ONLINE FIRST

Prevalence of Obesity and Trends in Body Mass Index Among US Children and Adolescents, 1999-2010

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Context The prevalence of childhood obesity increased in the 1980s and 1990s but there were no significant changes in prevalence between 1999-2000 and 2007-2008 in the United States.

Objectives To present the most recent estimates of obesity prevalence in US children and adolescents for 2009-2010 and to investigate trends in obesity prevalence and body mass index (BMI) among children and adolescents between 1999-2000 and 2009-2010.

Design, Setting, and Participants Cross-sectional analyses of a representative sample (N=4111) of the US child and adolescent population (birth through 19 years of age) with measured heights and weights from the National Health and Nutrition Examination Survey 2009-2010.

Main Outcome Measures Prevalence of high weight-for-recumbent length (≥95th percentile on the growth charts) among infants and toddlers from birth to 2 years of age and obesity (BMI ≥95th percentile of the BMI-for-age growth charts) among children and adolescents aged 2 through 19 years. Analyses of trends in obesity by sex and race/ethnicity, and analyses of trends in BMI within sex-specific age groups for 6 survey periods (1999-2000, 2001-2002, 2003-2004, 2005-2006, 2007-2008, and 2009-2010) over 12 years.

Results In 2009-2010, 9.7% (95% CI, 7.6%-12.3%) of infants and toddlers had a high weight-for-recumbent length and 16.9% (95% CI, 15.4%-18.4%) of children and adolescents from 2 through 19 years of age were obese. There was no difference in obesity prevalence among males (P=.62) or females (P=.65) between 2007-2008 and 2009-2010. However, trend analyses over a 12-year period indicated a significant increase in obesity prevalence between 1999-2000 and 2009-2010 in males aged 2 through 19 years (odds ratio, 1.05; 95% CI, 1.01-1.10) but not in females (odds ratio, 1.02; 95% CI, 0.98-1.07) per 2-year survey cycle. There was a significant increase in BMI among adolescent males aged 12 through 19 years (P=.04) but not among any other age group or among females.

Conclusion In 2009-2010, the prevalence of obesity in children and adolescents was 16.9%; this was not changed compared with 2007-2008.

JAMA. 2012;307(5):483-490
Published online January 17, 2012. doi:10.1001/jama.2012.40 www.jama.com

CHILDHOOD OBESITY CONTINues to be a major focus of public health efforts in the United States.[1] Obese children may be at risk for both short-term health consequences[2] and long-term tracking of obesity to adulthood.[3] In 2007-2008, 16.8% of US children and adolescents had a body mass index (BMI; calculated as weight in kilograms divided by height in meters squared) greater than or equal to the 95th percentile on the BMI-for-age growth charts and were considered obese. Although significant increases in obesity prevalence were seen in both sexes of children and adolescents during the 1980s and 1990s,[4] between 1999-2000 and 2007-2008, significant increases were seen only at the highest cut point of BMI, corresponding to the 97th percentile, in 6- through 19-year-old males. No change at any cut point was seen in females.[5]

In epidemiological studies, obesity is often defined based on BMI. But trends in obesity prevalence based on a BMI cut point do not describe changes in BMI for the entire population. Trends in the distribution of BMI can show how the entire population has changed over time.

New US data on weight and height from 2009-2010 are now available. The purpose of this study was to analyze the

See also p 491.

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most recent estimates of high weight-for-recumbent length or obesity prevalence in US infants, children, and adolescents for 2009-2010, to investigate trends in high weight-for-recumbent length or obesity prevalence among infants, children, and adolescents between 1999-2000 and 2009-2010, and to evaluate trends in BMI among children and adolescents aged 2 through 19 years between 1999-2000 and 2009-2010.

METHODS

Data were obtained from the National Health and Nutrition Examination Survey (NHANES),[6] a complex multistage, area probability sample of the US noninstitutionalized population. NHANES is conducted by the National Center for Health Statistics of the Centers for Disease Control and Prevention (CDC). The survey consists of an at-home interview and a physical examination, which includes measurements of weight and height, at a mobile examination center. NHANES was approved by the National Center for Health Statistics Ethics Review Board. Written informed consent was obtained from participants aged 12 years or older, and written child assent was obtained from those aged 7-11 years. Written parental consent was obtained for those younger than 18 years.

NHANES data have been collected continuously since 1999 and data are released in 2-year cycles. Between 1999-2000 and 2005-2006, Mexican Americans were oversampled. Beginning in 2007, all Hispanics were oversampled while allowing for a sufficient number of Mexican Americans. Race and ethnicity were self-reported with open-ended questions during the at-home interview. Participants could report multiple races; in this analysis, multiracial participants were classified as other.

There is no universally agreed on definition of obesity in infants and toddlers from birth to 2 years of age. Consequently, high weight in this age group is defined as weight-for-recumbent length at or above the 95th percentile on the CDC's 2000 growth charts.[7] This is consistent with the definition used for previously published estimates on infants and toddlers.[5] Nonetheless, the CDC recommends the use of the World Health Organization's growth charts to monitor growth in infants and toddlers younger than 2 years.[8]

Weight status among children and adolescents aged 2 through 19 years is defined based on BMI. In children and adolescents, overweight is defined as at or above the sex-specific 85th percentile on the CDC's 2000 BMI-for-age growth charts but less than the 95th percentile; obesity is defined as a BMI at or above the sex-specific 95th percentile.[9] Prevalence estimates at a higher cut point (≥97th percentile) also were studied. The percentage of school-aged children and adolescents with a BMI of 30 or greater (the adult definition of obesity[10]) also was estimated.

The prevalence of high weight-for-recumbent length and obesity in 2009-2010 were analyzed by sex, age, and racial/ethnic subgroups. Mean and median BMI for sex-specific age groups (2-5 years, 6-11 years, and 12-19 years) were investigated for 6 survey periods (1999-2000, 2001-2002, 2003-2004, 2005-2006, 2007-2008, and 2009-2010) over 12 years. Change in obesity prevalence and BMI distributions also were studied.

Analyses of trends in high weight-for-recumbent length and obesity prevalence were conducted using multiple logistic regression. The model for high weight-for-recumbent length among infants and toddlers was adjusted for sex, age, and race/ethnicity. Trends in obesity for children and adolescents aged 2 through 19 years were analyzed in sex-specific models, which were adjusted for age and race/ethnicity, and racial/ethnic-specific models, which were adjusted for age. These models were selected due to significant interactions between sex and race/ethnicity among children and adolescents aged 2 through 19 years. Using each of the 6 survey periods, linear trends were tested with survey period as both a continuous and a discrete variable in the models.

Analysis of potential changes in obesity prevalence among children and adolescents aged 2 through 19 years also were investigated by testing the difference in prevalence between 2009-2010 and earlier years grouped together. Details of 1999-2008 data have been previously published.[4,5] Specifically, comparisons were performed with 2007-2008, 2003-2008, and 1999-2002 to determine whether there have been changes in the more recent years. These tests were conducted within regression models using survey period as a discrete variable with appropriate contrast matrices.

Differences by race/ethnicity and age were tested in the sex-specific multiple logistic regression models in which survey period was treated as a continuous variable. Interaction terms were not significant for survey period and age or survey period and race/ethnicity, suggesting that any differences by age or race/ethnicity in obesity prevalence have not changed between 1999-2000 and 2009-2010. Differences by sex were tested overall and within racial/ethnic groups using *t* tests.

Because BMI is not normally distributed, analyses of trends in BMI were conducted on the log-transformed BMI values in sex-specific multiple linear regression models, adjusted for age (in months) and race/ethnicity. All models were run separately for each sex-specific age group because of age and sex differences in BMI.

All *P* values for trend tests and differences over time were based on the Satterthwaite-adjusted *F* statistic.[11] Odds ratios (ORs), which test for trends, were based on change between the 6 2-year survey periods.

Statistical analyses were conducted using SAS version 9.2 (SAS Institute Inc) and SAS callable SUDAAN version 10 (Research Triangle Institute). SUDAAN was used to allow for the complex sample design in the estimation of standard errors using the Taylor series linearization method and for statistical testing. Survey examination

sample weights, which adjust for nonresponse, oversampling, and noncoverage, were used in estimating all statistics presented in the text. An overall α level of .05 was used to test all statistical hypotheses. Adjustments were made for multiple comparisons. The 95% confidence limits of the prevalence of high weight-for-recumbent length and high BMI for age were constructed using the logit transformation[12] to avoid negative lower limits.

RESULTS

Of the children and adolescents from birth through 19 years of age selected to participate in the NHANES 2009-2010 survey, 88.6% were interviewed and 86.0% were interviewed and examined. Response rates across the survey cycles since 1999-2000 have been similar.[13] The NHANES 2009-2010 sample sizes and weighted percentage distribution for each sex, age, and racial/ethnic-specific subgroup appear in eTable 1 at http://www.jama.com. Of the 4183 examined children and adolescents, 72 were excluded because they had missing data. Thus, there were a total of 4111 children and adolescents from birth through 19 years of age in the sample; 1376 non-Hispanic white, 792 non-Hispanic black, and 1660 Hispanic children and adolescents. The smallest samples were non-Hispanic black infants and toddlers (51 males and 59 females).

The prevalence of high weight-for-recumbent length among infants and toddlers was 9.7% (95% CI, 7.6%-12.3%) in 2009-2010 (TABLE 1). When the data from 1999-2000 through 2009-2010 were analyzed together, there were significant differences by race/ethnicity, with Mexican Americans being significantly more likely to have high weight-for-recumbent length than non-Hispanic whites (adjusted for sex and survey period: OR, 1.67 [95% CI, 1.29-2.15]; eTable 2). In general, estimates of high weight-for-recumbent length based on the 97.7th percentile on the World Health Organization's growth charts[8] were slightly lower than the estimates presented in Table 1, but the World Health Organization–based estimates were within the confidence intervals in Table 1 (eTable 3).

Among children and adolescents aged 2 through 19 years, 16.9% (95% CI, 15.4%-18.4%) were obese in 2009-2010 and 31.8% (95% CI, 29.8%-33.7%) were either overweight or obese (TABLE 2). Also, 12.3% (95% CI, 11.1%-13.5%) were at or above the 97th percentile of BMI for age.

The prevalence of obesity among male children and adolescents aged 2 through 19 years (18.6%) was significantly higher than among female children and adolescents (15.0%) ($P=.01$). Among non-Hispanic white children and adolescents, the prevalence among males was 16.1%, which was significantly higher ($P=.02$) than among females (11.7%). There were no significant differences by sex among Hispanic ($P=.13$) or non-Hispanic black ($P=.99$) children and adolescents.

In 2009-2010, the prevalence of obesity was 12.1% (95% CI, 9.9%-14.8%) among children aged 2 through 5 years, 18.0% (95% CI, 16.3%-19.8%) among children aged 6 through 11 years, and 18.4% (95% CI, 15.8%-21.3%) among adolescents aged 12 through 19 years (Table 2). Among adolescents aged 12 through 19 years, 13.9% (95% CI, 11.5%-16.6%) met the adult definition of obesity with a BMI of 30 or greater. This included 12.2% (95% CI, 9.5%-15.5%) of non-Hispanic white, 15.8% (95% CI, 13.4%-18.5%) of Hispanic, and 21.4% (95% CI, 16.6%-27%) of non-Hispanic black adolescents.

Significant differences in obesity prevalence by race/ethnicity were found. In 2009-2010, 21.2% (95% CI, 19.5%-23.0%) of Hispanic children and adolescents and 24.3% (95% CI, 20.5%-28.6%) of non-Hispanic black children and adolescents were obese compared with 14.0% (95% CI, 11.7%-16.7%) of non-Hispanic white children and adolescents (Table 2).

During the past 12 years (1999-2010), the odds of being obese were significantly higher for non-Hispanic black males (OR, 1.27; 95% CI, 1.09-1.48) and females (OR, 1.99; 95% CI, 1.69-2.35) and Mexican American males (OR, 1.81; 95% CI, 1.56-2.09) and females (OR, 1.47; 95% CI, 1.23-1.76) compared with both non-Hispanic white males and females after controlling for age and survey period (TABLE 3). When combining all survey years together, children aged 2 through 5 years had a lower odds of obesity (males: OR, 0.58; 95% CI, 0.48-0.70; females: OR, 0.62; 95% CI, 0.51-0.74) compared with adolescents aged 12 through 19 years (Table 3) after adjusting for survey period and race/ethnicity. The odds of obesity were not significantly different for children aged 6 through 11 years compared with adolescents aged 12 through 19 years (males: OR, 1.02; 95% CI, 0.90-1.15; females: OR, 0.95; 95% CI, 0.82-1.08).

The prevalence of high weight-for-recumbent length among infants and toddlers did not change between 1999-2000 and 2009-2010 ($P=.97$). FIGURE 1 shows the trends by race/ethnicity.

Trend analyses over a 12-year period, however, indicate a significant trend in obesity prevalence between 1999-2000 and 2009-2010 in male children and adolescents aged 2 through 19 years (OR, 1.05; 95% CI, 1.01-1.10) but not in females (OR, 1.02; 95% CI, 0.98-

Table 1. Prevalence for 2009-2010 of High Weight-for-Recumbent Length in US Infants and Toddlers From Birth to 2 Years of Age[a]

	Infants and Toddlers, % (95% CI)[b]
All[c]	9.7 (7.6-12.3)
Sex	
Male	11.3 (7.9-15.9)
Female	8.1 (5.3-12.2)
Race/ethnicity	
Non-Hispanic white	8.4 (5.2-13.3)
Non-Hispanic black	8.7 (4.6-16.0)
Hispanic[d]	14.8 (11.3-19.2)
Mexican American	15.7 (11.2-21.7)

[a] Data are from the National Health and Nutrition Examination Survey. High weight-for-recumbent length indicates the 95th percentile or higher on the Centers for Disease Control and Prevention's 2000 growth charts. The data are weighted.
[b] The confidence intervals were constructed using logit transformations.
[c] Includes racial/ethnic groups not shown separately.
[d] Includes Mexican Americans.

1.07) per 2-year survey cycle. This translates into an annual increase in the odds of obesity prevalence of 1.03 (95% CI, 1.01-1.05) for males and 1.01 (95% CI, 0.99-1.03) for females. Results of trend tests based on analysis of survey period as a discrete variable were consistent with results based on survey period as a continuous variable; a significant increase in obesity prevalence over time was seen among males but no change was seen among females. Racial/ethnic-specific trend tests for males and females showed a significant increasing trend for non-Hispanic black males (OR, 1.10; 95% CI, 1.03-1.17), translating to an annual increase in the odds of obesity prevalence of 1.05 (95% CI, 1.02-1.08). No other racial/ethnic-specific trends were significant. FIGURE 2 shows obesity trends in males and females by racial/ethnicity.

There was no difference in obesity prevalence for males ($P=.62$) or females ($P=.65$) between 2007-2008 and 2009-2010. Similarly, comparison of 2009-2010 estimates with 2003-2008 showed no significant change among males ($P=.35$) or females ($P=.64$). There was a significant change between 1999-2002 and 2009-2010 among males ($P=.009$) but not among females ($P=.45$). The signifi-

Table 2. Prevalence for 2009-2010 of High Body Mass Index (BMI) in US Children and Adolescents From 2 Through 19 Years of Age[a]

	Children and Adolescents by Age Group, % (95% CI)[b]				
By BMI Percentile	2-19 y	2-5 y	6-19 y	6-11 y	12-19 y
Both Sexes					
All racial/ethnic groups[c]					
≥85th	31.8 (29.8-33.7)	26.7 (22.6-31.2)	33.2 (31.2-35.3)	32.6 (30.1-35.2)	33.6 (30.9-36.5)
≥95th	16.9 (15.4-18.4)	12.1 (9.9-14.8)	18.2 (16.5-20.1)	18.0 (16.3-19.8)	18.4 (15.8-21.3)
≥97th	12.3 (11.1-13.5)	9.7 (7.7-12.2)	13.0 (11.7-14.4)	13.0 (11.2-15.0)	13.0 (10.9-15.4)
Hispanic[d]					
≥85th	39.1 (36.9-41.4)	33.1 (29.7-36.6)	41.2 (38.0-44.4)	39.7 (35.2-44.3)	42.4 (37.2-47.8)
≥95th	21.2 (19.5-23.0)	16.2 (13.1-20.0)	22.9 (21.0-24.9)	22.5 (20.2-25.0)	23.2 (19.3-27.7)
≥97th	15.6 (14.3-16.9)	13.0 (10.1-16.5)	16.4 (15.0-18.0)	16.4 (13.6-19.8)	16.4 (13.4-20.0)
Mexican American					
≥85th	39.4 (35.8-43.1)	33.3 (28.2-38.9)	41.4 (36.4-46.6)	39.0 (33.3-45.1)	43.4 (36.6-50.4)
≥95th	21.2 (18.8-23.8)	15.5 (11.9-20.0)	23.1 (20.1-26.3)	22.1 (18.8-25.8)	23.9 (18.2-30.6)
≥97th	15.5 (13.6-17.7)	11.9 (8.4-16.6)	16.7 (14.7-19.0)	17.5 (13.9-21.7)	16.1 (12.2-20.8)
Non-Hispanic white					
≥85th	27.9 (25.1-31.0)	23.8 (17.9-31.0)	29.0 (25.8-32.4)	27.6 (23.6-31.9)	30.0 (25.4-34.9)
≥95th	14.0 (11.7-16.7)	9.2 (6.0-14.0)	15.2 (12.5-18.4)	13.9 (11.1-17.3)	16.1 (12.6-20.5)
≥97th	9.8 (8.0-12.0)	7.5 (4.6-12.0)	10.4 (8.3-12.9)	9.1 (6.7-12.3)	11.3 (8.4-15.0)
Non-Hispanic black					
≥85th	39.1 (35.5-42.8)	28.9 (21.8-37.3)	41.8 (38.3-45.4)	42.7 (36.2-49.4)	41.2 (35.0-47.8)
≥95th	24.3 (20.5-28.6)	18.9 (12.5-27.5)	25.7 (21.7-30.2)	28.6 (22.0-36.2)	23.7 (19.2-29.0)
≥97th	18.6 (15.4-22.2)	14.4 (9.1-22.2)	19.7 (16.5-23.4)	22.2 (16.9-28.6)	18.0 (14.1-22.6)
Males					
All racial/ethnic groups[c]					
≥85th	33.0 (30.5-35.6)	29.7 (24.0-36.1)	34.0 (30.5-37.6)	33.1 (30.0-36.3)	34.6 (29.2-40.5)
≥95th	18.6 (16.4-21.0)	14.4 (11.0-18.6)	19.8 (16.9-23.1)	20.1 (18.0-22.4)	19.6 (15.2-25.0)
≥97th	13.9 (12.2-15.9)	11.5 (8.4-15.4)	14.7 (12.5-17.1)	14.6 (11.9-17.9)	14.7 (11.2-19.0)
Hispanic[d]					
≥85th	39.6 (35.7-43.5)	34.1 (29.2-39.3)	41.5 (35.8-47.4)	39.7 (34.2-45.5)	42.9 (33.8-52.5)
≥95th	23.4 (20.5-26.6)	17.8 (13.6-23.1)	25.3 (21.8-29.2)	23.9 (20.5-27.7)	26.5 (19.9-34.3)
≥97th	17.6 (15.0-20.5)	14.1 (10.6-18.4)	18.8 (16.1-21.9)	18.3 (13.7-24.2)	19.2 (15.0-24.3)
Mexican American					
≥85th	40.5 (35.2-46.0)	34.0 (25.5-43.7)	42.6 (35.6-49.8)	38.5 (32.2-45.2)	46.0 (33.8-58.8)
≥95th	24.0 (20.6-27.8)	19.1 (13.5-26.4)	25.6 (21.6-30.2)	21.8 (16.6-28.2)	28.9 (19.8-40.1)
≥97th	18.2 (14.5-22.5)	15.0 (10.2-21.5)	19.2 (15.4-23.7)	18.0 (11.7-26.9)	20.2 (14.7-27.1)
Non-Hispanic white					
≥85th	30.1 (26.2-34.3)	26.0 (17.4-36.8)	31.1 (25.9-36.9)	29.7 (25.6-34.1)	32.2 (23.9-41.8)
≥95th	16.1 (12.6-20.3)	11.9 (7.3-18.9)	17.2 (13.0-22.5)	16.8 (13.2-21.3)	17.5 (11.5-25.8)
≥97th	11.6 (9.0-15.0)	9.3 (5.1-16.2)	12.3 (9.0-16.5)	11.1 (7.1-16.9)	13.1 (8.4-19.9)
Non-Hispanic black					
≥85th	36.9 (31.1-43.1)	30.5 (19.6-44.1)	38.8 (31.6-46.5)	40.9 (31.0-51.7)	37.4 (28.4-47.3)
≥95th	24.3 (18.7-30.8)	20.5 (10.6-36.0)	25.4 (18.7-33.5)	29.5 (17.1-45.8)	22.6 (17.1-29.3)
≥97th	19.4 (14.5-25.4)	16.1 (7.9-30.0)	20.3 (14.9-27.1)	23.4 (14.2-36.0)	18.3 (13.8-23.9)

(continued)

Table 2. Prevalence for 2009-2010 of High Body Mass Index (BMI) in US Children and Adolescents From 2 Through 19 Years of Age[a] (continued)

By BMI Percentile	Children and Adolescents by Age Group, % (95% CI)[b]				
	2-19 y	2-5 y	6-19 y	6-11 y	12-19 y
	Females				
All racial/ethnic groups[c]					
≥85th	30.4 (28.4-32.5)	23.4 (18.5-29.2)	32.4 (30.0-34.8)	32.1 (28.5-35.8)	32.6 (28.0-37.6)
≥95th	15.0 (13.3-16.8)	9.6 (6.6-13.8)	16.5 (14.7-18.5)	15.7 (13.7-18.0)	17.1 (14.4-20.1)
≥97th	10.5 (9.2-12.0)	7.9 (5.0-12.2)	11.2 (9.8-12.9)	11.3 (9.4-13.4)	11.2 (9.2-13.7)
Hispanic[d]					
≥85th	38.6 (34.9-42.4)	32.1 (23.3-42.3)	40.9 (37.3-44.6)	39.6 (32.4-47.3)	41.9 (36.5-47.5)
≥95th	18.9 (15.4-22.9)	14.6 (9.3-22.0)	20.4 (17.0-24.2)	21.0 (15.8-27.4)	19.8 (15.0-25.8)
≥97th	13.5 (10.7-16.8)	11.9 (7.4-18.5)	14.0 (11.2-17.4)	14.5 (10.7-19.3)	13.6 (9.6-18.8)
Mexican American					
≥85th	38.2 (33.8-42.8)	32.7 (22.7-44.6)	40.1 (35.7-44.6)	39.5 (31.3-48.4)	40.5 (35.0-46.3)
≥95th	18.2 (13.4-24.2)	11.9 (6.1-21.9)	20.3 (15.8-25.8)	22.4 (16.2-30.2)	18.6 (12.8-26.2)
≥97th	12.7 (9.3-17.2)	8.8 (4.4-16.9)[e]	14.0 (10.5-18.6)	16.8 (11.8-23.4)	11.7 (7.6-17.6)
Non-Hispanic white					
≥85th	25.6 (22.9-28.4)	21.3 (14.4-30.4)	26.6 (23.5-30.0)	25.2 (18.9-32.7)	27.6 (20.8-35.7)
≥95th	11.7 (9.5-14.2)	6.0 (2.9-12.1)[e]	13.0 (10.5-16.1)	10.7 (7.6-14.7)	14.7 (11.0-19.4)
≥97th	7.8 (5.9-10.1)	5.4 (2.4-12.0)	8.3 (6.1-11.3)	7.0 (4.7-10.1)	9.3 (5.7-14.8)
Non-Hispanic black					
≥85th	41.3 (37.0-45.7)	27.0 (19.9-35.6)	44.7 (39.9-49.7)	44.2 (36.4-52.4)	45.1 (37.5-52.9)
≥95th	24.3 (19.2-30.3)	17.0 (8.3-31.7)[e]	26.1 (21.0-32.0)	27.8 (20.5-36.5)	24.8 (19.0-31.8)
≥97th	17.8 (13.9-22.5)	12.4 (5.9-24.2)[e]	19.1 (15.0-24.1)	21.1 (13.9-30.7)	17.6 (12.4-24.3)

[a] Data are from the National Health and Nutrition Examination Survey. Body mass index (calculated as weight in kilograms divided by height in meters squared) was rounded to 1 decimal place and percentiles are from the Centers for Disease Control and Prevention's 2000 growth charts. The data are weighted.
[b] The confidence intervals were constructed using logit transformations.
[c] Includes racial/ethnic groups not shown separately.
[d] Includes Mexican Americans.
[e] Does not meet the standard of statistical reliability and precision (relative standard error ≥30% but <40%).

cant change found in males between 1999-2000 and 2009-2010 is due to the change between 1999-2002 and 2009-2010.

TABLE 4 contains trends in mean and median BMI among children and adolescents aged 2 through 5 years, 6 through 11 years, and 12 through 19 years for the 6 survey periods between 1999-2000 and 2009-2010. Regression models indicate a significant change in BMI only among adolescent males aged 12 through 19 years ($P=.04$) but not among males in the other age groups ($P=.36$ for those aged 2-5 years; $P=.42$ for those aged 6-11 years) or among females in any age group during the 12-year period. eFigures 1-3 show the change in the smoothed distribution of BMI between 1999-2000 and 2009-2010 for males and females in the 3 age groups.

COMMENT

In 2009-2010, 16.9% of US children and adolescents were obese. Obesity prevalence continues to be higher among non-Hispanic black and Hispanic children and adolescents than among non-Hispanic white youth. There was no change in obesity prevalence between 2007-2008 and 2009-2010. Overall trends in obesity prevalence between 1999-2000 and 2009-2010 among children and adolescents aged 2 through 19 years were significant for males but not for females. Similarly, trends in BMI indicate a significant increase among adolescent males but not females of any age. This is consistent with previously published results showing an increase in prevalence of BMI for age at or above the 97th percentile among males but no change in females at any cutoff based on data through 2007-2008.[5]

NHANES has consistently reported significant differences in obesity prevalence by race/ethnicity. Obesity, however, is defined based on BMI, which is an imperfect measure of body fat. Although BMI is highly correlated with body fat at the higher BMI levels,[14] non-Hispanic black children have significantly lower levels of body fat than do Mexican American or non-Hispanic white children at the same BMI level.[15] Consequently the racial or ethnic differences in obesity prevalence based on a BMI cut point, as shown in this analysis, may not represent actual differences in body fat. It is not clear, however, if body fatness is a stronger predictor of obesity-related health outcomes than is BMI.[16]

Because different definitions of obesity in children and adolescents are used throughout the world, it can be difficult to compare estimates in the United States with those in other countries. Nonetheless, estimates of childhood obesity in the United States tend to be higher than in other countries. Based on data from 2004 in Canada, a comparable obesity prevalence among adolescents aged 12 through 19 years was 11.7%; data from 2006 in Mexico in-

dicated a prevalence of 11.5%.[17] This compares with an 18.4% obesity prevalence among adolescents aged 12 through 19 years in the United States in 2009-2010.

Childhood obesity continues to increase in some countries while in other countries or US subgroups it has apparently plateaued. In Ontario, Canada, the prevalence of obesity among adolescents aged 14 through 15 years increased significantly between 2002 and 2008.[18] In contrast, a recently published review of studies found that there had been almost no change in childhood obesity prevalence in Australia between 1996 and 2008.[19] In primary school–aged children in France,[20] there was no statistically significant increase in obesity prevalence between 2000 and 2007; in Switzerland,[21] there was a decrease in obesity prevalence among children aged 6 through 13 years between 2002 and 2007. Reports of low-income children participating in nutrition assistance programs in the United States have indicated no change or a slight decrease in the prevalence of obesity between the early 2000s and 2007 or 2008.[22,23]

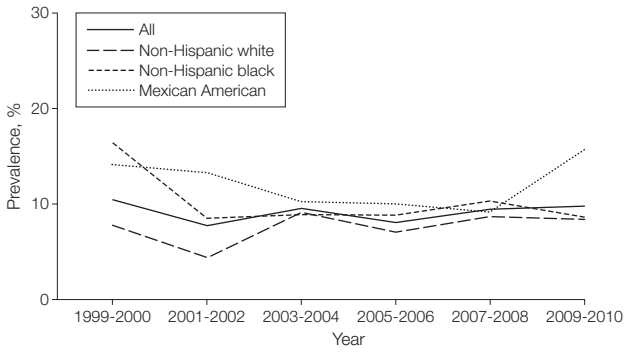
Similar to the results reported herein, sex differences in trends in BMI and obesity among children have been reported by others. In a study of German children and adolescents between 1999 and 2006, Meigen et al[24] found that a significant increase in childhood obesity was more pronounced in boys than in girls. In Iwata City, Japan, Kouda et al[25] found that based on annual data for fifth graders between 1993 and 2008, the 95th percentile of BMI increased in boys but not girls. And, in Sweden there is evidence that the prevalence of overweight plus obesity decreased in girls and remained stable in boys between 2000-2001 and 2004-2005.[26]

Table 3. Odds of Obesity in 1999-2010[a]

	Odds Ratio (95% CI)[b]	
	Males	Females
Age group, y		
2-5	0.58 (0.48-0.70)	0.62 (0.51-0.74)
6-11	1.02 (0.90-1.15)	0.95 (0.82-1.08)
12-19	1 [Reference]	1 [Reference]
Race/ethnicity		
Non-Hispanic white	1 [Reference]	1 [Reference]
Non-Hispanic black	1.27 (1.09-1.48)	1.99 (1.69-2.35)
Mexican American	1.81 (1.56-2.09)	1.47 (1.23-1.76)
Survey period, per 2-y survey cycle	1.05 (1.01-1.10)	1.02 (0.98-1.07)

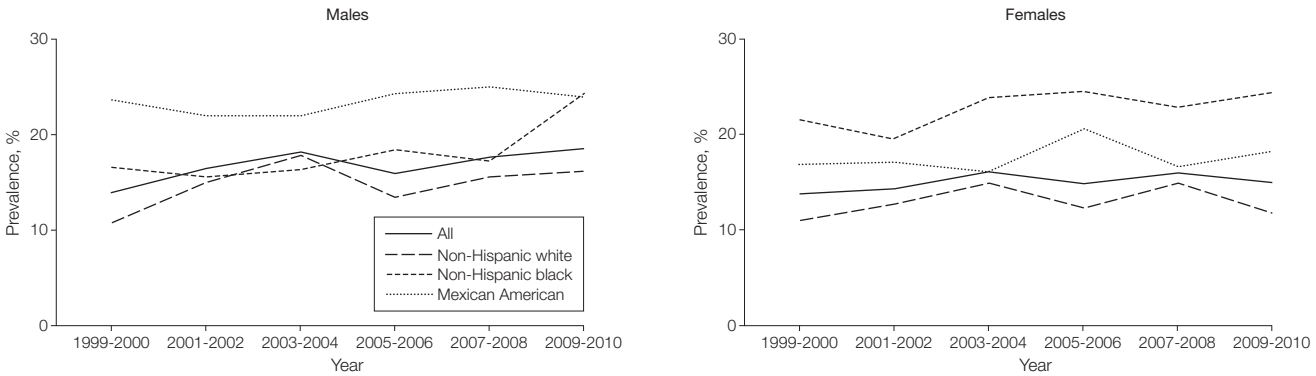
[a] Data are from the National Health and Nutrition Examination Survey. Obesity was defined as body mass index (calculated as weight in kilograms divided by height in meters squared) for age equal to or greater than the sex-specific 95th percentile on the Centers for Disease Control and Prevention's 2000 growth charts. The data are weighted.
[b] The odds ratios are based on logistic regression of obesity.

Figure 1. High Weight-for-Recumbent Length in US Infants and Toddlers From Birth to 2 Years of Age



Data are weighted.

Figure 2. Prevalence of Obesity in US Males and Females Aged 2 Through 19 Years



Data are weighted.

Changes in the distribution of BMI among US children between the 1960s and 1988-1994 have been reported.[27] Mean difference plots for adolescent males and females by single year of age showed that the distribution of BMI became more skewed during that period. Similarly, Kromeyer-Hauschild and Zellner[28] published graphical representations of changes in BMI, although not as dramatic as in the United States, among school children in Jena, East Germany, between 1995 and 2001. Changes in BMI percentile values also have been reported in German preschool-aged children. Using changes in upper percentile values, but not the lower, Kalies et al[29] showed that the distribution of BMI between 1982 and 1997 became more skewed among preschool-aged children in Bavaria. Similarly, Ekblom et al[30] reported shifts in the BMI distribution among Swedish children between 1987 and 2001. No reports have documented changes in the distribution of BMI among US children and adolescents in the last decade.

A strength of the NHANES is the measurement of weight and height. Reported weights and heights are not as accurate as actual measurements. Adolescent self-reported data result in underestimates of the prevalence of obesity, with reporting inaccuracies varying by sex and weight status.[31]

The main limitation to this study is the relatively small sample size based on 2 years of NHANES data and a potential concern over the power to detect changes in the prevalence of obesity. As was previously reported, NHANES was designed to detect a 10% difference between proportions with 80% power, a design effect of 1.5, and a sample size of approximately 420.[5] In our analysis, there was a 3 percentage point difference in childhood obesity prevalence between 1999-2000 and 2009-2010. To detect a change of this magnitude with 80% power requires a sample size of approximately 4000.

The definition of obesity in children is statistical based on a comparison to the reference population of the CDC growth charts. The charts were created for comparison within specific sex and age groups not across sex and age groups. Sex or age differences in prevalence in 2009-2010 may reflect differences in the original reference population.

Many efforts both at the national level[1] and at state and local levels[32] focus on reducing childhood obesity. Yet

Table 4. Trends in Mean and Median Body Mass Index Among Children and Adolescents From 2 Through 19 Years of Age[a]

By Age Group	Unweighted Sample Size	Body Mass Index[b]	
		Mean (95% CI)[c]	Median (IQR)
Males			
2-5 y			
1999-2000	374	16.2 (15.9-16.5)	16.0 (1.7)
2001-2002	383	16.5 (16.1-16.9)	16.1 (1.8)
2003-2004	402	16.7 (16.4-16.9)	16.3 (2.1)
2005-2006	473	16.3 (16.1-16.5)	16.0 (1.9)
2007-2008	465	16.3 (16.1-16.5)	16.0 (1.8)
2009-2010	471	16.6 (16.4-16.8)	16.2 (2.1)
6-11 y			
1999-2000	542	17.9 (17.4-18.4)	17.0 (3.8)
2001-2002	581	18.5 (17.9-19.0)	17.2 (4.5)
2003-2004	463	18.4 (18.0-18.9)	17.1 (4.9)
2005-2006	550	18.2 (17.8-18.6)	17.0 (3.5)
2007-2008	595	18.6 (18.0-19.1)	17.2 (5.2)
2009-2010	621	18.3 (18.2-18.5)	17.0 (5.0)
12-19 y			
1999-2000	1155	22.9 (22.3-23.4)	21.6 (6.1)
2001-2002	1162	23.1 (22.7-23.4)	21.8 (6.1)
2003-2004	1139	23.4 (22.7-24.1)	22.1 (6.8)
2005-2006	1091	23.2 (22.4-23.9)	21.8 (6.3)
2007-2008	641	23.5 (22.8-24.2)	22.1 (7.0)
2009-2010	685	23.8 (23.1-24.5)	22.5 (6.5)
Females			
2-5 y			
1999-2000	352	16.1 (15.8-16.4)	15.7 (1.9)
2001-2002	412	16.1 (15.9-16.4)	15.8 (2.2)
2003-2004	417	16.3 (16.0-16.6)	15.9 (2.0)
2005-2006	479	16.2 (16.1-16.4)	15.9 (1.8)
2007-2008	388	16.3 (15.9-16.6)	15.9 (1.7)
2009-2010	432	16.2 (16.0-16.5)	15.8 (2.0)
6-11 y			
1999-2000	506	18.0 (17.5-18.6)	16.7 (4.7)
2001-2002	584	18.4 (17.7-19.1)	17.3 (4.6)
2003-2004	519	18.9 (18.6-19.3)	17.5 (5.4)
2005-2006	564	18.2 (17.7-18.7)	17.0 (4.2)
2007-2008	602	18.5 (18.0-19.0)	17.1 (5.1)
2009-2010	592	18.5 (18.2-18.8)	17.4 (4.8)
12-19 y			
1999-2000	1110	23.3 (22.8-23.8)	21.9 (5.9)
2001-2002	1139	23.1 (22.6-23.6)	21.6 (6.1)
2003-2004	1021	23.6 (22.8-24.4)	22.0 (6.1)
2005-2006	1050	23.6 (23.0-24.2)	21.8 (7.1)
2007-2008	558	23.4 (22.7-24.0)	22.0 (6.3)
2009-2010	607	23.6 (23.1-24.2)	22.2 (6.4)

Abbreviation: IQR, interquartile range (75th percentile-25th percentile).
[a] Data are from the National Health and Nutrition Examination Survey. All data except sample size are weighted.
[b] Calculated as weight in kilograms divided by height in meters squared and rounded to 1 decimal place.
[c] The confidence intervals were constructed using the Wald method.

results from NHANES indicate that the prevalence of childhood obesity in the United States remains unchanged at approximately 17%, although increases in obesity prevalence may be occurring among males. Some have suggested[33] that the prevalence of obesity among children will reach 30% by 2030, but the data presented herein suggest that the rapid increases in obesity prevalence seen in the 1980s and 1990s have not continued in this decade and may be leveling off. More research is needed to understand why these changes may be occurring.

Published Online: January 17, 2012. doi:10.1001/jama.2012.40

Author Contributions: Dr Ogden had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Ogden.
Analysis and interpretation of data: Ogden, Carroll, Kit, Flegal.
Drafting of the manuscript: Ogden.
Critical revision of the manuscript for important intellectual content: Ogden, Carroll, Kit, Flegal.
Statistical analysis: Ogden, Carroll, Kit, Flegal.
Conflict of Interest Disclosures: The authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest and none were reported.
Disclaimer: The findings and conclusions in this report are those of the authors and not necessarily of the National Center for Health Statistics, Centers for Disease Control and Prevention.
Online-Only Material: The 3 eTables and 3 eFigures are available at http://www.jama.com.

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