Letters

RESEARCH LETTER

Trends in Obesity and Severe Obesity Prevalence in US Youth and Adults by Sex and Age, 2007-2008 to 2015-2016

Obesity prevalence has been increasing since the 1980s among adults, but among youth, prevalence plateaued between 2005-2006 and 2013-2014.[1,2] We analyzed trends in obesity prevalence among US youth and adults between 2007-2008 and 2015-2016 in order to determine recent changes.

Methods | The National Health and Nutrition Examination Survey (NHANES) is a cross-sectional survey with a complex, multistage probability design that represents the civilian, noninstitutionalized population with a response rate of 75.4% in 2007-2008 and 58.7% in 2015-2016.[3] Participants 18 years or older provided written consent, youth aged 7 to 17 years provided written assent, and parental permission was obtained in writing for youth younger than 18 years. NHANES was approved by the National Center for Health Statistics research ethics review board. Standardized measurements of weight and height were obtained.[3]

Among adults aged 20 years and older, obesity was defined as a body mass index (BMI; calculated as weight in kilograms divided by height in meters squared) of 30 or more and severe obesity was defined as a BMI of 40 or more.[4] Among youth aged 2 to 19 years, obesity was defined as a BMI at or above the 95th percentile of sex-specific BMI-for-age and severe obesity was defined as a BMI at or above 120% of the 95th percentile.[1] Pregnant females were excluded.

Prevalence and 95% CIs of obesity and severe obesity were estimated overall[5] and stratified by sex and age (2-5, 6-11, 12-19, 20-39, 40-59, and ≥60 years). Linear and quadratic trends overall and stratified by sex and age were examined in regression models with 2-year survey cycles modeled as an orthogonal polynomial and in adjusted models (including survey cycle, sex, age, race/Hispanic origin [non-Hispanic white, non-Hispanic black, Hispanic, or other], education [high school graduate or less, some college, and college graduate; education of household head for youth], and,

Table 1. Trends in Prevalence of Obesity and Severe Obesity Among US Youth Aged 2 to 19 Years, by Sex and Age Group, 2007-2008 to 2015-2016[a,b]

	2007-2008		2009-2010		2011-2012		2013-2014		2015-2016		*P* Value for Trend[c]	
	No. of Participants	% (95% CI)	No. of Participants	% (95% CI)	No. of Participants	% (95% CI)	No. of Participants	% (95% CI)	No. of Participants	% (95% CI)	Linear	Quadratic
Obesity[d]												
Overall	3249	16.8 (14.2-19.8)	3408	16.9 (15.4-18.4)	3355	16.9 (14.8-19.2)	3523	17.2 (14.9-19.6)	3340	18.5 (15.8-21.3)	.35	.53
Boys	1701	17.7 (14.8-20.9)	1777	18.6 (16.4-21.1)	1713	16.7 (13.8-19.8)	1794	17.2 (14.6-20.1)	1696	19.1 (15.6-23.0)	.78	.43
Girls	1548	15.9 (12.8-19.4)	1631	15.0 (13.3-16.9)	1642	17.2 (14.7-19.9)	1729	17.1 (13.8-20.8)	1644	17.8 (15.3-20.6)	.17	.86
2-5 y	853	10.1 (7.7-12.9)	903	12.1 (9.8-14.8)	871	8.4 (5.8-11.7)	843	9.4 (6.8-12.6)	814	13.9 (11.6-16.5)	.20	.04
6-11 y	1197	19.6 (17.1-22.4)	1213	18.0 (15.9-20.3)	1268	17.7 (14.4-21.5)	1294	17.4 (13.8-21.4)	1268	18.4 (14.9-22.3)	.52	.35
12-19 y	1199	18.1 (14.6-22.0)	1292	18.4 (15.7-21.3)	1216	20.5 (16.9-24.4)	1386	20.6 (16.2-25.6)	1258	20.6 (16.4-25.2)	.22	.69
Severe Obesity[e]												
Overall	3249	4.9 (3.7-6.5)	3408	5.6 (4.3-7.1)	3355	5.6 (4.2-7.3)	3523	6.0 (4.8-7.3)	3340	5.6 (4.0-7.6)	.43	.55
Boys	1701	5.5 (3.9-7.5)	1777	6.4 (4.5-8.8)	1713	5.7 (4.0-7.9)	1794	5.6 (4.5-7.0)	1696	6.3 (4.3-8.9)	.77	.96
Girls	1548	4.3 (2.9-6.2)	1631	4.7 (3.5-6.2)	1642	5.5 (3.9-7.5)	1729	6.3 (4.4-8.6)	1644	4.9 (3.2-7.2)	.29	.27
2-5 y	853	1.8 (0.6-3.9)	903	2.7 (1.6-4.1)	871	1.6 (0.7-3.2)	843	1.7 (0.8-3.3)	814	1.8 (0.8-3.4)	.63	.77
6-11 y	1197	5.7 (4.3-7.5)	1213	5.1 (3.7-6.8)	1268	6.9 (5.2-8.9)	1294	4.3 (3.0-6.1)	1268	5.2 (3.7-7.2)	.46	.67
12-19 y	1199	5.9 (3.9-8.6)	1292	7.4 (4.8-10.8)	1216	6.6 (4.4-9.5)	1386	9.1 (7.0-11.5)	1258	7.7 (5.0-11.2)	.18	.60

[a] Data source: National Health and Nutrition Examination Survey (NHANES). Prevalence estimates are weighted to represent the civilian, noninstitutionalized US population aged 2 to 19 y; weighting accounts for differential probabilities of selection and survey nonresponse.

[b] Age at the time of examination.

[c] *P* values for trends were calculated using regression models, with the 2-y survey cycles modeled as an orthogonal polynomial.

[d] Obesity was defined as a body mass index (BMI; calculated as weight in kilograms divided by height in meters squared) at or above the sex-specific 95th percentile on the US Centers for Disease Control and Prevention (CDC) BMI-for-age growth charts.

[e] Severe obesity was defined as a BMI at or above 120% of the sex-specific 95th percentile on the CDC BMI-for-age growth charts.

Table 2. Trends in Prevalence of Obesity and Severe Obesity Among US Adults 20 Years or Older by Sex and Age Group, 2007-2008 to 2015-2016[a,b]

	2007-2008		2009-2010		2011-2012		2013-2014		2015-2016		*P* Value for Trend[c]	
	No. of Participants	% (95% CI)	No. of Participants	% (95% CI)	No. of Participants	% (95% CI)	No. of Participants	% (95% CI)	No. of Participants	% (95% CI)	Linear	Quadratic
Obesity (BMI ≥30)												
Overall	5550	33.7 (31.5-36.1)	5926	35.7 (33.8-37.7)	5181	34.9 (32.0-37.9)	5455	37.7 (35.8-39.7)	5337	39.6 (36.1-43.1)	.001	.50
Men	2746	32.2 (29.3-35.2)	2889	35.5 (31.9-39.2)	2585	33.5 (30.7-36.5)	2638	35.0 (32.8-37.3)	2583	37.9 (33.1-42.8)	.05	.70
Women	2804	35.4 (33.1-37.8)	3037	35.8 (34.0-37.7)	2596	36.1 (32.6-39.9)	2817	40.4 (37.6-43.3)	2754	41.1 (37.8-44.5)	<.001	.45
20-39 y	1773	30.7 (26.4-35.1)	1957	32.6 (28.9-36.4)	1808	30.3 (26.5-34.5)	1810	34.3 (31.1-37.6)	1780	35.7 (31.7-39.8)	.05	.47
40-59 y	1791	36.2 (32.7-39.9)	2005	36.6 (34.5-38.7)	1727	39.5 (36.0-43.0)	1896	41.0 (36.5-45.5)	1785	42.8 (37.3-48.5)	.009	.83
≥60 y	1986	35.1 (32.9-37.3)	1964	39.7 (36.6-43.0)	1646	35.4 (31.2-39.7)	1749	38.5 (35.0-42.1)	1772	41.0 (36.9-45.3)	.03	.56
Severe Obesity (BMI ≥40)												
Overall	5550	5.7 (4.9-6.7)	5926	6.3 (5.7-7.0)	5181	6.4 (5.2-7.7)	5455	7.7 (6.3-9.4)	5337	7.7 (6.6-8.9)	.001	>.99
Men	2746	4.2 (3.3-5.3)	2889	4.4 (3.6-5.2)	2585	4.4 (2.6-6.8)	2638	5.5 (4.2-7.0)	2583	5.6 (4.3-7.2)	.04	.74
Women	2804	7.3 (6.2-8.5)	3037	8.1 (7.1-9.2)	2596	8.3 (6.9-9.8)	2817	9.9 (8.1-12.1)	2754	9.7 (8.4-11.2)	.002	.73
20-39 y	1773	5.9 (4.4-7.7)	1957	5.9 (4.7-7.2)	1808	5.6 (4.4-7.1)	1810	8.0 (6.3-10.0)	1780	7.8 (6.0-9.9)	.02	.44
40-59 y	1791	6.4 (5.2-7.7)	2005	6.8 (5.7-8.1)	1727	7.7 (6.1-9.4)	1896	8.6 (6.2-11.6)	1785	8.5 (6.6-10.7)	.02	.75
≥60 y	1986	4.5 (3.3-5.9)	1964	6.3 (4.7-8.3)	1646	5.6 (3.7-8.0)	1749	5.8 (4.2-7.7)	1772	6.3 (4.6-8.4)	.19	.62

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared).

[a] Data source: National Health and Nutrition Examination Survey (NHANES). Prevalence estimates are weighted to represent the civilian noninstitutionalized US population aged ≥20 y; weighting accounts for differential probabilities of selection and survey nonresponse. Prevalence estimates overall and by sex were age standardized using the direct method to the 2000 projected US census population using age groups 20-39, 40-59, and ≥60. In 2015-2016, the crude prevalence among adults overall was 39.8% (95% CI, 36.4%-43.2%) for obesity and 7.6% (95% CI, 6.5%-8.9%) for severe obesity.

[b] Age at the time of interview.

[c] *P* values for trends were calculated using regression models, with the 2-y survey cycles modeled as an orthogonal polynomial. Models for overall trends and those for men and women additionally included age group (20-39, 40-59, and ≥60 y).

among adults, smoking status [never, former, or current smoker]) to determine if trends could be explained by these factors. Interactions between survey cycle with sex and age were tested among youth and adults separately to supplement stratified analyses and were not significant. A 2-sided *P* value of .05 was used to assess statistical significance.

Statistical analyses accounted for the complex survey design, including examination sample weights, which adjusted for nonresponse and took into account loss between the screener and interview and between the interview and the examination. Analyses were conducted using R (R statistics), version 3.4.1[6]; SAS (SAS Institute), version 9.4; and SUDAAN (RTI International), version 11.0.

Results | Data from 16 875 youth (**Table 1**) and 27 449 adults (**Table 2**) were analyzed. Among youth, obesity prevalence was 16.8% (95% CI, 14.2%-19.8%) in 2007-2008 and 18.5% (95% CI, 15.8%-21.3%) in 2015-2016. Based on the unadjusted model, there were no significant linear trends in the prevalence of obesity or severe obesity overall, by sex or age group (*P* range = .17 to .78) (Table 1). Obesity prevalence among children aged 2 to 5 years showed a quadratic trend (*P* = .04), decreasing from 10.1% in 2007-2008 to 8.4% in 2011-2012 and then increasing to 13.9% in 2015-2016. Adjusted overall linear and quadratic trends for obesity and severe obesity among youth aged 2 to 19 years remained nonsignificant.

Age-standardized prevalence of obesity among adults increased from 33.7% (95% CI, 31.5%-36.1%) in 2007-2008 to 39.6% (95% CI, 36.1%-43.1%) in 2015-2016 (*P* = .001) (Table 2). Prevalence increased among women, and in adults aged 40 to 59 years and 60 years or older. The observed increases in men and adults aged 20 to 39 years did not reach statistical significance. There were no significant quadratic trends. The adjusted model also showed a significant overall linear trend for obesity among adults (*P* < .001; data not shown).

Age-standardized prevalence of severe obesity in adults increased from 5.7% (95% CI, 4.9%-6.7%) in 2007-2008 to 7.7% (95% CI, 6.6%-8.9%) in 2015-2016 (*P* = .001). Prevalence increased in men, women, adults aged 20 to 39 years and 40 to 59 years. There was no significant linear trend among adults 60 years and older. There were no significant quadratic trends. The adjusted model also showed a significant overall linear trend for severe obesity (*P* < .001; data not shown).

Discussion | Over the most recent decade between 2007-2008 and 2015-2016, increases in obesity and severe obesity prevalence persisted among adults, whereas there were no overall significant trends among youth. Changes in demographics did not explain the observed trends. Limitations include small sample sizes in the youngest age group. Residual bias

due to incomplete nonresponse adjustment is possible and may vary with changing response rates. Additional NHANES data will allow continued monitoring of trends in obesity and severe obesity prevalence among US youth and adults.

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