Consumption of added sugars is decreasing in the United States[1–4]

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ABSTRACT

Background: The consumption of added sugars (caloric sweeteners) has been linked to obesity, diabetes, and heart disease. Little is known about recent consumption trends in the United States or how intakes compare with current guidelines.

Objective: We examined trends in intakes of added sugars in the United States over the past decade.

Design: A cross-sectional study of US residents ≥2 y of age (n = 42,316) was conducted by using dietary data from NHANES 1999–2008 (five 2-y cycles) and data for added-sugar contents from the MyPyramid Equivalents Database. Mean intakes of added sugars (grams and percentage of total energy intake) were weighted to obtain national estimates over time across age, sex, and race-ethnic groups. Linear trends were tested by using Wald's F tests.

Results: Between 1999–2000 and 2007–2008, the absolute intake of added sugars decreased from a mean (95% CI) of 100.1 g/d (92.8, 107.3 g/d) to 76.7 g/d (71.6, 81.9 g/d); two-thirds of this decrease, from 37.4 g/d (32.6, 42.1 g/d) to 22.8 g/d (18.4, 27.3 g/d), resulted from decreased soda consumption (P-linear trend <0.001 for both). Energy drinks were the only source of added sugars to increase over the study period (P-linear trend = 0.003), although the peak consumption reached only 0.15 g/d (0.08, 0.22 g/d). The percentage of total energy from added sugars also decreased from 18.1% (16.9%, 19.3%) to 14.6% (13.7%, 15.5%) (P-linear trend <0.001).

Conclusion: Although the consumption of added sugars in the United States decreased between 1999–2000 and 2007–2008, primarily because of a reduction in soda consumption, mean intakes continue to exceed recommended limits. *Am J Clin Nutr* 2011;94:726–34.

INTRODUCTION

The contribution of added sugar (ie, caloric sweeteners added in the processing or preparation of foods and beverages) to the US diet has been shown to have increased through the mid-1990s. Dietary data show that between 1977–1978 and 1994–1996, the average daily consumption of added sugars by Americans ≥2 y of age increased from 235 to 318 calories, an increase of 35% (1). In 1994–1996, regular soft drinks were the largest contributor of added sugars and the greatest single source of calories in the US diet (2).

Although sugars used as caloric sweeteners are chemically indistinguishable from naturally occurring sugars, the USDA began to use the term *added sugars* in 2000 to help consumers identify foods with added energy but few additional micronutrients or phytochemicals (3). The increased consumption of added sugars has been linked to an overall decrease in diet quality (4), an increase in body weight and obesity (5), and the development of cardiovascular disease and its risk factors (6, 7). Sucrose (table sugar) and high-fructose corn syrup are the 2 forms of added sugar most commonly consumed in the United States. Both sucrose and high-fructose corn syrup are composed of nearly equal amounts of the simple sugars glucose and fructose.

Small experimental studies have shown that high intake of sugars, particularly those that contain fructose, can raise triglyceride concentrations and lower HDL (good cholesterol) concentrations (8). In addition, population-based data from NHANES have shown a link between the consumption of added sugars and cardiovascular disease risk factors, including dyslipidemia in adults (6) and adolescents (9) and measures of insulin resistance in overweight adolescents (9). Similarly, prospective data from the Nurses' Health Study have shown an association between the consumption of added sugars and an increased incidence of diabetes (10) and cardiac events (7).

Despite the substantial contribution of added sugars to the US diet in previous decades and the demonstrated association between sugar intakes and cardiovascular disease risk and obesity, little is known about recent trends in consumption. The last published description of added-sugar intake used dietary data collected in 1994–1996 (11). The purpose of this study was to provide updated national estimates of added-sugar consumption amounts among specific population groups and to analyze trends in the amount and sources of added sugars consumed between 1999–2000 and 2007–2008.

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SUBJECTS AND METHODS

Sample

Data for our study came from the NHANES. NHANES is a sequential series of cross-sectional surveys of the US civilian, noninstitutionalized population designed to obtain nationally representative estimates on diet and health indicators. A description of the complex sampling methodology used in NHANES is available elsewhere (12). The sample for this study consisted of individuals $\geq$2 y of age who live in the United States and were invited and agreed to participate in NHANES during one of the five 2-y data collection cycles between 1999 and 2008 (n = 47,396). Individuals who were selected to participate in NHANES but did not provide dietary information or whose dietary information was deemed unreliable (13) were excluded from the analysis (n = 4938) as were individuals who consumed one or more food items for which the added-sugar content information was not available and could not be estimated (n = 142), which gave a final sample of n = 42,316. Study protocols for NHANES 1999–2008 were approved by the institutional review board at the National Center for Health Statistics (14). Signed, informed consent was obtained from all participants or their parents or guardians.

Added sugars and other dietary intakes

One interviewer-assisted 24-h dietary recall was done in NHANES 1999–2000 and 2001–2002, and 2 recalls were done in subsequent cycles. For consistency with earlier cycles, we used only the first recall to assess dietary intakes in 2003–2004, 2005–2006, and 2007–2008. Proxy respondents were used for survey examinees who were <6 y of age, and children aged 6–11 y underwent assisted interviews (15). The nutrient content of foods consumed, including intakes of total calories, carbohydrates, fats, and proteins, was determined by NHANES by using the Food and Nutrient Database for Dietary Studies (16) which uses food-composition data from the USDA National Nutrient Database for Standard Reference (17).

Because the Standard Reference database does not maintain information on the added-sugar content of many foods, we merged the individual food files from NHANES with the USDA MyPyramid Equivalents database (MPED). The MPED provides the number of MyPyramid equivalents (standard serving sizes) of major food categories shown on the USDA Food Guide Pyramid (grains, meat, dairy, fruit, vegetables, and beans as well as for added sugars and discretionary fat) that are present in 100 g of each of the foods consumed by participants in NHANES. The MPED version 1.0 was used for data collected from 1999 to 2004, and version 2.0 was used for data from 2003 to 2004 (18).

Because MyPyramid serving-size equivalents are available only for foods reported as consumed through the 2003–2004 NHANES cycle (MPED version 2.0), we used 2003–2004 data to estimate the added-sugar content of foods consumed by participants in the more recent NHANES surveys. With the use of a method described in detail elsewhere (6), food codes for food items consumed in 2005–2006 and 2007–2008 were first matched with those in the 2003–2004 data set. Items with exact food-code matches were assigned the 2003–2004 value of added sugars. Independent estimates for foods items without an exact match were imputed by 2 investigators (JAW and LG). The first step was to use food codes and food descriptions to identify similar foods in the MPED 2003–2004 data set. For example, "SWEETPOTATO, CANNED IN SYRUP, W/ FAT ADDED" was reported in the 2005–2006 dietary recall but did not have a corresponding MPED equivalent. The added-sugar content of this food was assigned the same value as "SWEETPOTATO, CANNED, NS (not specific) AS TO SYRUP." For processed foods that had no similar comparison food in the MPED 2003–2004 data set, the product nutrition label information was used. For mixed foods with missing data, recipes from frequently accessed online recipes were used to determine whether they included added sugars.

The term *added sugars*, as defined for use in the MPED, includes all sugars used as ingredients in processed or prepared foods. These sugars include sugars eaten separately or added to foods at the table. Examples include white sugar, brown sugar, corn syrup, corn-syrup solids, high-fructose corn syrup, malt syrup, maple syrup, pancake syrup, fructose sweetener, liquid fructose, honey, molasses, anhydrous dextrose, crystal dextrose, and dextrin (19). Added sugars do not include naturally occurring sugars such as lactose in milk or the fructose in fruit. In the MPED, quantities of added sugar are expressed in terms of teaspoons equivalents of table (granulated white) sugar (food code 91101010) per each 100 g of a food. One teaspoon of added sugar is defined as the quantity of sweetener that contains the same amount of sugars provided by 1 teaspoon (4.2 g) of table sugar. Recipe information is used to determine the quantity of added sugars in mixed foods. A complete description of the MPED database (20) and the methods used to calculate the sugar content of foods can be seen elsewhere (21).

Of the 6113 food and beverage items in the 1999–2008 databases consumed by NHANES participants $\geq$2 y of age, values for added-sugar contents of 5834 of these foods were obtained directly from the MPED databases. With the use of the methods previously described, we imputed added sugars values for the remaining 279 foods (72 foods in NHANES 2005–2006 and 207 foods in 2007–2008). The added-sugar content was estimated by using data from foods with a similar description for 165 of these foods and from food labels for 75 of these foods. Of the remaining foods, a total of 20 foods were unprocessed meats, grains, fruit or vegetables without breading or sauces and were, therefore, coded as having no added sugars; for 9 foods, the NHANES description specified that there was no sugar, and for 3 mixed foods, recipes indicated that there was no sugar added. We were unable to use the total sugar content information to estimate the added-sugar content for 7 foods that contained both naturally occurring and added sugars. Consumers of these foods (n = 142) were excluded from the data set.

To determine the total amount of added sugars consumed in each food and beverage, we multiplied the total amount consumed in grams as provided in the NHANES database by the amount of added sugars in each of these foods (teaspoons/100 g) as provided in the MPED database or imputed as previously described. The results for each food consumed were summed to obtain the daily total added-sugar intake in teaspoons and converted to grams by multiplying by 4.2 g/teaspoon (17). This result was multiplied by 4 kcal to obtain the total energy from added sugars. To obtain the percentage of total energy from added sugars, the total energy from added sugars (in kcal) was divided by the total energy intake (in kcal/d), which was calculated in NHANES as the sum of calories from all foods consumed.

Food codes from the USDA's Food and Nutrient Database for Dietary Studies were used to code individual foods reported by participants in NHANES (22). These food codes were used to group foods and beverages that contained added sugars into the following food groups (subgroups): sweets [sodas, candies and gums, added sugars and syrups, fruit-flavored drinks (fruitades) and sports drinks, presweetened coffees and teas, alcohol-containing drinks, and energy drinks], grains (cakes and cookies, ready-to-eat cereals, breads and muffins, and other grains), dairy (dairy desserts, milk, yogurt, and other dairy), fruit and vegetables, protein sources (a combination of meat, eggs, beans), and fats and oils. Sugar-sweetened or sugar beverages included the combined intakes of sodas and fruitades. Low-calorie beverages included all beverages that included the terms diet or low-calorie in the NHANES food description. This definition did not include drinking water.

Demographic variables

Self-reported demographic information included the participant's age in years (categorized as 2–5, 6–11, 12–17, 18–34, 35–54, and ≥55 y), sex, education (of respondents for adults and of parents or guardians for children), and race-ethnicity (non-Hispanic white, non-Hispanic black, Mexican American, other Hispanic).

Data analysis

Statistical analysis software (SAS version 9.2; SAS Institute) was used for all analyses. Procedures that accounted for the complex sampling design used in NHANES were applied. To ensure that results were representative of the US population, sample weights that reflected the probability of selection, nonresponse, and poststratification were used to estimate the means (CIs). Contrast statements were specified in linear regression models, and Wald's F tests were used to test for linear trends in consumption over the 5 2-y cycles of NHANES. All P values were 2-sided. $P < 0.05$ was considered significant.

A sensitivity analysis was done in the subsample of respondents who participated in NHANES 2007–2008. The estimated mean added-sugar intake for those respondents with no imputed values was compared with the estimated intake in respondents who consumed at least one food item for which the added-sugar content was imputed.

TABLE 1
Trends in intakes and sources of added sugars in US children and adults (≥2 y of age), NHANES 1999–2000 to 2007–2008[1]

	1999–2000 (n = 8070)	2001–2002 (n = 9032)	2003–2004 (n = 8273)	2005–2006 (n = 8501)	2007–2008 (n = 8435)
Nutrient intake					
Added sugars (% of energy)[2,***]	18.1 ± 0.6	17.1 ± 0.4	15.9 ± 0.4	14.5 ± 0.2	14.6 ± 0.4
Added sugars (g)***	100.1 ± 3.4	93.9 ± 1.9	88.1 ± 1.7	80.1 ± 2.0	76.7 ± 2.4
Sugared beverages (% of energy)[2,3,***]	9.3 ± 0.5	8.7 ± 0.3	7.9 ± 0.4	6.6 ± 0.2	6.6 ± 0.4
Total energy intake (kcal)*	2145 ± 22	2168 ± 17	2195 ± 16	2161 ± 29	2069 ± 24
Fat (% of energy)[2,**]	32.6 ± 0.3	32.9 ± 0.2	33.4 ± 0.2	33.6 ± 0.2	33.4 ± 0.2
Protein (% of energy)[2,***]	14.8 ± 0.1	14.8 ± 0.1	14.9 ± 0.1	15.5 ± 0.1	15.3 ± 0.1
Carbohydrates (% of energy)[2,***]	52.0 ± 0.3	52.0 ± 0.3	50.6 ± 0.3	49.8 ± 0.3	50.4 ± 0.3
Carbohydrates other than added sugars (% of energy)[2,***]	33.8 ± 0.6	34.9 ± 0.4	34.7 ± 0.4	35.3 ± 0.3	35.8 ± 0.3
Added sugars by food source (g)					
Sweets***	67.1 ± 3.0	62.5 ± 1.8	57.1 ± 1.9	49.5 ± 1.7	47.8 ± 2.2
Sodas, regular***	37.4 ± 2.2	33.4 ± 1.7	31.5 ± 1.4	24.3 ± 1.0	22.8 ± 2.1
Fruitades and sports drinks***	10.7 ± 0.5	11.1 ± 0.8	9.4 ± 0.8	9.0 ± 0.5	7.4 ± 0.4
Sugar and syrups***	9.5 ± 0.7	8.3 ± 0.2	6.7 ± 0.3	6.4 ± 0.3	6.3 ± 0.2
Candy and gum	6.1 ± 0.4	5.97 ± 0.3	5.4 ± 0.3	5.5 ± 0.5	5.7 ± 0.4
Coffee and tea	3.1 ± 0.4	3.2 ± 0.4	3.4 ± 0.4	3.3 ± 0.3	3.9 ± 0.4
Alcohol-containing beverages	0.2 ± 0.1	0.35 ± 0.1	0.64 ± 0.1	0.38 ± 0.1	0.36 ± 0.1
Energy drinks***	0.00 ± 0.00	0.06 ± 0.02	0.08 ± 0.04	0.12 ± 0.04	0.15 ± 0.03
Grains*	19.5 ± 0.9	18.8 ± 0.4	19.0 ± 0.6	18.6 ± 0.5	17.0 ± 0.5
Cakes and cookies**	11.3 ± 0.7	10.4 ± 0.4	11.0 ± 0.5	10.7 ± 0.4	9.4 ± 0.4
RTE cereals**	3.9 ± 0.2	3.9 ± 0.2	3.4 ± 0.2	3.2 ± 0.1	3.0 ± 0.1
Breads and muffins***	2.8 ± 0.1	3.2 ± 0.2	3.2 ± 0.1	3.2 ± 0.1	3.1 ± 0.1
Other grains***	1.6 ± 0.1	1.3 ± 0.1	1.5 ± 0.1	1.6 ± 0.1	1.5 ± 0.1
Dairy products*	8.4 ± 0.3	9.0 ± 0.3	8.0 ± 0.3	8.3 ± 0.4	7.9 ± 0.2
Dairy desserts*	4.9 ± 0.3	4.4 ± 0.2	4.0 ± 0.2	4.5 ± 0.2	3.8 ± 0.2
Sweetened milk	1.8 ± 0.2	2.1 ± 0.1	2.2 ± 0.1	1.9 ± 0.2	1.9 ± 0.2
Yogurt	0.78 ± 0.13	1.3 ± 0.06	0.88 ± 0.08	1.1 ± 0.07	1.1 ± 0.07
Other dairy	0.98 ± 0.77	1.2 ± 0.1	0.95 ± 0.06	0.95 ± 0.06	0.88 ± 0.08
Fruit and vegetables***	2.4 ± 0.1	1.8 ± 0.1	1.9 ± 0.2	1.7 ± 0.1	1.7 ± 0.1
Protein sources	1.8 ± 0.1	1.4 ± 0.1	1.8 ± 0.1	1.7 ± 0.1	1.8 ± 0.1
Oils**	0.85 ± 0.07	0.57 ± 0.05	0.56 ± 0.05	0.52 ± 0.06	0.60 ± 0.05

[1] All values are means ± SEs. RTE, ready to eat. One gram of added sugars = 4 calories; 1 teaspoon = 4.2 g. *,**,***Tests for linear trend over the five 2-y cycles between 1999–2000 and 2007–2008 were performed by using Wald's F tests: *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

[2] Percentage of total calorie intake.

[3] Sodas + fruitades and sports drinks.

RESULTS

The absolute intake of added sugars (g) in US residents ≥2 y of age decreased from 100.1 g (95% CI: 92.8, 107.3 g) (401 kcal) in 1999–2000 to 76.7 g (95% CI: 71.6, 81.9 g) (307 kcal) in 2007–2008, which was a decline of 24% (P-trend < 0.001; **Table 1**). The intake was significantly higher in male subjects than in female subjects in all age groups (P-trend < 0.009 for all), but there were no significant differences by sex when the consumption amount was adjusted for the total energy intake (data not shown). The intake of added sugars as a percentage of total energy in all participants also decreased significantly from 18.1% (16.9%, 19.3%) to 14.6% (13.7%, 15.5%) (P-trend < 0.001) over the same period.

Two-thirds of the decrease in the added-sugar intake resulted from a daily reduction of sugars consumed in soda from 37.4 g (32.6, 42.1 g) to 22.8 g (18.4, 27.3 g) (P-linear trend < 0.001; Table 1). Energy drinks were the only source of added sugars to increase over the study period (P-linear trend <0.001), although the peak consumption was minimal [0.15 g/g (0.08, 0.22 g/g) in 2007–2008; the mean consumption was highest in young adults (aged 18–34 y) at 0.40 g (0.15, 0.65 g)].

In parallel with the decreasing trend in added-sugar intakes, the total energy intake decreased from 2145 kcal/d (2098, 2192 kcal/d) to 2069 kcal/d (2018, 2121 kcal/d) (a decrease of 76 kcal/d), which was a decline of 4% (P-trend = 0.004), total carbohydrates decreased from 52.0% (51.3%, 52.6%) to 50.4% (49.8%, 52.1%) of the total energy intake (P-trend < 0.001), and percentages of total energy intake from fats, proteins, and other carbohydrates (excluding added sugars) each increased slightly (P-trend = 0.003, < 0.001, and < 0.001, respectively) (Table 1). Low-calorie beverage consumption also increased from 116 g (96, 136 g) to 140 g (125, 155 g) (P-trend = 0.006; data not shown).

The decreasing trend in added-sugar consumption over the study period was observed across all age, race-ethnicity, and income groups. The percentage of total calories from added sugars declined from 22.3% (20.5%, 24.1%) to 17.3% (15.9%, 18.7%) (a decrease of 22%; P-trend < 0.001) in adolescents (aged 12–17 y) (**Table 2**, **Figure 1**) and from 21.4% (19.3, 23.5)

TABLE 2
Food sources of added sugar in the diets of US children and adolescents (2–17 y of age), 1999–2000 to 2007–2008[1]

	2–5 y of age		6–11 y of age		12–17 y of age	
	1999–2000 (n = 665)	2007–2008 (n = 823)	1999–2000 (n = 961)	2007–2008 (n = 1107)	1999–2000 (n = 1708)	2007–2008 (n = 869)
Nutrient						
Added sugars (% of energy)[2]	17.0 ± 0.9	13.4 ± 0.3***	20.6 ± 0.9	17.0 ± 0.4***	22.3 ± 0.8	17.3 ± 0.7***
Added sugars (g)	68.4 ± 4.8	51.6 ± 1.2***	106 ± 6.6	83.6 ± 2.5**	124 ± 4.8	89.9 ± 3.5***
Sugared beverages (% of energy)[2,3]	6.3 ± 0.6	4.0 ± 0.3***	9.3 ± 0.6	6.2 ± 0.3***	12.9 ± 0.8	9.1 ± 0.7***
Total energy intake (kcal)	1597 ± 36	1525 ± 25*	2033 ± 61	1914 ± 31	2223 ± 52	2091 ± 44**
Fat (% of energy)[2]	31.4 ± 0.5	32.4 ± 0.5	33.2 ± 0.4	32.9 ± 0.5	32.4 ± 0.4	32.5 ± 0.4
Protein (% of energy)[2]	13.4 ± 0.2	14.1 ± 0.1*	13.1 ± 0.2	13.7 ± 0.2	13.7 ± 0.2	14.6 ± 0.3**
Total carbohydrates (% of energy)[2]	56.9 ± 0.5	55.0 ± 0.5	55.1 ± 0.4	54.6 ± 0.5*	54.9 ± 0.5	53.8 ± 0.5*
Carbohydrates other than added sugars (% of energy)[2]	39.9 ± 1.1	41.5 ± 0.4*	34.5 ± 0.8	37.7 ± 0.5**	32.7 ± 0.7	36.5 ± 0.5***
Added sugars by food source (g)						
Sweets	39.7 ± 4.0	24.0 ± 1.2***	67.1 ± 5.9	48.6 ± 1.9***	86.8 ± 3.8	59.6 ± 3.6***
Sodas, regular	9.5 ± 1.2	5.7 ± 0.8**	28.3 ± 1.8	17.8 ± 1.7***	51.7 ± 3.2	30.0 ± 3.2***
Fruitades and sports drinks	14.8 ± 1.7	8.5 ± 0.6***	15.8 ± 1.8	11.2 ± 0.8***	15.2 ± 1.4	10.7 ± 0.9**
Sugars and syrups	8.5 ± 1.3	4.5 ± 0.4**	11.5 ± 2.2	9.3 ± 0.14	8.2 ± 1.1	5.8 ± 0.7*
Candy and gum	6.3 ± 1.0	4.5 ± 0.4	9.7 ± 2.0	7.8 ± 0.7	8.8 ± 1.1	7.6 ± 0.8
Coffee and tea	0.57 ± 0.2	0.74 ± 0.2	1.7 ± 1.0	1.8 ± 0.5	2.7 ± 0.6	3.5 ± 0.8
Alcohol-containing drinks	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.01 ± 0.01
Energy drinks	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.10 ± 0.10
Grains	16.3 ± 1.0	14.0 ± 0.7*	22.6 ± 1.5	19.5 ± 1.2	24.0 ± 1.8	18.9 ± 1.0*
Cakes and cookies	7.9 ± 0.7	6.8 ± 0.4	9.2 ± 0.8	9.7 ± 0.8	12.8 ± 1.2	9.2 ± 0.9*
RTE cereals	5.0 ± 0.5	3.6 ± 0.3*	7.8 ± 0.8	5.0 ± 0.4**	6.7 ± 0.6	5.1 ± 0.3*
Breads and muffins	1.7 ± 0.2	1.6 ± 0.2	3.6 ± 0.8	3.2 ± 0.3	2.9 ± 0.2	2.4 ± 0.2
Other grains	1.8 ± 0.2	1.9 ± 0.2	2.0 ± 0.3	1.6 ± 0.2	1.7 ± 0.2	2.2 ± 0.3*
Dairy products	8.3 ± 1.0	10.8 ± 0.7	11.1 ± 1.3	12.1 ± 0.4	8.7 ± 0.7	7.7 ± 1.1
Dairy desserts	2.7 ± 0.3	2.7 ± 0.3	6.4 ± 1.1	5.2 ± 0.6	4.6 ± 0.6	4.4 ± 1.0
Sweetened milk	3.3 ± 0.9	5.2 ± 0.7	3.9 ± 0.6	5.6 ± 0.5	3.3 ± 0.6	2.5 ± 0.5
Yogurt	1.2 ± 0.3	2.0 ± 0.3	0.6 ± 0.21	1.0 ± 0.17	0.2 ± 0.09	0.5 ± 0.12
Other dairy	3.7 ± 0.5	0.9 ± 0.19***	0.2 ± 0.07	0.3 ± 0.07	0.6 ± 0.31	0.3 ± 0.09
Fruit and vegetables	2.7 ± 0.4	2.0 ± 0.4***	3.4 ± 0.5	3.1 ± 0.3**	2.5 ± 0.5	1.8 ± 0.2
Meats, beans, and eggs	1.1 ± 0.1	0.8 ± 0.11	1.2 ± 0.1	1.3 ± 0.1	1.4 ± 0.1	1.7 ± 0.1
Oils	0.16 ± 0.02	0.15 ± 0.08	0.38 ± 0.06	0.22 ± 0.03*	0.48 ± 0.07	0.28 ± 0.04*

[1] All values are means ± SEs. RTE, ready to eat. One gram of added sugars = 4 calories; 1 teaspoon = 4.2 g. *,**,***Tests for linear trend over the five 2-y cycles between 1999–2000 and 2007–2008 were performed by using Wald's F tests: *P < 0.05, **P < 0.01, ***P < 0.001.

[2] Percentage of total calorie intake.

[3] Sodas + fruitades and sports drinks.

to 16.3% (15.0, 17.5) (a decrease of 16%; *P*-trend $<$ 0.001) (**Table 3**) in young adults (aged 18–34 y), which were the highest-consuming age groups. Similar decreases in consumption were observed in children of other ages from 17.0% (15.1%, 18.9%) to 13.4% (12.8%, 14.1%) in children 2–5 y of age and 20.6% (18.%, 22.5%) to 17.0% (16.1%, 17.8%) in children 6–11 y of age (Table 2).

The percentage of total calories from added sugars decreased from 20.5% (19.2%, 21.7%) to 16.1% (15.6%, 16.5%) (a decrease of 21%; *P*-trend $<$ 0.001) in non-Hispanic blacks, who were the highest-consuming race-ethnic group. The decline was similar in non-Hispanic whites (20%; *P*-trend = 0.003) and Mexican Americans (20%; *P*-trend = 0.005). In other Hispanics, who were the lowest-consuming group, intake decreased from 15.9% (13.2%, 18.6%) to 13.4% (12.2%, 14.6%) (a decrease of 16%; *P*-trend = 0.001) (**Figure 2**).

Subjects in the lowest quartile of income were the highest consumers of total added sugars, and subjects in the highest income quartile were the lowest consumers of total added sugars. Consumption in both income groups decreased by 15–16% over the study period from 20.1% (18.4%, 21.7%) to 16.8% (14.9%, 18.7%) in quartile 1 (lowest income group) and from 16.2% (14.9%, 17.5%) to 13.7% (12.7%, 14.7%) in quartile 4 (highest income group) (**Figure 3**). Intakes in the middle income groups decreased 22–23% (*P*-trend $<$ 0.001 for all income groups).

Among all ages combined, sodas were the largest single contributor of added sugars throughout the years studied from 37.4% in 1999–2000 to 22.8% in 2007–2008 followed by cakes and cookies, fruitades and sports drinks, sugar and syrups, and candies and gum (Table 1). Sodas, together with these items, contributed 67% of added sugars consumed in 2007–2008. Sodas were the leading contributor of added sugars for all age groups except for the youngest children (aged 2–5 y) (Table 2) and oldest adults (aged $\geq$55 y) (Table 3). Fruitades and sports drinks were the leading sources of added sugars for children aged 2–5 y (Table 2), despite a 43% reduction in sugars from these beverages between 1999–2000 and 2007–2008 (*P*-trend $<$ 0.001).

In 2007–2008, the largest proportion of added sugars (ie, 41.4%) were consumed as part of a either lunch or dinner; 34.9% of added sugars were consumed as part of a snack, 31% of added sugars s were consumed as part of breakfast, and 2.4% of added sugars in food and beverage items were consumed over an extended period throughout the day. The majority of added sugars were consumed at home (ie, 64%; data not shown).

When the mean added-sugar intake for the subsample of respondents in 2007–2008 whose diets contained no foods with imputed added-sugar content was compared with the intake in respondent who consumed at least one food with imputed added sugar data, there was no significant difference. The total added sugar consumption in the former group was 14.6% of the daily energy intake and 13.9% in the latter group (*P* = 0.67; data not shown).

DISCUSSION

The results of our analyses show that the consumption of added sugars in the United States decreased significantly between 1999–2000 and 2007–2008. In place of added sugars, the percentage of total calories from protein, fat, and other carbohydrates have risen slightly. Although the total calorie intake remained stable over the first years of the study, it decreased in 2007–2008; therefore, to facilitate comparisons between years, results for added-sugar

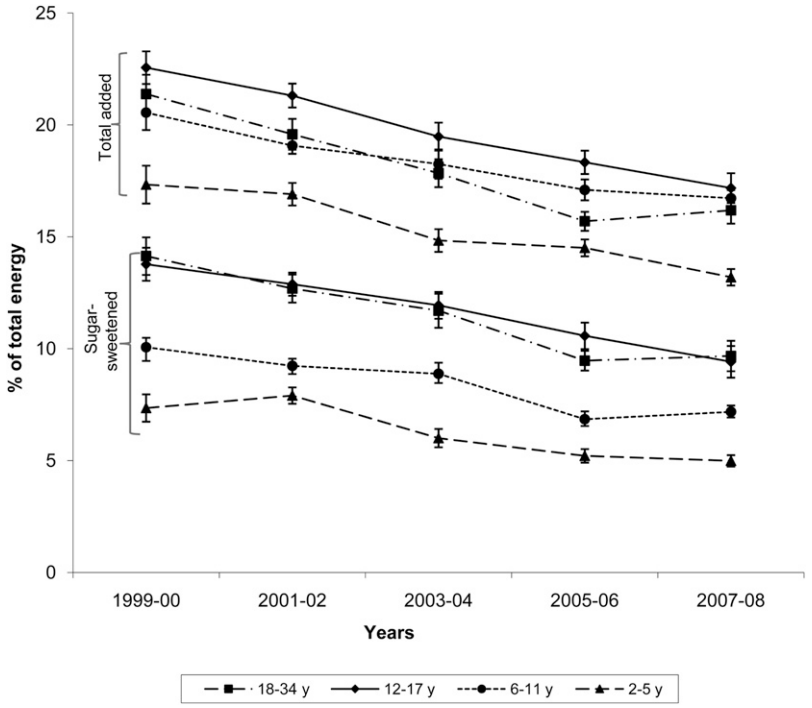

FIGURE 1. Mean (±SE) trends in the proportion of total energy intake consumed as added sugars and as sugar-sweetened beverages (SSBs) in US children and young adults by age group, NHANES 1999–2000 to 2007–2008. Results of linear trends by using Wald's *F* tests were $P < 0.0001$ for total added-sugar and SSB intakes for all subjects aged $<$35 y. In subjects aged 35–54 y, *P*-trend = 0.0005 for total added-sugar intake and *P*-trend = 0.001 for SSB intake; in subjects aged $\geq$55 y, *P*-trend = 0.002 for total added-sugar intake and *P*-trend = 0.01 for SSB intake.

TABLE 3
Food sources of added sugar in the diets of US adults (≥18 y of age), 1999–2000 to 2007–2008[1]

	18–34 y of age		35–54 y of age		≥55 y of age	
	1999–2000 (n = 1635)	2007–2008 (n = 1518)	1999–2000 (n = 1343)	2007–2008 (n = 1832)	1999–2000 (n = 1758)	2007–2008 (n = 2286)
Nutrient						
Added sugars (% of energy)[2]	21.4 ± 0.9	16.3 ± 0.6***	16.7 ± 0.9	14.3 ± 0.6*	13.3 ± 0.3	11.8 ± 0.2**
Added sugars (g)	132 ± 6.1	92.3 ± 4.1**	93.1 ± 5.1	80.7 ± 3.5*	65.1 ± 1.8	54.8 ± 1.4***
Sugared beverages (% of energy)[2,3]	13.8 ± 0.9	9.5 ± 0.7***	8.0 ± 0.6	6.7 ± 0.6***	4.7 ± 0.3	3.4 ± 0.2***
Total energy intake (kcal)	2455 ± 47	2268 ± 39***	2198 ± 42	2251 ± 36	1856 ± 26	1813 ± 39
Fat (% of energy)[2]	31.6 ± 0.4	32.1 ± 0.4	33.4 ± 0.6	34.1 ± 0.3	32.8 ± 0.5	34.3 ± 0.3*
Protein (% of energy)[2]	14.4 ± 0.3	15.3 ± 0.3**	15.6 ± 0.2	15.7 ± 0.1	15.9 ± 0.1	16.0 ± 0.2
Carbohydrates (% of energy)[2]	52.6 ± 0.5	50.8 ± 0.5**	49.4 ± 0.7	48.2 ± 0.5*	50.6 ± 0.4	49.1 ± 0.4*
Carbohydrates other than added sugars (% of energy)[2]	31.2 ± 0.6	34.6 ± 0.6*	32.7 ± 0.9	33.9 ± 0.5*	37.3 ± 0.6	37.3 ± 0.4
Added sugars by food source (g)						
Sweets	99.8 ± 54.	65.4 ± 4.0***	59.3 ± 4.3	51.7 ± 3.4	35.9 ± 1.3	26.1 ± 1.1***
Sodas, regular	65.9 ± 5.0	36.5 ± 4.1***	31.2 ± 2.8	25.2 ± 2.5***	15.7 ± 1.1	9.4 ± 0.8***
Fruitades and sports drinks	13.3 ± 1.4	9.2 ± 0.8**	8.6 ± 1.0	6.7 ± 0.8	5.0 ± 0.6	3.5 ± 0.3
Sugars and syrups	10.0 ± 1.2	6.1 ± 0.5**	10.5 ± 1.5	6.9 ± 0.4*	7.3 ± 0.5	5.4 ± 0.3**
Candy and gum	5.7 ± 0.8	5.1 ± 0.7	5.0 ± 0.6	6.4 ± 0.8	5.3 ± 0.6	4.5 ± 0.5
Coffee and tea	4.5 ± 0.8	5.6 ± 0.9	3.5 ± 0.6	4.63 ± 0.6	2.4 ± 0.5	2.9 ± 0.5
Alcohol-containing drinks	0.36 ± 0.2	0.62 ± 0.1	0.27 ± 0.1	0.44 ± 0.11	0.34 ± 0.0	0.12 ± 0.1*
Energy drinks	0.00 ± 0.00	0.40 ± 0.12**	0.00 ± 0.00	0.07 ± 0.03*	0.00 ± 0.00	0.09 ± 0.08
Grains	19.7 ± 1.7	15.3 ± 0.7*	20.0 ± 1.2	17.4 ± 0.9	16.1 ± 0.9	17.4 ± 0.5
Cakes and cookies	11.4 ± 1.4	7.9 ± 0.4**	13.0 ± 1.1	10.3 ± 0.8	10.0 ± 0.8	10.6 ± 0.6
RTE cereals	3.7 ± 0.6	2.8 ± 0.3**	2.8 ± 0.3	2.3 ± 0.2	2.2 ± 0.1	2.4 ± 0.2
Breads and muffins	2.8 ± 0.2	3.1 ± 0.2	2.8 ± 0.1	3.4 ± 0.3	2.7 ± 0.2	3.1 ± 0.1*
Other grains	1.7 ± 0.2	1.5 ± 0.2*	1.4 ± 0.2	1.3 ± 0.1*	1.3 ± 0.1	1.3 ± 0.1
Dairy products	7.5 ± 0.5	6.6 ± 0.4	8.7 ± 0.5	7.8 ± 0.4	8.0 ± 0.4	7.3 ± 0.3
Dairy desserts	3.1 ± 0.2	3.1 ± 0.3	4.8 ± 0.4	3.8 ± 0.2**	5.6 ± 0.5	4.3 ± 0.3*
Sweetened milk	2.0 ± 0.4	1.3 ± 0.7	1.0 ± 0.2	1.4 ± 0.3	0.6 ± 0.1	1.0 ± 0.2
Yogurt	0.62 ± 0.15	1.2 ± 0.3*	1.3 ± 0.3	1.0 ± 0.3	0.5 ± 0.1	1.0 ± 0.2*
Other dairy	4.2 ± 0.4	1.0 ± 0.2*	1.6 ± 0.3	1.5 ± 0.1	1.2 ± 0.2	1.0 ± 0.1
Fruit and vegetables	2.3 ± 0.1	1.8 ± 0.2*	2.0 ± 0.2	2.6 ± 0.3**	2.4 ± 0.2	1.8 ± 0.1**
Meats, beans, and eggs	2.1 ± 0.2	2.3 ± 0.1	2.1 ± 0.3	1.8 ± 0.1	1.8 ± 0.2	1.8 ± 0.2
Oils	1.1 ± 0.2	0.86 ± 0.15	1.1 ± 0.11	0.73 ± 0.10	0.88 ± 0.11	0.52 ± 0.04**

[1] All values are means ± SEs. RTE, ready to eat. One gram of added sugars = 4 calories; 1 teaspoon = 4.2 g. *,**,***Tests for linear trend over the five 2-y cycles between 1999–2000 and 2007–2008 were performed by using Wald's F tests: *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.
[2] Percentage of total calorie intake.
[3] Sodas + fruitades and sports drinks.

intakes are presented relative to total energy intakes. Our findings, combined with those obtained by Popkin and Nielsen (1) who used earlier dietary data, showed that national consumption rates increased from 59.0 g (13.1% of total energy) in 1977–1978 (1) to 79.5 g (16.0% of total energy) in 1994–1996 (1) and 100.1 g (18.1% of total energy) in 1999–2000. After 1999–2000, rates progressively decreased to a low of 76.7 g (14.6% of total energy) in 2007–2008. These data demonstrated that the consumption of added sugars peaked in the early part of the decade and declined steadily in all age, sex, and income groups since then.

Our findings are supported by estimates from loss-adjusted food disappearance data, which, although known to overestimate intakes, are useful measures of trends. Disappearance-data estimates show that intake of caloric sweeteners increased from 108 g in 1995 to a peak of 115 g in 2000. Between 2000 and 2003, intake of caloric sweeteners, as measured by disappearance data, decreased by 6.3% (23). This intake compares with a decrease of 10.6% in the dietary intake of caloric sweeteners between 1999–2000 and 2003–2004 as measured in our study.

Although overall consumption of added sugars has decreased, the relative contribution of the various sources of added sugars in the US diet did not change between 1999–2000 and 2007–2008. Similar to Guthrie and Morton (11), who examined sources of added sugars by using data from 1994 to 1996, we observed that regular soft drinks were the largest source of added sugars, followed by candies and sugars, cakes and cookies, fruitades and sports drinks, and dairy desserts.

The US Dietary Guidelines provide evidence-based dietary recommendations to promote health and prevent disease. In the 2000 Dietary Guidelines, which were released at the beginning of this study period, Americans were advised to "choose beverages and foods to moderate intake of sugars," but no specific upper limit for the consumption of added sugars was given (24). The 2005 Dietary Guidelines advised that discretionary calories, including those from added sugars, additional fats, and alcohol, that were not needed to meet dietary requirements should be limited, although no specific limit was given (25). The recently released 2010 Dietary Guidelines do provide a specific limit for

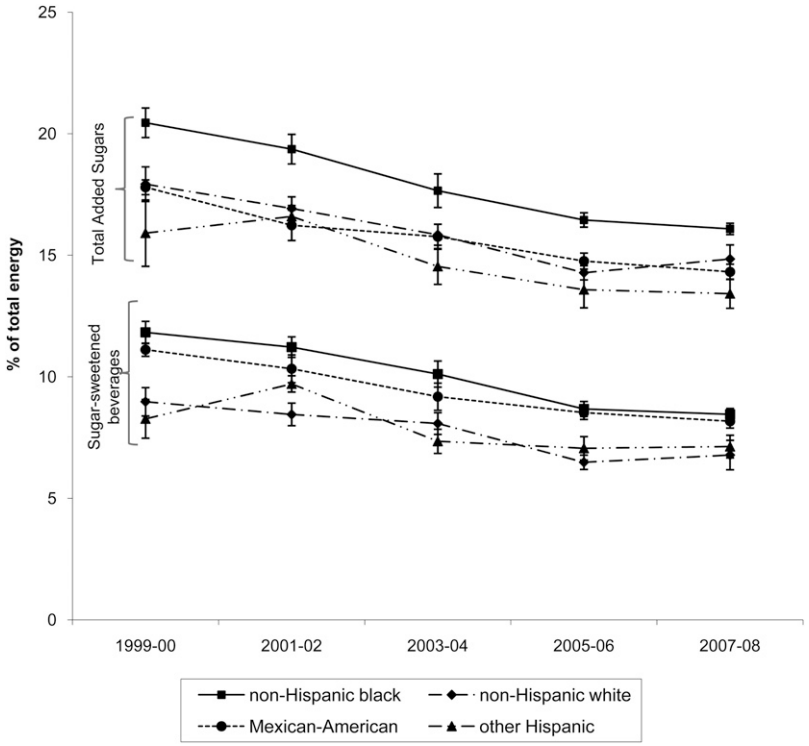

FIGURE 2. Mean (±SE) trends in the proportion of total energy intake consumed as added sugars and as sugar-sweetened beverages (SSBs) by race-ethnic group, NHANES 1999–2000 to 2007–2008. The results of linear testing by using Wald's F tests were $P < 0.0001$ for total added sugar in all races and ethnicities. P-trend for SSB intake was <0.0001 for non-Hispanic blacks and other Hispanics, 0.0006 for Mexican Americans, and 0.0002 for non-Hispanic whites.

discretionary calories, recommending that total intake be limited to 5–15% of total energy intake depending on energy needs (26). The results of our study highlight the fact that, despite the steady decrease over the past decade, the intake of added sugars by many Americans has exceeded and continues to exceed dietary recommendations.

Although the driving force behind the reversal in the trends in added-sugar consumption is unknown, it is undoubtedly multifactorial. The popularity of low-carbohydrate diets in the late 1990s and early 2000s, which discouraged the consumption of soft drinks and other sources of refined carbohydrates, may have had an influence on trends in added-sugar intakes observed in our study. In addition, this period was marked by an increasing public interest and concern regarding the rising obesity prevalence in the United States and its associated health risks, which were highlighted by the release of the Surgeon General's report on obesity in 2001 (27). Surveillance data show that the rise in the prevalence of obesity among children began to plateau in 1999–2000 (28), which is the same time that our data show the beginning of a decline in the consumption of added sugars. Although the timing of these changes support the findings of previous studies that suggest that there may be a causal role between high amounts of added-sugar intake and obesity (5), our use of cross-sectional data precluded the determination of any conditions that may have resulted from this consumption. The observed association between trends in added-sugar intakes and obesity prevalence may simply be a reflection of other related factors occurring simultaneously.

Clearly, the decrease in added sugars has been driven by a reduction in soda consumption. Although national efforts to promote a reduction in soft drinks were limited until the mid-2000s (29), efforts such as those of the Center for Science in the Public Interest to raise awareness of the increasing trends in sugar-sweetened beverage consumption and the associated health effects in the late 1990s (30) may have helped to stimulate state and local efforts to promote a reduction in consumption. In 2001, California was the first state to adopt legislation regulating access to sugar-sweetened beverages in public schools (31). Subsequently, a 2005 review identified a total of 34 states with legislation or regulations of some form restricting this access (32). In 2006, the Clinton Foundation and the American Heart Association obtained agreements from the American Beverage Association and several bottlers to work to reduce the amount of sugar-sweetened beverages sold in schools (29). An independent report published by the American Beverage Association in 2010 indicated that, between 2004–2005 and 2009–2010, the number of beverage calories delivered to schools decreased by 88% (33).

Our study had several important strengths. These strengths included the use of a large, national sample from which we were able to estimate intakes for US children, adolescents, and adults. The availability of dietary data obtained by using the same or similar methods spanning 10 y made valid comparisons and the testing of trends possible. Information on the full day's diet, in addition to data on intakes of sources of added sugars, allowed us to estimate of intakes of total energy, total carbohydrates, and other nutrients that helped us identify changes in the diet that occurred in parallel with those in added-sugar intakes.

Our study was also subject to some limitations. The quantity of added sugars in foods in the MPED database was calculated rather than measured, which could have resulted in under- or overestimations of intakes. In addition, although nutrient values for many foods were revised on the basis of improvements in the

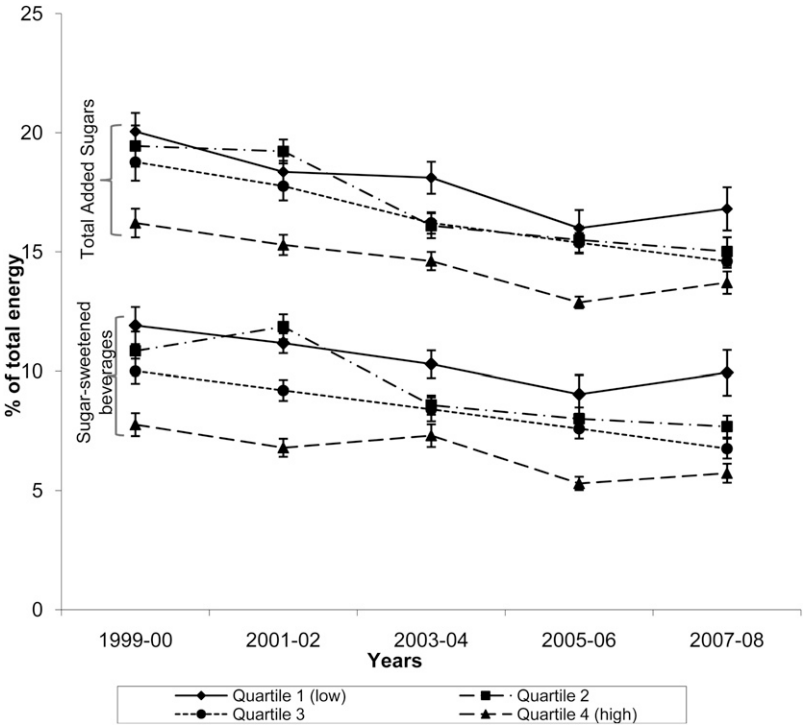

FIGURE 3. Mean (±SE) trends in the proportion of total energy intake consumed as added sugars and as sugar-sweetened beverages (SSBs) by income quartile, NHANES 1999–2000 to 2007–2008. The results of linear trends by using Wald's F tests were $P < 0.0001$ for total added-sugar intake in all income groups. P-trend for SSB intake was <0.0001 for all but the lowest income group for whom the P-trends for total added sugar and SSB intake were 0.0009 and 0.02, respectively.

sampling and analysis of foods (34) between 1999–2000 and 2001–2002, the effect of the revised values on estimates of added-sugar intakes is unknown. Previous research suggests that the consumption of foods that contain caloric sweeteners may be underreported by people who are obese (35). If the likelihood of this underreporting has increased with time as the public awareness of possible health effects associated with high sugar consumption has increased, this could have resulted in a greater underestimate of total added-sugar intake in the latter years of our study. Because overweight and obese individuals have also been shown to underreport total energy intakes, presenting results as a proportion of total energy intake could be expected to minimize the effect of any underreporting of added-sugar intakes (36). Also, although data from a single 24-h dietary recall may not represent the usual diet of individuals, the data can be useful to assess group means as was done in the current study.

In conclusion, since 1999–2000, the consumption of added sugars has decreased but continues to exceed, among all age groups, the limits advised in the US Dietary Guidelines. The biggest decrease was in the consumption of sodas, which may reflect some success of early public health efforts to limit sugar-sweetened beverage consumption. The reduced but continued high consumption of added sugars by all ages highlights the need to identify and build on successful public health strategies to promote further reductions in the consumption of added sugars.

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The authors' responsibilities were as follows— JAW and MBV: designed the research; JAW: conducted the research, analyzed data, wrote the manuscript, and had primary responsibility for the final content of the manuscript; JAW and LG: provided essential materials; and AJS and MBV: provided advice and consultation. MBV is the author of *The No-Diet Obesity Solution for Kids* (Bethesda, MD: AGA Institute Press, 2007). and receives royalties. JAW, AJS, and LG had no conflicts of interest.

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