water. Intake of 100% fruit juice, unsweetened milk, coffee, tea, and other similar unsweetened beverages were not categorized as SSBs, as they are not a source of added sugar. Flavored milk, which contains other nutrients in addition to added sugar, was not included as a SSB because the study intended to focus on beverages with little nutritional value that could be replaced with water. Plain water included all unsweetened water sources: tap water, bottled water, and unsweetened carbonated water. Both SSB and plain water intakes were converted to eight fluid ounce servings and treated as categorical variables: zero servings (reference), more than zero to one serving, more than one to two servings, and more than two servings.

Diet quality was measured by the HEI-2010.[23] The HEI-2010 was developed by the U.S. Department of Agriculture to measure compliance with national dietary guidelines. The HEI-2010 total score has a maximum of 100, and is comprised of 12 component scores: total vegetables (maximum[max] score=5), total fruit (max score=5), whole fruit (max score=5), greens and beans (max score=5), whole grains (max score=10), dairy (max score=10), total

protein foods (max score=5), seafood and plant proteins (max score=5), fatty acids (max score=10), refined grains (max score=10), sodium (max score=10), and empty calories (solid fats, alcohol, and added sugars) (max score=20). For refined grains, sodium, and empty calories, a higher score indicates a lower intake. HEI-2010 total and component scores were calculated according to the Simple HEI Scoring Algorithm using public SAS macros provided by National Cancer Institute. TEI was based on the type and amount of all caloric foods and beverages reported. As secondary outcomes, HEI-2010 scores and TEI were also estimated, excluding the contributions of SSBs. All dietary variables were estimated per day and then averaged across the 2 days.

Variables chosen a priori to control for potential confounding included: sex, age, race/ethnicity (white, Hispanic, black, other), household reference education (high school graduate and below, some college and above), family poverty to income ratio (<130%, 130% to <300%, ≥300%), household reference marital status (married/living with partner, single/divorced/widowed/ separated), and child weight status. The household reference is the first person aged ≥18 years listed under household members who owns or rents the place of residence. Weight status was categorized using measured height and weight and converted into age- and sex-specific BMI percentiles (normal weight: <85th percentile, overweight: 85th to <95th percentile, obese: ≥95th percentile). Missing data for household reference education (*n*=211), marital status (*n*=183), family poverty to income ratio (*n*=551), and weight status (*n*=93) were handled using the missing indicator method.[24]

Statistical Analysis

All statistical analyses were performed using SAS, version 9.3 and Stata, version 12.1 SE. NHANES dietary survey weights and robust estimates of variance were used for all analyses to account for differential selection probabilities, nonresponse in the various NHANES components, and to make nationally representative estimates.

Multivariable linear regression was used to estimate the associations between beverage intake **X** total HEI-2010 score and TEI, adjusting for all covariates. Tests for trend for both exposure variables (water and SSB intake) were conducted by examining the significance for the ordinal exposure variables in models. Multivariable generalized linear models with a gamma distribution and log-link function were used to estimate relative differences of HEI-2010 component scores by beverage intake levels, which can appropriately accommodate the skewed distributions of the HEI-2010 variables.[25] In these models, the effect measures were exponentiated to report the relative difference (e.g., the percent difference) in HEI-2010 scores between one beverage category and the reference group. Models were fit for the total analytic population and separately for each age group. To examine heterogeneity by age, statistical significance threshold of the cross-product terms between each exposure variable (water and SSB intake) and age group (aged 2–5, 6–11, 12–18 years) for the primary outcomes (HEI-2010 and TEI) was examined using Wald tests. Associations were also examined between beverage intake **X** total HEI-2010 score **X** TEI excluding the contributions of SSBs. Data were analyzed in 2016–2017.

RESULTS

Children in the analytic population were evenly distributed by age group and sex (Table 1). Two thirds of participants were normal weight, 15% were overweight, and 17% were obese. On

average, children consumed 1.3 (SE=0.04) servings of SSBs and 2.3 (SE=0.07) servings of water per day. Water and SSB intakes were inversely correlated ($r = -0.06$, $p<0.0001$). The mean HEI-2010 score was 49.7 (SE=0.3, range, 9.4–93.9). Excluding the contribution of SSBs, the mean HEI-2010 score was 51.0 (SE=0.3, range, 13.3–93.8) (Appendix Table 1).

In the study population, 22.5% of children drank more than two servings/day of SSBs (referred to as heavy SSB drinkers) and 24.8% of children drank zero servings/day of SSBs (non-SSB drinkers). Greater SSB consumption was associated with lower HEI-2010 total score (Table 2). Compared with children who drank no SSBs, drinking more than two servings of SSBs/day was associated with a 9.5-point lower HEI-2010 score (95% CI= −10.8, −8.3, p-trend <0.0001). Associations were statistically different by age group (p-interaction <0.0001), ranging from an 8.5-point lower HEI-2010 score for children aged 12–18 years to 13.6-point lower HEI-2010 score for children aged 2–5 years, comparing the heavy SSB drinkers to non-SSB drinkers. Exclusion of the contributions of SSBs in HEI-2010 scores diminished the magnitude of the associations; however, high SSB intake remained significantly associated with lower HEI-2010 scores in every age group (Appendix Table 2).

With respect to water intake, 42.3% of children drank more than two servings/day (high water drinkers) and 11.7% of children drank zero servings/day (non-water drinkers). Higher water consumption was associated with a higher HEI-2010 total score, with a 4.8-point higher HEI-2010 score (95% CI=3.6, 6.0, p-trend<0.0001) comparing high water drinkers with non-water drinkers. There were no significant differences by age group for the association between water consumption X HEI-2010 total score (p-interaction=0.20). Exclusion of the contribution of SSBs

to HEI-2010 scores reduced the magnitude of the associations; however, in every age group, high water intake remained significantly associated with higher HEI-2010 scores.

Greater SSB consumption, but not water consumption, was positively associated with TEI (Table 3). Compared with non-SSB drinkers, children who were heavy SSB drinkers consumed, on average, 394.4 more kcal (95% CI=318.6, 470.2, *p*-trend <0.0001). There were no significant differences by age group in the associations with TEI. After excluding the contributions of SSBs to TEI, the associations between SSB **X** TEI were attenuated among young children and adolescents, suggesting that the higher consumption of calories among heavy SSB drinkers were mostly because of the SSBs (Appendix Table 3). However, a significant positive association between SSB **X** TEI remained among children aged 6–11 years, suggesting that the higher consumption of calories among heavy SSB drinkers might be attributed to other foods potentially consumed with SSBs and not simply to SSBs alone.

Compared with non-SSB drinkers, heavy SSB drinkers (more than two servings/day) were negatively associated with scores for the following HEI components: 14% lower vegetables (95% CI= −19%, −8%), 31% lower total fruit (95% CI= −39%, −23%), 34% lower whole fruit (95% CI= −42%, −25%), 32% lower greens and beans (95% CI= −44%, −16%), 42% lower whole grains (95% CI= −49%, −34%), 14% lower dairy (95% CI= −18%, −10%), 17% lower seafood and plant proteins (95% CI= −26%, −7%), 25% higher sodium (95% CI=17%, 33%), 7% higher refined grains (95% CI=3%, 12%), and 39% lower empty calories (95% CI= −42%, −36%; Table 4). High water intake was positively associated with scores for the following HEI components: 13% higher vegetables (95% CI=5%, 21%), 21% higher total fruit (95% CI=8%,

34%), 40% higher whole fruit (95% CI=26%, 55%), 41% higher greens and beans (95% CI=11%, 80%), 48% higher whole grains (95% CI=32%, 66%), 33% higher seafood and plant proteins (95% CI=15%, 52%), 14% lower sodium (95% CI= −22%, −6%), 14% lower refined grains (95% CI= −19%, −8%) and 29% higher empty calories (95% CI=23%, 35%). When the contributions of SSBs were removed from the estimation of HEI-2010 scores, associations between SSB **X** water intake with HEI-2010 component scores were largely unchanged; however, the association between SSB intake **X** total vegetables was attenuated, and the associations between SSB intake **X** sodium **X** refined grains were reversed (where heavy SSB intake was associated with lower scores, suggesting higher intakes; Appendix Table 4).

DISCUSSION

Beverage choices have been increasingly recognized as critical to overall health as well as risk for chronic diseases.[10–13] Consistent with the study hypotheses, there were strong dose–response relationships between beverage intake and overall diet quality, suggesting that children who consume more SSBs have lower diet quality, whereas those who consume more water have higher diet quality. These associations persisted even with the exclusion of SSBs from HEI-2010 estimations (SSBs contribute directly to the total HEI scores through the empty calories component, as well as indirectly to all component scores via the denominator of component score calculations). Although there were significant differences by age group, with the largest associations observed in children aged 2–5 years, associations between beverage intake and diet quality were also observed in older children (6–11 years) and adolescents (12–18 years). These associations were also apparent with the majority of individual HEI-2010 component scores. Although the modest increase in total HEI-2010 scores excluding the contribution from SSBs

suggests that replacing SSBs with water would lead to a small increase in diet quality among the general population, a larger increase would be expected among SSB drinkers. Together, the results of the present study are aligned with prior evidence demonstrating that children's unhealthy dietary habits cluster, suggesting that beverage choice not only contributes directly to diet quality but may also be a marker of underlying diet quality and lifestyle habits.[8,26,27]

Not surprisingly, SSB intake was associated with substantially higher energy intake, whereas water intake was not associated with TEI. The attenuation of these associations when SSBs were excluded suggests that the excess calories consumed by SSB drinkers were primarily attributed to SSBs and not to other foods correlated with SSB consumption. These findings are consistent with prior evidence showing that children and adults who consume added sugar in beverage form do not offset the additional calories consumed with reductions in intake of other foods or beverages.[2–4] A previous analysis of NHANES by Wang and colleagues[28] found that holding other beverages and fast food constant, children would consume 235 fewer daily calories by substituting all SSBs with water.

These results have implications for chronic disease prevention. The first issue is whether targeting SSBs exclusively could be effective strategy for reducing childhood obesity. A *Healthy People 2020* goal is to reduce childhood obesity prevalence to 14.6% by 2020. According to Wang et al.,[9] a decrease in TEI of only 64 kcal/day for children aged 2–19 years would meet this goal (22 kcal for 2–5 years, 77 kcal for 6–11 years, 98 kcal for 12–19 years). A systematic review of experimental studies to reduce SSB intake found that six of eight interventions led to significant improvements in children's BMI or weight status, though the long-term effects were

mixed.[29] The present study supports the focus on reduction of children's SSB consumption for obesity prevention, as the findings suggest that SSBs are a primary contributor to children's excess caloric intake when compared with their non-consuming peers.

On the other hand, it has been argued by some researchers that SSBs are a marker of overall poor diet quality and alone may not be an effective target to improving children's health.[26] In the present study, higher SSB consumption was inversely associated with multiple HEI-2010 component scores, suggesting that children who are heavy SSB drinkers are also lacking in other key food groups and nutrients. Thus, the findings affirm that SSB reduction alone is not likely to be a complete remedy to poor diet quality among children who are heavy SSB drinkers, and efforts to improve other aspects of dietary intake (e.g., fruits, vegetables, whole grains) will be necessary for overall health promotion and chronic disease prevention. To date, only one SSB intervention has examined concurrent changes in diet quality. Results from the Talking Health study, a community-based randomized clinical trial of Virginian adults, showed that in addition to reductions in SSBs, there were also marked improvements in empty calories, total vegetable, and total HEI scores.[30] Although this intervention focused primarily on SSB reduction and physical activity promotion, it holds promise for future SSB interventions to address other aspects of a healthful diet.

Limitations

This study has several limitations. First, the cross-sectional design means causality of the exposures and outcomes cannot be inferred, and in particular, whether beverage consumption directly influences diet quality or both are influenced by other contextual or health factors. As in many nutrition studies, diet was self-reported and thus prone to measurement error and response

bias. However, it is likely that this bias is non-differential as the 24-hour recall is less prone to social desirability bias than other dietary recall methods, and participants were unaware of the study hypotheses at the time of the interview.[31] A systematic review also concluded that 24-hour multiple pass recalls with parents as proxy reports are the most accurate method to estimate TEI in children.[32] Nevertheless, differential bias may exist such that children could differentially report the intake of other foods depending on their intake of beverages. The exposures (SSB and water intake) and outcomes (HEI-2010 and TEI) were based on 2 days of dietary recall and may not be representative of usual dietary intake. Methods for estimating usual dietary intakes regarding individual HEI scores are still under development and should be used in future analyses. One final limitation is that though many individual characteristics were included in the analysis, the possibility of confounding from unmeasured factors, such as child physical activity, other markers of parental socioeconomic status, and contextual factors related to neighborhood food availability, remains.

CONCLUSIONS

In this nationally representative sample of U.S. children, the finding that SSB intake is associated with lower diet quality and higher TEI adds to the growing body of evidence showing harmful associations between SSBs and children's health. This study provides additional support for obesity prevention efforts encouraging children to replace SSB consumption with plain water, although it does not find that water consumption on its own is associated with reduced caloric consumption among children. The findings also suggest that public health interventions should focus on improving overall diet quality more generally for chronic disease prevention, as SSB

consumption may contribute excess calories to children's diets, but is also associated with other markers of poor diet quality.

ACKNOWLEDGMENTS

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Table 1. Characteristics of Study Participants, National Health and Nutrition Examination Survey 2009–2014

Characteristics	Total sample (n=7,757)	2–5 years (n=1,972)	6–11 years (n=2,890)	12–18 years (n=2,895)
Sex, n (weighted %)				
Male	3,928 (50.5)	1,002 (52.2)	1,466 (51.4)	1,460 (48.9)
Female	3,829 (49.5)	970 (47.8)	1,424 (48.6)	1,435 (51.1)
Weight status,[a] n (weighted %)				
Normal weight	5,068 (66.7)	1,443 (74.5)	1,845 (64.5)	1,780 (64.2)
Overweight	1,199 (15.2)	255 (13.3)	461 (16.7)	483 (15.0)
Obese	1,397 (17.2)	221 (10.2)	572 (18.3)	604 (20.1)
Race/ethnicity, n (weighted %)				
Non-Hispanic white	2,178 (54.8)	561 (52.4)	829 (54.3)	788 (56.6)
Non-Hispanic black	1,877 (14.0)	446 (13.9)	716 (14.1)	715 (13.9)
Hispanic	2,654 (22.7)	686 (24.3)	987 (23.4)	981 (21.2)
Other race/multi-race, non-Hispanic	1,048 (8.5)	279 (9.5)	358 (8.2)	411 (8.3)
Education (household reference),[b] n (% weighted)				
High school education and below	3,737 (40.6)	968 (40.4)	1,366 (40.7)	1,403 (40.5)
Some college and above	3,809 (56.8)	959 (57.3)	1,444 (56.3)	1,406 (57.0)
Marital status (household reference), n (% weighted)				
Married/living with partner	5,413 (75.0)	1,425 (78.5)	2,026 (75.8)	1,962 (72.4)
Divorced/separated/widowed/never married	2,161 (23.0)	503 (20.0)	824 (23.0)	834 (24.6)
Family poverty income ratio, n (weighted %)				
<130%	3,356 (33.0)	962 (38.4)	1,280 (34.2)	1,114 (29.2)
130%–<300%	1,992 (27.6)	470 (26.0)	730 (28.0)	792 (28.1)
≥300%	1,858 (33.1)	405 (29.8)	701 (31.9)	752 (35.9)
Daily intake 8 oz servings, mean (SE)				
Sugar-sweetened beverages	1.3 (0.04)	0.6 (0.03)	1.1 (0.04)	1.7 (0.07)
Water	2.3 (0.07)	1.4 (0.05)	1.9 (0.08)	3.2 (0.14)
Daily total energy intake (kcal), mean (SE)	1,866 (16.4)	1,521 (15.0)	1,910 (19.9)	2,016 (28.1)

[a]Normal weight: BMI for age and sex less than 85th percentile; overweight: 85th to less than 95th percentile; obese: 95th percentile or greater.

[b]Household reference is the first person aged ≥18 years listed under household members who owns or rents the place of residence.

Table 2. Adjusted Differences in Total Healthy Eating Index-2010 Scores by Beverage Consumption in Children Aged 2–18 Years: National Health and Nutrition Examination Surveys 2009–2014[a]

Beverage intake	n (weighted %)	Total sample (n=7,757)	2-5 years (n=1,972)	6-11 years (n=2,890)	12-18 years (n=2,895)
Sugar-sweetened beverages[b,c]					
0 servings/day	1,819 (24.8)	ref	ref	ref	ref
>0–1 serving/day	2,460 (30.4)	**–3.5***	**–3.7**	–1.7	**–3.9**
		(–5.1, –1.9)	**(–5.9, –1.5)**	(–3.4, 0.02)	**(–6.4, –1.5)**
>1–2 servings/day	1,855 (22.3)	**–6.1***	**–7.9***	**–4.3**	**–5.6***
		(–7.6, –4.7)	**(–10.2, –5.6)**	**(–6.4, –2.1)**	**(–8.1, –3.1)**
>2 servings/day	1,623 (22.5)	**–9.5***	**–13.6***	**–9.0***	**–8.5***
		(–10.8, –8.3)	**(–15.8, –11.4)**	**(–10.7, –7.4)**	**(–10.5, –6.4)**
p-trend		**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Water[b,c]					
0 servings/day	920 (11.7)	ref	ref	ref	ref
>0–1 serving/day	1,725 (21.2)	**2.0**	1.5	**3.5**	0.8
		(0.9, 3.1)	(–0.9, 3.9)	**(1.5, 5.6)**	(–1.3, 2.9)
>1–2 servings/day	2,024 (24.7)	**2.9***	**3.1***	**4.3**	1.6
		(1.6, 4.1)	**(0.4, 5.7)**	**(1.9, 6.6)**	(–0.4, 3.6)
>2 servings/day	3,088 (42.3)	**4.8***	**4.3**	**6.1**	**3.8***
		(3.6, 6.0)	**(1.7, 7.0)**	**(3.2, 9.1)**	**(2.2, 5.4)**
p-trend		**<0.0001**	**0.0005**	**0.0009**	**<0.0001**

Notes: Boldface indicates statistical significance compared to reference (ref) group of 0 servings (*$p<0.05$; **$p<0.01$; ***$p<0.0001$).
[a]Adjusted for age, sex, race, poverty income ratio, household reference education, household reference marital status, and weight status.
[b]p-values from Wald tests for heterogeneity of OR by age group were: <0.0001 for sugar-sweetened beverages and 0.20 for water.
[c]1 serving is defined as 8 fl oz.

Table 3. Adjusted Differences in Total Energy Intake by Beverage Consumption in Children Aged 2–18 Years: National Health and Nutrition Examination Survey 2009–2014[a]

Beverage intake	n (weighted %)	Total sample (n=7,757)	2–5 years (n=1,972)	6–11 years (n=2,890)	12–18 years (n=2,895)
Sugar-sweetened beverages[b,]					
0 servings/day	1,819 (24.8)	ref	ref	ref	ref
>0–1 serving/day	2,460 (30.4)	**82.4***	22.1	**101.3**	53.3
		(17.5, 147.2)	(−62.9, 107.1)	**(43.8, 158.9)**	(−86.1, 192.6)
>1–2 servings/day	1,855 (22.3)	**171.5***	**111.5***	**164.6***	**153.1***
		(103.7, 239.4)	**(4.6, 218.4)**	**(77.9, 251.3)**	**(26.7, 279.5)**
>2 servings/day	1,623 (22.5)	**394.4***	**266.3***	**384.2***	**393.9***
		(318.6, 470.2)	**(154.4, 378.2)**	**(264.0, 504.4)**	**(266.8, 521.1)**
p-trend		**<0.0001**	**0.0008**	**<0.0001**	**<0.0001**
Water[b,c]					
0 servings/day	920 (11.7)	ref	ref	ref	ref
>0–1 serving/day	1,725 (21.2)	−42.3	−76.8	−104.3	36.5
		(−125.1, 40.4)	(−185.6, 31.9)	(−233.6, 25.0)	(−116.8, 189.9)
>1–2 servings/day	2,024 (24.7)	−25.8	−71.7	−20.4	−42.8
		(−108.3, 56.7)	(−193.2, 49.7)	(−130.3, 89.4)	(−204.9, 119.2)
>2 servings/day	3,088 (42.3)	17.2	−40.1	−6.0	32.8
		(−75.1, 109.5)	(−174.4, 94.2)	(−118.4, 106.5)	(−100.6, 166.1)
p-trend		0.30	0.95	0.19	0.65

Notes: Boldface indicates statistical significance compared to reference (ref) group of 0 servings (*$p<0.05$; **$p<0.01$; ***$p<0.0001$).
[a]Adjusted for age, sex, race, poverty income ratio, household reference education, household reference marital status, and weight status.
[b]*p*-values from Wald tests for heterogeneity of OR by age group were: 0.88 for sugar-sweetened beverages and 0.07 for water.
[c]1 serving is defined as 8 fl oz.

Table 4. Adjusted Relative Differences in Healthy Eating Index-2010 Component Scores by Beverage Consumption: National Health and Nutrition Examination Survey 2009–2014

Beverage intake[a]	Sugar-sweetened beverage intake β (95% C)[b]	Water intake β (95% CI)[b]
Vegetables		
0 servings/day	ref	ref
>0–1 serving/day	0.95 (0.89, 1.01)	1.00 (0.93, 1.07)
>1–2 servings/day	**0.91 (0.84, 0.99)***	**1.08 (1.01, 1.15)***
>2 servings/day	**0.86 (0.81, 0.92)*****	**1.13 (1.05, 1.21)****
Total fruit		
0 servings/day	ref	ref
>0–1 serving/day	**0.91 (0.85, 0.98)***	1.08 (0.98, 1.19)
>1–2 servings/day	**0.82 (0.75, 0.89)*****	**1.15 (1.03, 1.28)***
>2 servings/day	**0.69 (0.61, 0.77)*****	**1.21 (1.08, 1.34)****
Whole fruit		
0 servings/day	ref	ref
>0–1 serving/day	**0.88 (0.81, 0.96)****	**1.13 (1.02, 1.26)***
>1–2 servings/day	**0.82 (0.75, 0.91)*****	**1.27 (1.14, 1.41)*****
>2 servings/day	**0.66 (0.58, 0.75)*****	**1.40 (1.26, 1.55)*****
Greens and beans		
0 servings/day	ref	ref
>0–1 serving/day	**0.81 (0.70, 0.94)****	1.18 (0.91, 1.54)
>1–2 servings/day	**0.75 (0.63, 0.90)****	1.28 (1.00, 1.64)
>2 servings/day	**0.68 (0.56, 0.84)*****	**1.41 (1.11, 1.80)****
Whole grains		
0 servings/day	ref	ref
>0–1 serving/day	**0.88 (0.78, 0.98)***	**1.27 (1.13, 1.43)*****
>1–2 servings/day	**0.73 (0.64, 0.84)*****	**1.28 (1.14, 1.43)*****
>2 servings/day	**0.58 (0.51, 0.66)*****	**1.48 (1.32, 1.66)*****
Dairy		
0 servings/day	ref	ref
>0–1 serving/day	0.98 (0.94, 1.02)	1.04 (0.99, 1.09)
>1–2 servings/day	**0.94 (0.90, 0.99)***	1.02 (0.97, 1.07)
>2 servings/day	**0.86 (0.82, 0.90)*****	1.00 (0.96, 1.05)
Total protein foods		
0 servings/day	ref	ref
>0–1 serving/ day	1.00 (0.96, 1.03)	0.99 (0.95, 1.04)
>1–2 servings/day	1.00 (0.96, 1.04)	1.01 (0.95, 1.07)
>2 servings/day	0.96 (0.93, 1.00)	1.06 (1.00, 1.12)
Seafood and plant proteins		
0 servings/day	ref	ref
>0–1 serving/day	1.01 (0.91, 1.11)	**1.20 (1.05, 1.36)****
>1–2 servings/day	0.96 (0.84, 1.09)	**1.20 (1.09, 1.33)****
>2 servings/day	**0.83 (0.74, 0.93)****	**1.33 (1.15, 1.52)*****
Fatty acids		
0 servings/day	ref	ref

>0–1 serving/day	0.98 (0.92, 1.05)	0.96 (0.87, 1.05)
>1–2 servings/day	1.03 (0.96, 1.11)	1.00 (0.91, 1.10)
>2 servings/day	1.06 (0.98, 1.15)	1.05 (0.95, 1.17)
Sodium		
0 servings/day	ref	ref
>0–1 serving/day	1.05 (0.99, 1.12)	0.98 (0.90, 1.07)
>1–2 servings/day	**1.09 (1.02, 1.16)***	0.92 (0.84, 1.01)
>2 servings/day	**1.25 (1.17, 1.33)*****	**0.86 (0.78, 0.94)****
Refined grains		
0 servings/day	ref	ref
>0–1 serving/day	0.95 (0.90, 1.00)	**0.91 (0.86, 0.97)****
>1–2 servings/day	0.96 (0.91, 1.02)	**0.89 (0.84, 0.95)****
>2 servings/day	**1.07 (1.03, 1.12)****	**0.86 (0.81, 0.92)*****
Empty calories		
0 servings/day	ref	ref
>0–1 serving/day	**0.88 (0.85, 0.91)*****	**1.13 (1.08, 1.18)*****
>1–2 servings/day	**0.77 (0.74, 0.80)*****	**1.17 (1.12, 1.23)*****
>2 servings/day	**0.61 (0.58, 0.64)*****	**1.29 (1.23, 1.35)*****

Notes: Boldface indicates statistical significance compared to reference (ref) group of 0 servings ($*p<0.05$; $**p<0.01$; $***p<0.0001$).

[a]1 serving is defined as 8 fl oz.

[b]Adjusted for age, sex, race, poverty income ratio, household reference education, household reference marital status, and weight status.

Appendix Table 1. Healthy Eating Index (HEI)-2010 Component Scores Including and Excluding Contributions From Sugar-sweetened Beverages (SSBs) in Children Aged 2–18 Years: National Health and Nutrition Examination Surveys 2009–2014

HEI-2010 component	Max score	Including SSBs	Excluding SSBs
Vegetables	5	2.3 (0.03)	2.4 (0.03)
Total fruit	5	2.6 (0.05)	2.6 (0.05)
Whole fruit	5	2.4 (0.05)	2.4 (0.05)
Greens and beans	5	1.0 (0.03)	1.0 (0.03)
Whole grains	10	2.6 (0.06)	2.7 (0.06)
Dairy	10	7.2 (0.06)	7.4 (0.06)
Total protein foods	5	3.7 (0.03)	3.8 (0.03)
Seafood and plant proteins	5	1.6 (0.03)	1.6 (0.03)
Fatty acids	10	3.9 (0.06)	4.0 (0.06)
Sodium	10	4.7 (0.07)	4.1 (0.07)
Refined grains	10	5.2 (0.05)	4.7 (0.05)
Empty calories	20	12.5 (0.10)	14.3 (0.09)
Total score	100	49.7 (0.3)	51.0 (0.3)

[a] All standard criteria, except for fatty acids and empty calories, are per 1,000 kcal.

Appendix Table 2. Adjusted Differences in Healthy Eating Index-2010 Total Scores (Excluding Contributions From Sugar-sweetened Beverages) by Beverage Consumption in Children Aged 2–18 Years: National Health and Nutrition Examination Surveys 2009–2014

Beverage intake	Total (n=7,757)	2–5 years (n=1,972)	6–11 years (n=2,890)	12–18 years (n=2,895)
Sugar-sweetened beverages				
0 servings/day	ref	ref	ref	ref
>0–1 serving/day	**–2.8****	**–3.1****	–1.1	**–3.2***
	(–4.4, –1.2)	**(–5.3, –0.9)**	(–2.8, 0.6)	**(–5.6, –0.7)**
>1–2 servings/day	**–4.6*****	**–6.3*****	**–2.7***	**–4.1****
	(–6.1, –3.1)	**(–8.6, –4.0)**	**(–4.9, –0.6)**	**(–6.5, –1.6)**
>2 servings/day	**–6.4*****	**–10.7*****	**–6.3*****	**–5.2*****
	(–7.7, –5.2)	**(–13.1, –8.4)**	**(–7.9, –4.6)**	**(–7.3, –3.0)**
p-trend	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Water				
0 servings/day	ref	ref	ref	ref
>0–1 serving/day	**1.5***	1.1	**3.2****	0.0
	(0.4, 2.6)	(–1.4, 3.7)	**(1.1, 5.3)**	(–2.0, 2.1)
>1–2 servings/day	**2.2*****	2.6	**3.6****	0.9
	(1.0, 3.4)	(–0.1, 5.3)	**(1.2, 6.0)**	(–1.0, 2.9)
>2 servings/day	**3.8*****	**3.7****	**5.4****	**2.6****
	(2.8, 4.9)	**(1.0, 6.4)**	**(2.5, 8.2)**	**(1.1, 4.1)**
p-trend	**<0.0001**	**0.002**	**0.002**	**<0.0001**

Notes: Boldface indicates statistical significance compared to reference (ref) group of 0 servings (*p<0.05; **p<0.01; ***p<0.0001).

[a]Adjusted for age, sex, race, poverty income ratio, household reference education, household reference marital status, weight status, and total energy intake.

[b]*p*-values from Wald tests for heterogeneity of OR by age group were: <0.0001 for sugar-sweetened beverages and 0.21 for water.

[c]1 serving is defined as 8 fl oz.

Appendix Table 3. Adjusted Differences in Total Energy Intake (Excluding Contributions From Sugar-sweetened Beverages) by Beverage Consumption in Children Aged 2–18 Years: National Health and Nutrition Examination Surveys 2009–2014

Beverage intake	Total (n=7,757)	2–5 years (n=1,972)	6–11 years (n=2,890)	12–18 years (n=2,895)
Sugar-sweetened beverages				
0 servings/day	ref	ref	ref	ref
>0–1 serving/day	29.9 (–34.7, 94.6)	–22.4 (–106.6, 61.9)	51.1 (–6.7, 108.9)	–11.0 (–148.9, 126.9)
>1–2 servings/day	45.9 (–22.3, 114.1)	–9.8 (–116.0, 96.5)	35.3 (–53.6, 124.1)	20.4 (–105.3, 146.2)
>2 servings/day	**101.8 (28.8, 174.8)****	38.2 (–58.0, 134.4)	**126.5 (5.7, 247.4)***	64.8 (–54.2, 183.8)
p-trend	**0.003**	0.81	0.07	0.20
Water				
0 servings/day	ref	ref	ref	ref
>0–1 serving/day	14.0 (–61.9, 89.9)	–56.8 (–151.9, 38.4)	–56.5 (–179.8, 66.8)	115.3 (–19.0, 249.7)
>1–2 servings/day	46.0 (–28.5, 120.6)	–32.6 (–139.9, 74.8)	39.1 (–69.4, 147.5)	53.0 (–92.7, 198.8)
>2 servings/day	**113.1 (33.4, 192.7)****	4.4 (–114.7, 123.5)	66.0 (–39.6, 171.5)	**170.6 (56.3, 285.0)****
p-trend	0.0005	0.42	**0.005**	**0.007**

Notes: Boldface indicates statistical significance compared to reference (ref) group of 0 servings (*p<0.05; **p<0.01; ***p<0.0001).

[a]Adjusted for age, sex, race, poverty income ratio, household reference education, household reference marital status, weight status, and total energy intake.

[b]*p*-values from Wald tests for heterogeneity of OR by age group were: 0.59 for sugar-sweetened beverages and 0.004 for water.

[c]1 serving is defined as 8 fl oz.

Appendix Table 4. Adjusted Relative Differences (95% CI) of Healthy Eating Index-2010 Component Scores (Excluding Contributions From Sugar-sweetened Beverages) by Beverage Intake in Children Aged 2–18 Years: National Health and Nutrition Examination Surveys 2009–2014

Beverage intake[a]	Sugar-sweetened beverage intake β (95% CI)[b]	Water intake β (95% CI)[b]
Vegetables		
0 servings/day	ref	ref
>0–1 serving/day	0.97 (0.91, 1.04)	0.97 (0.91, 1.04)
>1–2 servings/day	0.96 (0.89, 1.04)	1.04 (0.98, 1.11)
>2 servings/day	0.97 (0.91, 1.03)	**1.08 (1.01, 1.16)***
Total fruit		
0 servings/day	ref	ref
>0–1 serving/day	**0.91 (0.85, 0.97)****	1.08 (0.97, 1.20)
>1–2 servings/day	**0.79 (0.73, 0.86)*****	**1.15 (1.02, 1.28)***
>2 servings/day	**0.67 (0.59, 0.76)*****	**1.20 (1.07, 1.35)****
Whole fruit		
0 servings/day	ref	ref
>0–1 serving/day	**0.88 (0.81, 0.96)****	**1.12 (1.01, 1.24)****
>1–2 servings/day	**0.82 (0.75, 0.90)*****	**1.25 (1.13, 1.39)*****
>2 servings/day	**0.67 (0.59, 0.76)*****	**1.37 (1.23, 1.52)*****
Greens and beans		
0 servings/day	ref	ref
>0–1 serving/day	**0.82 (0.71, 0.95)****	1.16 (0.90, 1.51)
>1–2 servings/day	**0.78 (0.65, 0.93)****	1.26 (0.99, 1.61)
>2 servings/day	**0.71 (0.58, 0.87)****	**1.39 (1.09, 1.77)****
Whole grains		
0 servings/day	ref	ref
>0–1 serving/day	0.90 (0.80, 1.01)	**1.24 (1.10, 1.39)****
>1–2 servings/day	**0.78 (0.68, 0.89)*****	**1.24 (1.10, 1.38)*****
>2 servings/day	**0.65 (0.57, 0.74)*****	**1.42 (1.28, 1.59)*****
Dairy		
0 servings/day	ref	ref
>0–1 serving/day	0.99 (0.95, 1.03)	1.02 (0.97, 1.07)
>1–2 servings/day	0.98 (0.93, 1.02)	1.00 (0.96, 1.05)
>2 servings/day	**0.93 (0.88, 0.97)****	0.98 (0.94, 1.03)
Total protein foods		
0 servings/day	ref	ref
>0–1 serving/day	1.01 (0.98, 1.04)	0.99 (0.95, 1.03)
>1–2 servings/day	1.03 (0.99, 1.07)	1.00 (0.94, 1.05)
>2 servings/day	1.03 (0.99, 1.06)	1.04 (0.98, 1.09)
Seafood and plant proteins		
0 servings/day	ref	ref
>0–1 serving/day	1.01 (0.92, 1.12)	**1.19 (1.06, 1.34)****
>1–2 servings/day	0.97 (0.85, 1.11)	**1.18 (1.07, 1.30)****
>2 servings/day	**0.84 (0.76, 0.94)****	**1.30 (1.14, 1.50)*****

Fatty acids		
0 servings/day	ref	ref
>0–1 serving/day	0.98 (0.92, 1.05)	0.96 (0.87, 1.05)
>1–2 servings/day	1.04 (0.96, 1.12)	1.00 (0.91, 1.10)
>2 servings/day	1.07 (0.99, 1.15)	1.05 (0.96, 1.16)
Sodium		
0 servings/day	ref	ref
>0–1 serving/day	0.98 (0.92, 1.04)	1.04 (0.94, 1.15)
>1–2 servings/day	**0.91 (0.85, 0.98)***	1.00 (0.90, 1.11)
>2 servings/day	**0.89 (0.83, 0.95)***	0.95 (0.84, 1.07)
Refined grains		
0 servings/day	ref	ref
>0–1 serving/day	**0.90 (0.85, 0.95)*****	0.96 (0.90, 1.04)
>1–2 servings/day	**0.84 (0.79, 0.90)*****	0.95 (0.88, 1.02)
>2 servings/day	**0.83 (0.78, 0.87)*****	0.95 (0.88, 1.02)
Empty calories		
0 servings/day	ref	ref
>0–1 serving/day	**0.94 (0.92, 0.97)*****	1.03 (0.99, 1.08)
>1–2 servings/day	**0.92 (0.89, 0.96)*****	**1.05 (1.01, 1.10)***
>2 servings/day	**0.91 (0.87, 0.94)*****	**1.10 (1.07, 1.14)*****

Notes: Boldface indicates statistical significance compared to reference (ref) group of 0 servings (*p*<0.05; **p*<0.01; ***p*<0.0001).
[a]1 serving is defined as 8 fl oz.
[b]Adjusted for age, sex, race, poverty income ratio, household reference education, household reference marital status, and weight status.