

# 20-Year Trends in Dietary and Meal Behaviors Were Similar in U.S. Children and Adolescents of Different Race/Ethnicity<sup>1-3</sup>

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## Abstract

Recent survey data reveal persistent race/ethnic disparities in prevalence of adiposity in U.S. children and adolescents. We examined race/ethnic differentials in time trends in dietary behaviors of Americans 2–19 y of age to understand if these trends track those observed for body weight. We used dietary data from the NHANES 1988–1994, 1999–2002, and 2003–2008 ( $n = 24,131$ ) to examine changes in reported energy intake, amount of foods and beverages, number of eating occasions, and percent of energy from foods and beverages, among non-Hispanic white, non-Hispanic black, and Mexican American 2–19 y olds. Multivariable regression analyses appropriate for complex surveys were used to examine these associations. The secular increase in mean number of eating occasions was significant ( $P$ -trend  $< 0.0001$ ) in all age and race/ethnic groups; however, a corresponding increase in the amount of foods and beverages, or total energy intake was not observed. In non-Hispanic black and Mexican American 2–5 and 12–19 y olds, the secular increase in number of eating occasions, and in non-Hispanic black 12–19 y olds, the increase in percent of energy from all beverages or non-nutritive beverages were greater relative to non-Hispanic whites. In conclusion, the observed race/ethnic differences in trajectory of changes in dietary behaviors over past 20 y were modest and were not accompanied by a significant increase in energy intake. Cautious interpretation is urged due to potential underreporting of dietary intake in national surveys. There was a suggestion of convergence in some race/ethnic differentials in dietary behaviors due to greater relative changes in possibly adverse behaviors in non-Hispanic blacks, especially adolescents. *J. Nutr.* 141: 1880–1888, 2011.

## Introduction

Considerable race/ethnic disparities in prevalence of adiposity in U.S. children and adolescents have been recognized (1–3). In the 20-y period from 1971–1974 to 1988–1994, the prevalence of obesity increased in children from all race/ethnic groups; however, the percentage increase was greater for non-Hispanic black and Mexican American children and adolescents (2,3). In a recent assessment of change in prevalence of obesity from 1988–1994 to 2007–2008, the increase in prevalence of obesity among Mexican American and non-Hispanic black adolescents 12–19 y of age far exceeded that observed in non-Hispanic white adolescents (1). Higher adiposity in children is a predictor of a variety of adverse health outcomes (4–6); in minority children, childhood and adolescent body weight track with adult body

weight to a greater extent than in non-Hispanic white children (7).

Complex interactions of biological and environmental factors, including diet, determine energy balance and contribute to ethnic differentials in body weight (8). Ethnic differences in dietary patterns reflect a confluence of cultural beliefs and food practices modified by the social, economic, and environmental contexts of food desirability, affordability, and availability (9). Kumanyika (9) has argued that a study of dietary behaviors of different ethnic groups not only helps in identifying behaviors associated with higher body weight in the high-risk ethnic groups but also provides information about which behaviors may have causal associations with body weight for the population as a whole. Assessment of time trends in possible ethnic differentials in dietary behaviors also sheds light on whether the changing food norms, availability, and marketplace have a differential impact on different ethnic groups. Such knowledge is necessary for the identification, design, and targeting of suitable interventions to achieve the goal of elimination of health disparities that are part of the national health promotion agenda.

Several prior studies have made important contributions to our understanding of changing dietary profiles of American children (10–37). However, most studies using nationally representative data

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<sup>3</sup> Supplemental Tables 1–7 are available from the “Online Supporting Material” link in the online posting of the article and from the same link in the online table of contents at [jn.nutrition.org](http://jn.nutrition.org).

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have not examined recent trends, most have not examined if there are race/ethnic differentials in observed trends, and many did not adjust for changes in distribution of socio-demographic and dietary collection variables across surveys (10–24). Other studies mentioned above have examined selected age groups (25–37). A comprehensive picture of dietary and meal attributes is important to appreciate whether the observed dietary changes track with other possible compensatory or complementary dietary and meal behaviors, yet few of the previous studies provide this information.

Therefore, to understand the possible contribution of dietary behaviors to different race/ethnic trajectories of weight gain, we examined race/ethnic differences in 20-y time trends (from 1988–1994 to 2007–2008) in dietary and meal characteristics of Americans children and adolescents using multivariable methods to adjust for family income and education.

## Methods

To answer the above question, we analyzed public domain data from the NHANES conducted from 1988–1994, 1999–2000, 2001–2002, 2003–2004, 2005–2006, and 2007–2008 (38). This study was approved by the Queens College institutional review board for protection of human participants with an exempt review. The NHANES is conducted by the NCHS and consists of a nationally representative, stratified, multistage, probability sample of the U.S. population. The NHANES III (1988–1994) was a multi-year survey; beginning with 1999, the NHANES became a continuous annual survey and data are released for 2 combined years at a time. Each survey included a home interview of the sample person and an examination in the MEC<sup>6</sup>. The examination components included a complete physical exam, anthropometry, and a dietary interview. The unweighted response rates for the MEC examined sample of all ages combined for NHANES III (1988–1994), 1999–2000, 2001–2002, 2003–2004, 2005–2006, and 2007–2008 were 78, 76, 80, 76, 77, and 75%, respectively (38). The response rates for the ages examined in the current analysis (2–19 y) were generally higher than the rates mentioned above. The NHANES III oversampled 2–5 y olds and black and Mexican American populations; surveys conducted from 1999 to 2006 oversampled low-income persons, non-Hispanic blacks, Mexican Americans, and 12–19 y olds (38). The surveys conducted prior to 1988 did not include a large enough sample of Mexican Americans as an ethnic group to provide reliable estimates; therefore, these surveys were not included in the present analysis.

### Race/ethnicity information in each survey

Respondents to each survey self-reported race/ethnicity; for public domain release, the NCHS provides variables that combine race and ethnicity by adjudicating the available information. The public release data for 1999–2008 provide non-Hispanic white, non-Hispanic black, Mexican American, and other race/ethnic categories. The other category includes Hispanics who were not Mexican Americans and all other ethnic groups. The present analyses included non-Hispanic white, non-Hispanic black, and Mexican American race/ethnic groups.

### Dietary information

The NHANES III and the NHANES 1999–2008 collected dietary information using an interviewer-administered, computer-assisted, 24-h dietary recall interview. For children 2–5 y of age, the recall was provided by parents or other caregivers; recalls of 6–11 y olds were self-reported with assistance from parents or other caregivers; and 12–19 y olds self-reported their intake (38). In the NHANES III, the dietary recall was collected using a 3-step procedure that changed to a 4-step process in 1999–2001 and finally to the 5-step AMPM beginning with the 2002

survey year. In 2002, the NHANES was integrated with the USDA food consumption surveys as part of “What We Eat in America” protocol (38,39) and all subsequent surveys (2003–2008) used the same methods. The NHANES III and publicly available dietary data for the NHANES 1999–2002 included 1 recall; 2 recalls (one via telephone) were collected in the NHANES 2003–2008. The analyses reported in the present study used the first recall for all surveys. The NHANES III survey used the USDA’s Survey Nutrient Database (40) and surveys from 1999–2008 used the USDA Food and Nutrient Database for Dietary Studies (versions 1–4.1) (41) to code and estimate the nutrient content of foods and beverages reported in these surveys.

### Analytic sample

For each survey, non-Hispanic white, non-Hispanic black, and Mexican American children and adolescents 2–19 y of age with a dietary recall considered by the NCHS to be complete and acceptable (38) were eligible for inclusion in the analytic sample for this study (NHANES III,  $n = 9871$ ; NHANES 1999–2002,  $n = 7382$ ; NHANES 2003–2008,  $n = 9749$ ). From this eligible sample, we excluded pregnant and lactating females (NHANES III,  $n = 52$ ; NHANES 1999–2002,  $n = 85$ ; NHANES 2003–2006,  $n = 107$ ) and those missing information on family income and education level of head of household (NHANES III,  $n = 918$ ; NHANES 1999–2002,  $n = 728$ ; NHANES 2003–2008,  $n = 779$ ). The 2007–2008 survey years included up to 17 12–19 y olds whose pregnancy and lactation information was not available in the public domain data. One respondent in each survey (NHANES III, 1999–2002 and 2003–2008) reported no energy intake (zero calorie) and was excluded from the analytic sample. The final analytic sample size was: NHANES III, 8900; NHANES 1999–2002, 6369; and NHANES 2003–2008, 8862.

### Dietary and meal intake variables

To obtain a comprehensive picture of dietary profiles, we examined 3 types of dietary variables in this study: diet quantity and composition, food form, and meal patterns. The decision to examine these variables was based on the current speculation in the literature about the possible roles of food portions, energy density, sweetened beverages, and snacking as contributors to increasing body weights of U.S. children (8,9). Therefore, in our presentation and narrative of results and their interpretation, we considered energy intake, amount (grams) of foods and beverages, percent energy from beverages, and number of eating occasions as “key dietary outcomes” and all other dietary attributes as “secondary dietary outcomes.”

**Diet quantity and composition.** These included total energy, percentage of energy from macronutrients, dietary fiber, amount (g) of all reported foods and beverages, and energy density (energy content/g) of all foods and beverages and of foods only.

**Food form.** To examine hypotheses related to the association of food form (liquid vs. solid), we created variables that identified all beverages and nonbeverage foods in the recall. Using previously reported methods, all types of liquid milk, 100% juices, juice drinks, shakes, infant formula, carbonated beverages, coffee and tea, and alcohol, etc. were considered as beverages (42). Plain tap or bottled water (unsweetened) was considered a beverage for this purpose. From this group, juice drinks, carbonated or noncarbonated beverages, coffee or tea, and alcohol were considered non-nutritive beverages. The variables created examined the total amount (g) and the percent of 24-h energy intake from foods and beverages.

**Meal intake.** The number of eating occasions was determined from number of discrete clock times any food, beverage, or their combinations were reported in the dietary recall. All foods or beverages reported at one clock time (e.g. as part of a meal) were considered one eating occasion. We have used these methods in our previous examination of trends in adults (43). Eating occasions when the only reported item was plain water or unsweetened bottled water were not counted as eating occasions. In the recall, respondents were asked to name each eating occasion. Using previously published methods, occasions named as breakfast, desayuno,

<sup>6</sup> Abbreviations used: AMPM, automated multiple pass method; EI:BEE, energy intake:estimated basal energy expenditure; MEC, mobile examination center; NCHS, National Center for Health Statistics; PIR, poverty income ratio.

or almuerzo were considered breakfast (44). Eating occasions named as snack, drink, other, or equivalents in Spanish were considered a snack (43). Eating occasions not named as snack or other were considered main meals and included breakfast, brunch, lunch, dinner, supper, or equivalents in Spanish. The percent of 24-h energy intake from main meals, snacks/other, and that reported at or after 1700 h was computed for each respondent (43).

Because of reports of the occurrence of low-energy reporting in national surveys, we also compared the ratio of reported EI:BEE. The BEE was computed using age-sex-BMI-for-sex-age percentile specific equations developed by the committee on Dietary Reference Intakes (45). We considered an EI:BEE ratio of  $<0.92$  to indicate low energy reporting. Because new recommended methods for the determination of implausible dietary reports could not be implemented for all surveys included in our analyses (46), the cutoff used was based on methods described by Goldberg et al. (47) and has been used by other investigators (48).

### Statistical analyses

NCHS recommends combining data from the recent 2-y NHANES cycles to provide more reliable estimates for subgroup analyses (49). Therefore, we combined 1999–2000 with 2001–2002, and 2003–2004 and 2005–2006 with 2007–2008. Thus, the trend analyses included combined data from the 6 y of the NHANES III (1988–1994), 4 y of NHANES 1999–2002, and 6 y of NHANES 2003–2008.

The age range from 2 to 19 y includes a wide range of developmental stages, varying degree of family, social, and environmental influences, the extent of autonomy in food selection, and age differences in prevalence of adiposity. Therefore, our analyses were stratified by the age categories of 2–5, 6–11, and 12–19 y. These age categories are consistent with the age categories used for reporting of NHANES body weight data by the NCHS (1) and also reflect the age differences in respondents for the dietary recall.

We used multivariable linear and logistic regression analyses for continuous and dichotomous dependent variables, respectively, to examine the independent association of each dietary attribute with race/ethnicity across surveys in analyses stratified by age group (2–5, 6–11, and 12–19 y). These analyses included each dietary/meal characteristic as a continuous or dichotomous outcome and the covariates potentially related to race/ethnicity and diet as independent variables. Because race/ethnic group membership in the US is correlated with family income and level of education (50), all regression analyses included variables for family income as PIR and education level of head of household. Other covariates that are possibly differentially distributed among surveys and race/ethnic groups included day of week of dietary intake, season of MEC exam, country of birth of household reference person, household size, and BMI for gender-age percentile based on 2000 CDC growth charts (51). The multiple regression models thus included dummy variables for race/ethnicity (non-Hispanic white, non-Hispanic Black, and Mexican American), the covariates (mentioned above), and variables indicating survey(s) (NHANES 1988–1994, 1999–2002, and 2003–2008) as independent variables. In this analysis, the combined surveys (1988–1994, 1999–2002, and 2003–2008) were included together as independent samples representing the U.S. population corresponding to the time period of each survey. We tested whether the trends in dietary characteristics across surveys among race/ethnic groups were similar by testing the interaction of race/ethnicity and survey using models in which survey was either categorical or as a scored variable for survey year, where the midpoint of the time span of the survey is the score.

To enable interpretation of race/ethnic and survey effects when significant race/ethnicity by survey interactions were not present, we tested the main effects of race/ethnicity and survey using the above regression models without the race/ethnicity by survey interaction term. For uniformity and descriptive purposes, we provided estimates of the adjusted means and proportions of dietary outcomes for each race and survey combination (obtained from models that included a race by survey interaction term) and main effects of race/ethnicity and survey (obtained from models without the interaction term), adjusted for other covariates in the multivariable regression (52,53). For energy intake, we reanalyzed the regression models after excluding respondents with a

low EI:BEE ratio. Wald F tests were used for all statistical tests, with level of significance set at  $P \leq 0.05$  (53). The reported *P* values for tests of significance are not adjusted for multiple comparisons; this criterion of significance is used as a guide to identify dietary relationships of potential interest. Multiple comparisons increase the probability of finding significant associations; therefore, the reported *P* values should be interpreted with caution.

We followed NCHS recommendations for sample weights applicable to analyses from combined surveys (49). This weighting produced estimates that represented the population included in each individual survey. These analyses were carried out using SAS version 9.2 (RTI) and SAS-callable SUDAAN (54) to adjust for the complex, stratified sample design of the NHANES (53).

## Results

**Characteristics of the population.** Relative to the other 2 race/ethnic groups, a slightly higher proportion of Mexican Americans were 2–5 y of age and a slightly lower proportion were 12–19 y of age (Table 1). Over 30% of non-Hispanic black and >50% of Mexican American household head or reference persons had <12 y of education and ~40% had a family PIR <1 in all surveys. Over 50% of Mexican American household reference persons were born in countries other than the US.

The following narrative of results related to the study question is divided into 2 parts. The first part is focused on key dietary outcomes of energy intake, amount (g) of foods and beverages, percent of 24-h energy from beverages, and number of eating occasions for 2–5, 6–11, and 12–19 y olds, respectively (Fig. 1–3; Supplemental Tables 1–3). The second part summarizes findings about secondary dietary outcomes of percent of 24-h energy from macronutrients; fiber (g); amount of foods; amount of beverages; percent of 24-h energy from foods and nonnutritive beverages; energy density of foods; mention of breakfast; mention of a snack; percent of 24-h energy from main meals or snacks and at or after 1700 h (Supplemental Tables 4–6). For all dietary outcomes, first we described the results of race by survey interactions; for dietary outcomes without significant race by survey interaction, we presented the main effect of race/ethnicity across all surveys combined (Supplemental Tables 1–6). For context, we provided information on BMI in Figures 1–3 and Supplemental Tables 3–6.

### Time trends in self-reported dietary outcomes

**Did the association of race/ethnicity with key dietary outcomes (energy intake, amount of foods and beverages, percent of 24-h energy from beverages, and number of eating occasions) change from 1988–1994 to 2003–08?** In all age groups, the interaction of race/ethnicity and survey was not significant for total energy intake, the amount (g) of foods and beverages, and percent of 24-h energy from beverages (except in 12–19 y olds) (Fig. 1–3; Supplemental Tables 1–3). Although the reported number of eating occasions increased over time in all race/ethnic groups, the secular increase in non-Hispanic black and Mexican American 2–5 and 12–19 y olds was higher relative to non-Hispanic whites (*P* for race by survey interaction  $\leq 0.02$ ). A similar trend was also noted for percent energy from beverages in 12–19 y old non-Hispanic blacks.

**Was there a main effect of race/ethnicity for key dietary outcomes?** In all age groups, the race/ethnic differences in mean energy intakes were not significant; however, the mean amounts of foods and beverages differed among race/ethnic groups, with non-Hispanic whites reporting the highest and the non-Hispanic blacks reporting the lowest amounts (marginals in

**TABLE 1** Characteristics of 2–19 y old children and adolescents, by race/ethnicity and by survey, NHANES III, NHANES 1999–2002, and NHANES 2003–2008<sup>1</sup>

NHANES	Non-Hispanic white			Non-Hispanic black			Mexican American		
	1988–1994	1999–2002	2003–2008	1988–1994	1999–2002	2003–2008	1988–1994	1999–2002	2003–2008
<i>n</i>	2656	1965	2923	3130	2018	3063	3114	2386	2876
Females, %	48.4 ± 1.2	48.7 ± 1.3	47.3 ± 1.3	49.6 ± 1.0	50.3 ± 1.4	50.4 ± 1.1	50.4 ± 1.6	49.5 ± 1.3	48.8 ± 1.3
Age group, %									
2–5 y	21.9 ± 1.0	21.4 ± 1.0	20.4 ± 1.2	22.9 ± 0.8	20.6 ± 1.4	21.5 ± 1.1	26.0 ± 1.1	24.4 ± 1.2	26.4 ± 1.0
6–11 y	35.1 ± 1.3	35.3 ± 1.6	32.4 ± 1.3	34.3 ± 1.0	36.6 ± 1.5	32.9 ± 1.4	34.4 ± 0.9	35.8 ± 1.1	34.8 ± 1.4
12–19 y	43.0 ± 1.4	43.3 ± 1.4	47.2 ± 1.9	42.7 ± 1.3	42.8 ± 1.2	45.5 ± 1.4	39.5 ± 1.3	39.7 ± 0.9	38.7 ± 1.6
Education of household head or reference person, %									
<12 y	16.6 ± 1.4	15.4 ± 2.3	9.8 ± 1.4	32.0 ± 1.5	38.8 ± 2.7	27.0 ± 1.7	59.8 ± 2.7	55.1 ± 2.8	52.1 ± 2.5
12 y	35.0 ± 1.7	26.3 ± 1.7	26.7 ± 1.8	40.7 ± 1.8	28.5 ± 1.9	27.3 ± 1.9	23.0 ± 1.8	19.8 ± 2.0	20.9 ± 1.7
>12 y	48.4 ± 2.1	58.3 ± 3.2	63.5 ± 2.2	27.4 ± 1.7	32.8 ± 2.5	45.7 ± 2.0	17.2 ± 1.8	25.1 ± 2.2	27.0 ± 2.5
Family PIR, %									
<1	14.6 ± 1.3	15.0 ± 1.4	15.3 ± 1.7	45.4 ± 2.3	44.0 ± 2.8	39.8 ± 2.2	47.8 ± 1.6	40.2 ± 2.7	37.9 ± 1.7
1–2	23.1 ± 1.4	22.9 ± 2.1	19.4 ± 1.4	29.0 ± 1.8	27.0 ± 1.7	27.2 ± 1.5	28.8 ± 1.2	33.6 ± 1.7	31.2 ± 2.2
>2	62.4 ± 1.7	62.1 ± 2.6	65.2 ± 2.6	25.6 ± 1.9	29.0 ± 2.6	33.0 ± 2.3	23.3 ± 2.0	26.2 ± 2.2	30.9 ± 2.1
Household size, %									
1–2	5.4 ± 0.8	6.0 ± 0.7	8.0 ± 0.8	8.0 ± 0.8	8.2 ± 0.8	11.2 ± 1.5	3.3 ± 0.5	3.2 ± 0.5	2.6 ± 0.4
3–4	54.2 ± 0.2	55.1 ± 2.1	57.2 ± 1.4	47.5 ± 1.8	45.0 ± 2.4	47.0 ± 1.9	31.6 ± 2.4	33.7 ± 1.5	36.9 ± 1.8
≥5	40.3 ± 1.6	40.5 ± 2.4	36.8 ± 1.4	44.5 ± 1.9	46.8 ± 2.5	41.8 ± 1.6	65.1 ± 2.6	63.1 ± 1.7	60.5 ± 2.0
Country of birth of household reference person, %									
Non-US	4.6 ± 0.8	6.6 ± 1.1	5.4 ± 0.9	4.7 ± 0.6	9.9 ± 2.3	7.3 ± 1.4	55.1 ± 3.1	57.1 ± 3.0	58.5 ± 3.2
Percentile of BMI specific for gender and age, %									
<85th	76.9 ± 1.1	71.3 ± 1.4	68.4 ± 1.8	74.2 ± 0.8	62.4 ± 1.4	63.1 ± 1.7	69.3 ± 1.7	59.5 ± 1.5	61.7 ± 1.6
85 to <95th	12.9 ± 0.8	12.9 ± 1.0	15.6 ± 1.0	12.5 ± 0.5	15.8 ± 0.9	14.8 ± 0.9	14.7 ± 0.8	15.3 ± 0.9	16.0 ± 1.0
≥95th	9.3 ± 0.8	12.8 ± 0.9	14.5 ± 1.2	12.5 ± 0.7	18.5 ± 1.0	20.2 ± 1.2	14.5 ± 1.5	20.5 ± 0.9	20.7 ± 1.3
Missing	0.8 ± 0.2	2.9 ± 0.4	1.5 ± 0.3	0.8 ± 0.2	3.2 ± 0.7	1.9 ± 0.4	1.5 ± 0.4	4.7 ± 1.0	1.5 ± 0.2
Weekday of recalled dietary intake, %									
Friday–Sunday	50.6 ± 2.2	42.0 ± 1.9	43.2 ± 1.7	49.9 ± 1.5	43.7 ± 2.5	43.5 ± 2.1	48.3 ± 1.7	42.9 ± 1.8	43.2 ± 1.8
Month of MEC exam, %									
Nov–April	65.0 ± 4.2	31.0 ± 4.9	30.1 ± 3.6	47.1 ± 5.5	44.6 ± 8.3	50.2 ± 6.2	33.6 ± 6.3	61.9 ± 6.3	79.8 ± 4.8
May–Oct	35.0 ± 4.2	69.0 ± 4.9	69.9 ± 3.6	52.9 ± 5.5	55.4 ± 8.3	49.8 ± 6.2	66.4 ± 6.3	38.1 ± 6.3	25.4 ± 4.8
El:BEE <sup>2</sup>	1.56 ± 0.01	1.54 ± 0.02	1.52 ± 0.01	1.55 ± 0.01	1.49 ± 0.02	1.47 ± 0.02	1.51 ± 0.02	1.52 ± 0.02	1.52 ± 0.03
<0.92 <sup>3</sup> , %	13 ± 1.0	14 ± 0.8	14 ± 0.8	15 ± 0.8	16 ± 0.7	18 ± 1.3	13 ± 1.1	15 ± 1.0	14 ± 1.0

<sup>1</sup> Values are percent or mean ± SE. BEE, basal energy expenditure; El:BEE, energy intake:estimated BEE; MEC, mobile examination center; PIR, poverty income ratio.

<sup>2</sup> The BEE was estimated using age, gender, BMI-for-age percentile specific equations (42).

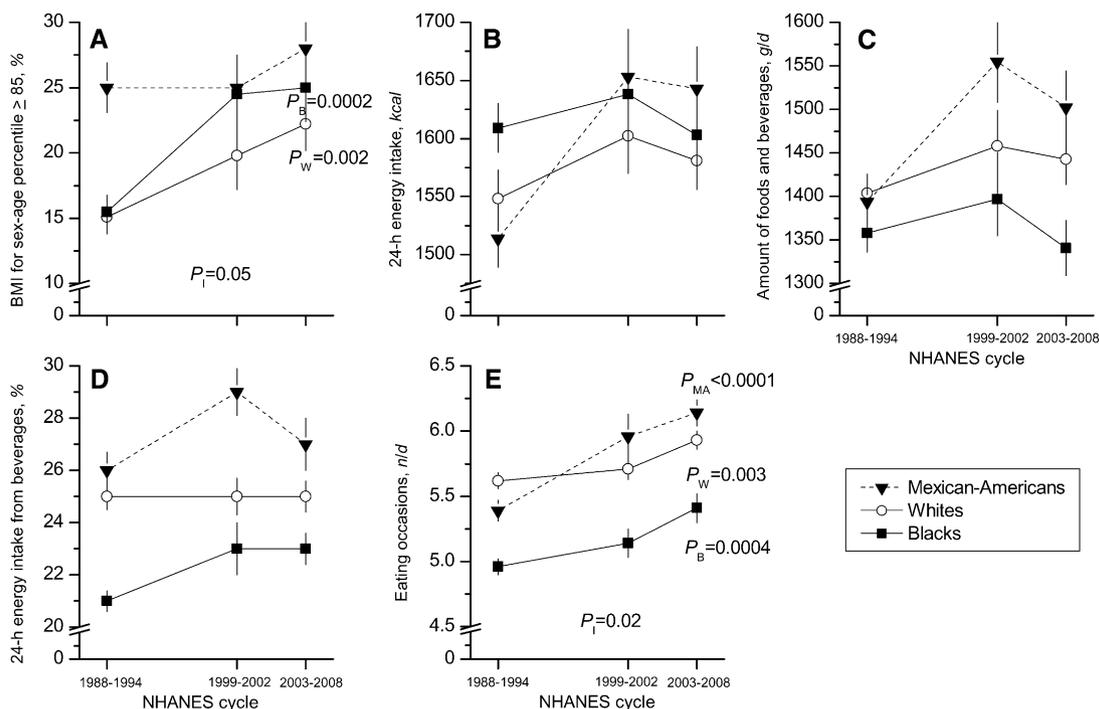
<sup>3</sup> Estimated from multivariate regression models that included race/ethnicity, age, gender, family PIR, education of head of household, day of dietary recall, month of MEC exam, household size, country of birth of household head, and gender-specific BMI for age percentile.

Supplemental Tables 1–3). The mean percent of 24-h energy intake from beverages also differed among race/ethnic groups for 2–5 and 6–11 y olds, with non-Hispanic blacks reporting the lowest percentage (Supplemental Tables 1 and 2).

*Did the association of race/ethnicity with secondary dietary outcomes [percent of 24-h energy from macronutrients; fiber (g); amount of foods; amount of beverages; percent of 24-h energy from foods and nonnutritive beverages; energy density of foods; mention of breakfast; mention of a snack; percent of 24-h energy from main meals or snacks and at or after 1700 h] change from 1988–1994 to 2003–2008?* In children 2–5 y of age, the decline in dietary fiber intake (also noted in 6–11 y olds) and the reported amount of foods (only) was greater in non-Hispanic blacks relative to other race/ethnic groups (Supplemental Tables 4–5). Among adolescents 12–19 y of age, the interactions of race and

survey were significant for several dietary outcomes [percent of energy from fat and carbohydrate, percent of 24-h energy intake from foods (only) and nonnutritive beverages, percent reporting breakfast, and percent of energy reported at or after 1700 h] (Supplemental Table 6). The decline in percent of energy from fat and foods (only) and increase in percent energy from carbohydrate and nonnutritive beverages was larger and significant in non-Hispanic blacks relative to non-Hispanic whites.

*Was there a main effect of race/ethnicity for secondary dietary outcomes?* With a few exceptions, significant race/ethnic differences for a majority of the secondary dietary outcomes were observed at all ages (marginals in Supplemental Tables 3–6). Non-Hispanic black 2–5 and 6–11 y olds were less likely to mention a snack in the recall and reported lower mean number of snacks relative to non-Hispanic whites (Supplemental Tables 4 and 5).



**FIGURE 1** Race/ethnic trends in reporting of key dietary characteristics in children 2–5 y of age, NHANES 1988–1994 to NHANES 2007–2008. Values are adjusted means and proportions  $\pm$  SE obtained from multivariable regression models with each dietary variable as the dependent variable. The independent variables were: race/ethnicity, age, gender, family poverty income ratio, education of head of household, day of dietary recall, month of mobile examination center exam, household size, country of birth of household head, BMI for age percentile, surveys, and race/ethnicity by survey interaction. *n* for models included those with complete covariate information, 6476.  $P_I$ : *P* value for significance of the test of survey by race/ethnicity interaction that tests for differences in time trends among race/ethnic groups;  $P_W$ ,  $P_B$ ,  $P_{MA}$ : *P* values for significance of the survey trend in non-Hispanic whites, non-Hispanic blacks, and Mexican Americans, respectively. These are presented when there was a significant race/ethnicity by survey interaction.

The secular changes in percent of 2–5 y olds with gender-age-specific BMI percentile of  $\geq 85$  and in 12–19 y olds, the mean BMI, differed among race/ethnic groups (Supplemental Tables 4–6). The race/ethnicity differences (main effect) in percent with  $\geq 85$ th BMI percentile or mean BMI were significant (marginals in Supplemental Tables 4–6).

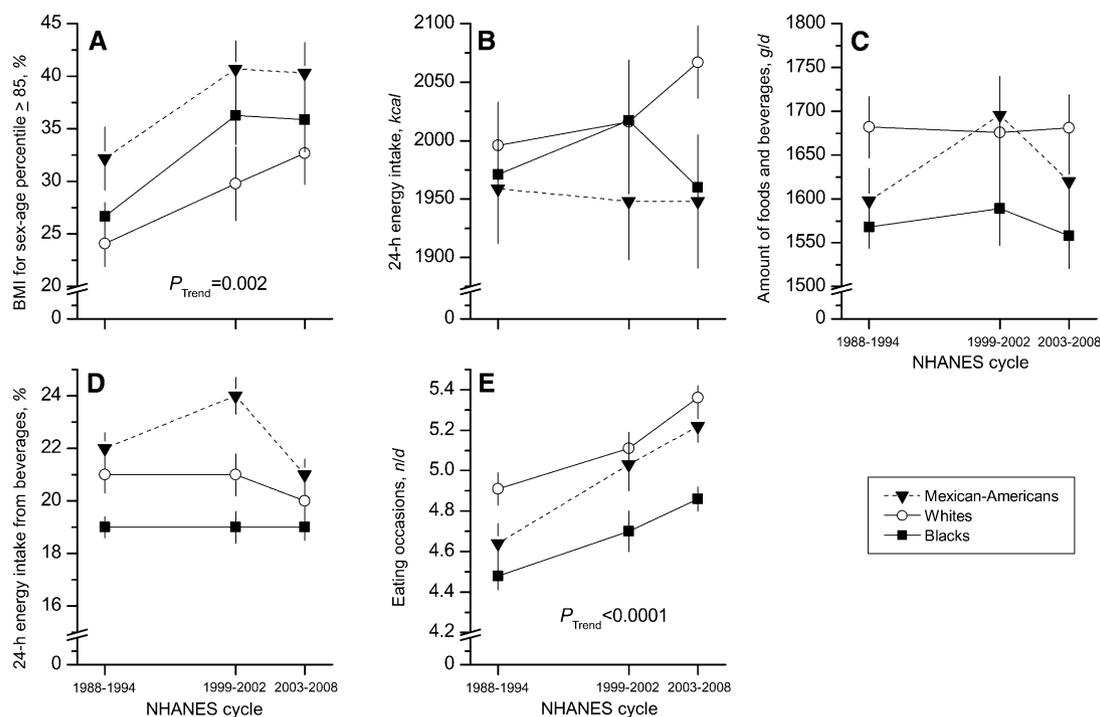
In regression analyses that excluded respondents with a low EI:BEE ratio, the adjusted mean energy intakes were expectedly higher, but race/ethnic differentials and trends were similar to estimates without exclusions (Supplemental Table 7). Similar results were observed for amounts of foods and beverages, percent of 24-h energy from beverages, and energy density of foods (data not shown).

## Discussion

The most popular dietary hypotheses for explaining increasing adiposity of American children and adolescents are secular increases in portion sizes, number of eating occasions, sweetened beverage consumption, and energy density of foods (8,9). The only hypothesis unequivocally supported by the present study is that of a secular increase in the number of eating occasions in children and adolescents of all race/ethnic backgrounds. However, the relative importance of this observation is open to debate given that the increase in eating occasions was not accompanied by the expected secular increase in energy intake and amount of foods and beverages (expected because of possible increases in portion sizes). To our knowledge, few other studies have examined race/ethnic diet trends over the time period examined in this study to make informed comparisons.

The observed secular changes in dietary behaviors were small and their direction was generally similar in all race/ethnic groups. However, there is a suggestion of a somewhat larger change in some dietary behaviors among 2–5 and 12–19 y old non-Hispanic blacks. For example, in 1988–1994, non-Hispanic whites of all ages reported the highest number of eating occasions; however, in minority 2–5 and 12–19 y olds, the incline was steeper, leading to convergence and narrowing of the ethnic differential by 2003–2008. In 1988–1994, the race differences in breakfast reporting by 12–19 y olds were not significant but became significant in 2003–2008 because of a decline in the percent of non-Hispanic blacks and an increase in the percent of Mexican Americans who reported breakfast. Non-Hispanic black and Mexican American adolescents increased their intake of energy from carbohydrate and decreased their energy intake from fat so that race differences in these behaviors were present in 1988–1994 but not in later surveys. However, in these adolescents, given the larger decline in dietary fiber over time and the significant secular increase in percent energy from all beverages or nonnutritive beverages (in non-Hispanic black adolescents), the higher percent of carbohydrate energy does not indicate improved dietary selections. These results collectively suggest that relative changes in adoption of possibly adverse dietary behaviors affected non-Hispanic black adolescents to a greater extent. Overall, therefore, the apparent convergence of trends in many dietary attributes appeared to be not due to greater improvement of behavior in non-Hispanic blacks but due to greater worsening of dietary behaviors.

Despite widely held beliefs about large increases in beverage consumption in the U.S. population, the relative mean contri-



**FIGURE 2** Race/ethnic trends in reporting of key dietary characteristics in children 6–11 y of age, NHANES 1988–1994 to NHANES 2007–2008. Values are adjusted means or proportions  $\pm$  SE obtained from multivariable regression models with each dietary variable as the dependent variable. The independent variables were: race/ethnicity, age, gender, family poverty income ratio, education of head of household, day of dietary recall, month of mobile examination center exam, household size, country of birth of household head, BMI for age percentile, surveys, and race/ethnicity by survey interaction. *n* for models included those with complete covariate information, 6823. *P*-trend: *P* value for the significance of the main effect of survey (secular trend) across all 3 race/ethnic groups combined. These are presented when there was no significant race/ethnicity by survey interaction.

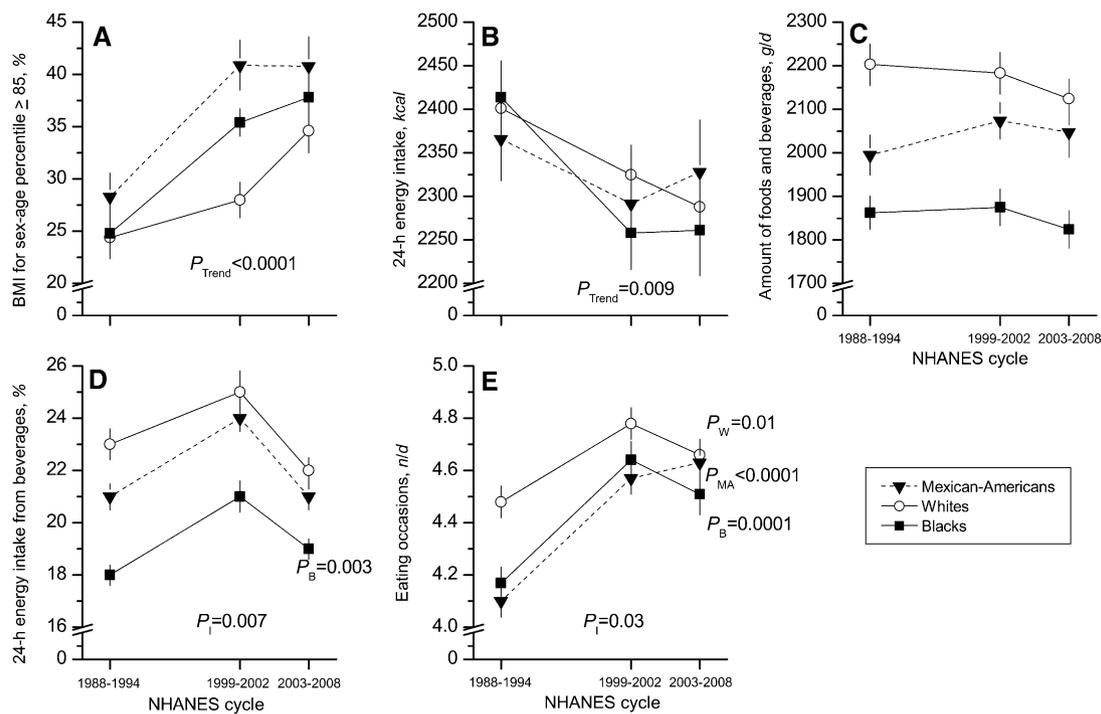
bution of energy from all beverages, nonnutritive beverages, and foods changed little across surveys. At all ages, there were significant race/ethnic differences in percent energy from beverages, non-Hispanic blacks reported a lower percentage of daily energy from beverages and a higher percentage from foods in all surveys. However, these differences in beverage intake were not similarly reflected in race/ethnic differences in total energy intake. We note that our analytic approach differs from that used in previous analyses that found total energy intake of consumers of sweetened beverages to be higher than that of nonconsumers (55). In children and adolescents of all races/ethnicities, the reported percent of 24-h energy from nonnutritive beverages in the 1999–2002 surveys was higher relative to 1988–1994 but declined in the 2003–2008 period. Whether these results reflect an aberration or a possible beginning of a downward trend in consumption of these beverages (due to heightened awareness of their poor nutritional quality) or reporting bias (due to social undesirability of their consumption) cannot be deduced from the available data. We await other recent independent estimates of consumption of non-nutritive beverages to assess if the tide is turning.

To our knowledge, the only study to publish estimates of dietary energy density in children from different race/ethnicity found that non-Hispanic black children had higher energy density (56). However, these estimates were based on dietary energy density defined to include all foods plus beverages. Our results suggest that due to lower overall beverage intake of non-Hispanic black children and adolescents (a consistent finding in all age groups), examination of energy density of foods (only) is more informative about the nature of foods selected. Using this definition (foods only), non-Hispanic black adolescents, but not

younger children, did consistently report foods of higher energy density at each examined time period. This may reflect a preference for certain types of foods that adolescents may express with increasing autonomy about food selections.

We note that although all NHANES used in the current analyses collected dietary information using a computer-assisted 24-h recall, the methodology of recall collection in 1988–1994 differed from that used in 1999–2001 and again from 2002 onwards (38). To our knowledge, there are no published bridging studies to determine the contribution of change in methodology to population estimates. Nevertheless, it is generally accepted that the AMPM for collecting dietary recall, implemented in 2002, have improved the completeness of the recall (57,58). However, the published validation studies of the AMPM have studied adults and not children and adolescents. If we accept that the newer recall methods have improved the completeness of recalled intake, we should expect the amount of foods and beverages and total energy intake to be higher in later surveys. However, we observed no such trends. Nevertheless, we were mindful of the potential methodological differences and confine our narrative of results and discussion to whether the association of race/ethnicity and diet changed over time. In each survey, dietary assessment methods used for all race/ethnic groups were the same; therefore, our approach allows valid conclusions about this primary study objective.

The dietary and meal attributes reported in this paper were derived from a single 24-h recall. Because of intra-individual variability of food intake, estimates from a single 24-h recall are not appropriate for the estimation of usual intakes of individuals, examination of population distributions of usual intake, or prevalence of nutrient adequacy; therefore, we did not attempt



**FIGURE 3** Race/ethnic trends in reporting of key dietary characteristics in adolescents 12–19 y of age, NHANES 1988–1994 to NHANES 2007–2008. Values are adjusted means or proportions  $\pm$  SE obtained from multivariable regression models with each dietary variable as the dependent variable. The independent variables were: race/ethnicity, age, gender, family poverty income ratio, education of head of household, day of dietary recall, month of mobile examination-center exam, household size, country of birth of household head, BMI for age percentile, surveys, and race/ethnicity by survey interaction.  $n$  for models included those with complete covariate information, 10,345.  $P_I$ :  $P$  value for significance of the test of survey by race/ethnicity interaction that tests for differences in time trends among race/ethnic groups.  $P_W$ ,  $P_B$ ,  $P_{MA}$ :  $P$  values for significance of the survey trend in non-Hispanic whites, non-Hispanic blacks, and Mexican Americans, respectively. These are presented when there was a significant race/ethnicity by survey interaction.  $P_{Trend}$ :  $P$  value for the significance of the main effect of survey (secular trend) across all three race/ethnic groups combined. These are presented when there was no significant race/ethnicity by survey interaction.

such analyses (59). However, the regression-adjusted means of observed 24-h dietary attributes examined in the present analyses are considered as appropriate for estimation of mean usual intakes of groups (59).

Another concern with dietary measurement pertains to dietary reporting errors, especially underreporting of food intake (59). The problem of dietary reporting error may be greater in the age groups we studied for a variety of reasons (60,61). It is possible that with increasing adiposity and health in the spotlight, the population may be wary of reporting dietary behaviors that are perceived negatively, with a consequent increase in prevalence of biased dietary reporting over time. We note that our analytic approach adjusted for several possible correlates, such as income, education, and body weight, of dietary underreporting. Also, the mean ratios of EI:BEE (a rough indicator of possible low energy reporting status) and the percentage of the population below an EI:BEE of  $<0.92$  appeared to be similar across race groups in the 3 surveys (Table 1). Finally, the results of time trends for energy intake after exclusion of possible underreporters were generally similar to those without exclusions (Supplemental Table 7). Gibson also did not observe an increase in energy intakes of British children from 1987 to 1993 with or without adjustment for low energy reporting (62). Nevertheless, because the NHANES dietary data are used for national nutrition monitoring, meaningful interpretation of these data for children requires more study of reporting bias, especially using the AMPM, race/ethnic differences in the nature and extent of underreporting, and possible drift in dietary reporting.

The reasons for lack of concordance between race/ethnic differences in the trajectory of changes in body weight but generally unchanged energy intake or modest changes in other dietary behaviors are likely to be complex and may reflect the above-discussed issues about validity of methods used to estimate dietary intakes in these surveys (9) or possible contribution of the energy expenditure side of the energy balance equation.

In conclusion, although the direction of changes in dietary attributes appeared to be similar in all race/ethnic groups, there is a suggestion of convergence due to somewhat larger changes in possibly adverse dietary behaviors in non-Hispanic blacks, especially adolescents. However, the magnitude of observed changes in dietary behaviors was modest and not accompanied by changes in energy intake. There is a continued need for understanding dietary contributors to positive energy balance in children and adolescents from all race/ethnic groups of the U.S. population.

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