

# Five-year obesity incidence in the transition period between adolescence and adulthood: the National Longitudinal Study of Adolescent Health<sup>1-3</sup>

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## ABSTRACT

**Background:** No nationally representative longitudinal data have been analyzed to evaluate the incidence of obesity in the transition between adolescence and adulthood.

**Objective:** The objective was to examine dynamic patterns of change in obesity among white, black, Hispanic, and Asian US teens as they transitioned to young adulthood.

**Design:** We used nationally representative, longitudinally measured height and weight data collected from US adolescents enrolled in wave II (1996; ages 13–20 y) and wave III (2001; 19–26 y) of the National Longitudinal Study of Adolescent Health ( $n = 9795$ ). Obesity incidence was defined on the basis of International Obesity Task Force (IOTF) cutoffs (wave II), which link childhood body mass index (BMI) centiles to adult cutoffs (BMI  $\geq 30$ ; wave III), for comparability between adolescence and adulthood. In addition, the more commonly used cutoff of BMI  $\geq 95$ th percentile for age- and sex-specific cutoffs from the 2000 Centers for Disease Control and Prevention growth charts for adolescents (wave II) were compared with adult cutoffs (BMI  $\geq 30$ ; wave III).

**Results:** On the basis of the IOTF cutoffs, obesity incidence over the 5-y study period was 12.7%; 9.4% of the population remained obese and 1.6% shifted from obese to nonobese. Obesity incidence was especially high in non-Hispanic black (18.4%) females relative to white females. The prevalence of obesity increased from 10.9% in wave II to 22.1% in wave III, and extreme obesity was 4.3% at wave III on the basis of a BMI  $\geq 40$ .

**Conclusions:** During a 5-y transitional period between adolescence and young adulthood, the proportion of adolescents becoming and remaining obese into adulthood was very high. This upward trend is likely to continue. Effective preventive and treatment efforts are critically needed. *Am J Clin Nutr* 2004;80:569–75.

**KEY WORDS** Obesity, longitudinal data analysis, minority population, overweight, National Longitudinal Study of Adolescent Health

## INTRODUCTION

We know a great deal about overweight and obesity as major public health issues both in the United States and abroad (1–3). Early development of overweight leads to obesity in adulthood (4–6) and, independently of adult overweight, has adverse effects on risk factors for cardiovascular and other chronic diseases (7–9). We know far less about longitudinal obesity trends in populations during the transition from adolescence to adulthood.

The classic approach to understanding obesity trends has been to look at large cross-sectional data sets, such as the National Health and Nutrition Examination Survey (NHANES). In comparison, longitudinal data are critical to understanding the patterns of obesity development over time, the permanency of obesity at each age, and the ideal points for intervention.

The traditional prevalence studies have examined childhood (eg, Ogden et al; 2) separately from adulthood (eg, Flegal et al; 1) using distinct definitions of overweight and obesity for youth compared with adults. Among adults, risk-based body mass index (BMI; in  $\text{kg}/\text{m}^2$ ) cutoffs of 25 and 30 have been used to define overweight and obesity, respectively (10, 11). Because BMI changes during growth, age- and sex-specific BMI percentiles are used as cutoffs during childhood and adolescence. The 85th and 95th percentiles, based on nationally representative data from the 2000 growth curves of the Centers for Disease Control and Prevention (CDC), have been recommended for use in classifying persons as being overweight or at risk of overweight in the United States (12).

Discrepancies between adolescent and adult definitions limit the ability to generate comparable prevalence measures or to calculate obesity incidence over this transition period. For example, an 18-y-old female with a BMI of 30.2 would not be considered overweight according to the age- and sex-specific CDC growth charts (ie, her BMI is less than the 95th percentile). If she remained the same height, gained no weight, and had the same BMI at age 21 y, when the adult definition would apply, she would be classified as obese. Herein lies the difficulty in assessing overweight in the transition from adolescence to young adulthood. When calculating obesity incidence, it is paramount that obesity definitions be comparable across the age groups of interest. Otherwise, incidence estimates will reflect both changing definitions of the outcome and true weight gain. To allow greater

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**TABLE 1**

Sample sizes by ethnicity in the National Longitudinal Study of Adolescent Health, waves II (1996; ages 13–20 y) and III (2001; ages 19–26 y)

Ethnicity	Males	Females	Total
	<i>n</i> (%)		
White	2677 (55.8)	2799 (56.0)	5476 (55.9)
Black	914 (19.1)	1089 (21.8)	2003 (20.5)
Hispanic	814 (17.0)	770 (15.4)	1584 (16.2)
Asian	392 (8.2)	340 (6.8)	732 (7.5)
Total	4797 (49.0)	4998 (51.0)	9795

consistency in definition across ages, the International Obesity Task Force developed BMI curves with percentile cutoffs for children and adolescents that correspond to the adult BMI cutoffs, which thus provide good comparative reference data during this transitional period (13).

In this article, we examined longitudinal obesity trends across the transition to adulthood using nationally representative data from the National Longitudinal Study of Adolescent Health (Add Health). We describe obesity incidence as well as the percentage of adolescents who became nonobese as adults, which has not yet been quantified in this age group.

## SUBJECTS AND METHODS

### Survey design

The study population consisted of >20 000 adolescents enrolled in Add Health, a longitudinal, nationally representative, school-based study of US adolescents in grades 7–12 plus selected oversampled groups, including minority groups (eg, blacks from well-educated families), and collected under protocols approved by the Institutional Review Board of the University of North Carolina at Chapel Hill. Wave II included 14 438 eligible wave I (1994–1995) adolescents who would be still enrolled in high school during 1996, including dropouts, measured between April and August 1996. Thus, older youths who were high school graduates in wave I were not followed in wave II. In wave III, all wave I respondents were followed (regardless of participation in wave II). Wave III included 15 197 eligible original wave I respondents, measured between August 2001 and April 2002, including 218 who were pretested in April 2001. Our final analysis sample included 9795 adolescents present at both waves II and III with complete measured height and weight data (**Table 1**). In wave II, the age of the participants ranged from 13 to 20 y ( $\bar{x}$ : 16.0 y; 95% CI: 15.8, 16.2 y) and in Wave III from 19 to 26 y ( $\bar{x}$ : 21.4 y; 95% CI: 21.2, 21.7 y). Exclusions included seriously disabled respondents, pregnant females, Native Americans and a small group of participants aged outside the range used in the study. The survey design and sampling frame were described elsewhere (14, 15).

### Body mass

Height and weight were measured in waves II and III during in-home surveys according to standardized procedures. On the basis of the wave III data, a large number of respondents refused height and weight measurements, and 71 weighed in excess of the scale capacity (330 lb, or 150 kg). When respondents who refused measurements had self-reported weight or height, we used

these self reported values because they have been shown to correctly classify a large proportion of the Add Health sample (16). In the analysis sample, this substitution was done for 105 respondents in wave II and 371 respondents in wave III, yielding a slightly higher prevalence of overweight at wave II (BMI  $\geq$  95th percentile of age- and sex-specific cutoffs from the 2000 CDC growth charts;  $\bar{x}$ : 12.5 compared with 11.8) and a slightly higher prevalence of obesity at wave III (BMI  $\geq$  30;  $\bar{x}$ : 22.1 compared with 21.4).

To deal with the discrepant obesity definitions for adolescents and adults, we used the International Obesity Task Force (IOTF; 13) reference to determine the prevalence of obesity at wave II. The IOTF reference is based on pooled international data (including 4 national US surveys) and links childhood and adolescent BMI centiles to adult cutoffs of BMI of 25 and 30. However, we also present overweight (BMI  $\geq$  95th percentile) prevalence data based on the widely used CDC reference to allow for comparison of the Add Health population to other US samples (1, 2). For the young adult population at wave III (ages 19–26 y), we consistently use the BMI cutoff of 30. Thus, the only difference in obesity definition occurs at wave II (ages 13–20 y; IOTF compared with CDC 2000 growth charts), because the adult definition remains consistent. In addition, we compare the BMI distribution in waves II and III.

### Study variables

A combination of in-home surveys of parents and adolescents provided race-ethnicity data. Race-ethnicity was categorized as Hispanic, non-Hispanic white, non-Hispanic black, or Asian-American. Age was the reported age at the participant's last birthday.

### Statistical analysis

Statistical analyses were carried out by using STATA version 8.0 (17). We examined BMI trends from wave II to wave III by graphing BMI distributions at each point in time. We were particularly interested in determining the extent to which the BMI trends reflect an expected increase in BMI with age, compared with our main interest—the age-independent increase in obesity in the same youths over a 5-y period as they become young adults. We therefore used cross-sectional comparisons to compare the BMI distribution of wave II adolescents with same age (13–20 y) participants in NHANES I (1971–1974; 18) and then compared the BMI distribution of wave III young adults with that in the same age (19–26 y) NHANES I participants. These distributions illustrate population-wide increases in BMI over time versus those increases expected with age during the transition from adolescence to early adulthood. We standardized the age distribution of the NHANES adolescents to that of the Add Health study population to allow for an age-appropriate comparison.

To calculate the incidence and prevalence of obesity, we used the widely accepted series of STATA survey procedures to correct for multiple stages of cluster sample design and unequal probability of selection to ensure that our results were nationally representative and that bias in estimates and SEs was reduced. Longitudinal sample weights were used in the longitudinal analyses. For graphic comparisons, we used a kernel density estimator to examine frequency distributions. This was a descriptive study, the aim of which was to investigate the dynamic patterns of change in prevalent, incident, reversal, and maintenance cases

**TABLE 2**

Prevalence of obesity and of extreme obesity among US young adults in the National Longitudinal Study of Adolescent Health, wave III (2001; ages 19–26 y)<sup>1</sup>

	Total	White (n = 5476)	Black (n = 2003)	Hispanic (n = 1584)	Asian (n = 732)
Obesity (BMI ≥ 30) <sup>2</sup>			%		
Total (n = 9795)	22.1 (0.8)	20.9 (1.0)	28.9 (1.7)	23.5 (1.5)	14.1 (2.9)
Males (n = 4797)	21.2 (0.9)	20.8 (1.2)	23.8 (2.1)	20.7 (1.9)	19.1 (3.7)
Females (n = 4998)	23.2 (1.0)	21.0 (1.3)	34.5 (2.4) <sup>3</sup>	26.7 (2.1)	7.7 (2.7) <sup>3</sup>
Extreme obesity (BMI ≥ 40) <sup>4</sup>					
Total (n = 9795)	4.3 (0.4)	3.8 (0.5)	7.5 (0.9)	4.2 (0.6)	1.1 (1.0)
Males (n = 4797)	3.5 (0.4) <sup>5</sup>	3.3 (0.6)	5.1 (1.1)	2.9 (0.8)	1.3 (1.7)
Females (n = 7998)	5.2 (0.5)	4.3 (0.6)	10.2 (1.4) <sup>3</sup>	5.7 (1.2)	0.8 (0.7) <sup>3</sup>

<sup>1</sup> SEs in parentheses. Results were weighted for national representation, and SEs were corrected for multiple stages of cluster sample design and unequal probability of selection. Interaction terms were tested by using ANOVA with Bonferroni’s adjustment.

<sup>2</sup> Main effect of race-ethnicity and the interaction between race-ethnicity and sex were statistically significant,  $P \leq 0.01$ .

<sup>3</sup> Significantly different from same-sex, non-Hispanic whites,  $P \leq 0.01$  (*t* test with Bonferroni’s adjustment).

<sup>4</sup> Main effects of race-ethnicity and sex and the interaction between race-ethnicity and sex were statistically significant,  $P \leq 0.01$ .

<sup>5</sup> Significantly different from females within group,  $P \leq 0.01$  (*t* test with Bonferroni’s adjustment).

of obesity among white, black, Hispanic, and Asian US teens as they transition to young adulthood. We used a *t* statistic to test the statistical significance of differences in group means for obesity prevalence and incidence between the 1996 and 2001 data. For racial-ethnic differences within sex, Bonferroni’s correction for multiple comparisons was applied, with 3 implied comparisons (ie, females: white compared with black, white compared with Hispanic, and white compared with Asian); the  $\alpha$  level of 0.05 or 0.01 was divided by 3 (0.0167 or 0.0033, respectively). For age differences, we used Bonferroni’s correction, with 2 implied comparisons (ie, ages 13–15 y compared with ages 17–18 y; ages 13–15 y compared with ages 18–20 y); the  $\alpha$  level of 0.05 or 0.01 was divided by 2 (0.0250 or 0.0050, respectively).

**RESULTS**

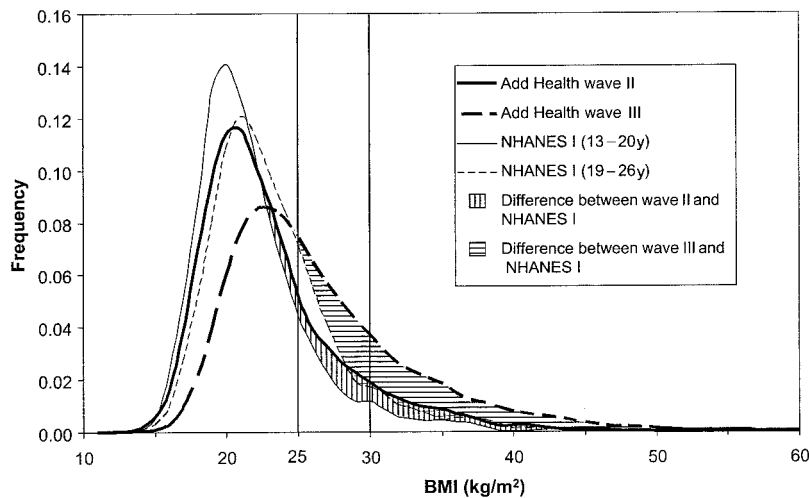
**Prevalence of obesity**

As a starting point, we described the prevalence patterns of obesity among the Add Health wave III young adults to demonstrate the magnitude of the problem in this population (Table 2).

Overall, 22.1% of the wave III young adults ( $\bar{x}$ : 21.4 y) had a BMI ≥ 30 on the basis of adult cutoffs. In comparison, on the basis of the IOTF cutoffs at wave II ( $\bar{x}$ : 16.0 y), the prevalence of overweight was 10.9% in 1996. The prevalence of obesity was highest among non-Hispanic black and Hispanic young adult females. Of note, the prevalence of extreme obesity (BMI ≥ 40; on the basis of the adult cutoffs at wave III) was 4.3% for the total study population; the highest values were for females (5.2%) compared with males (3.5%) and for non-Hispanic black (10.2%) females.

As expected, the BMI of young adults was higher than the BMI of adolescents (Figure 1). However, the positive shift was greater at the upper end of the distribution, suggesting an increase in obesity rather than simply normal growth. The figure also shows the increased proportion of respondents classified as overweight and obese in wave III.

To determine the shift in BMI not inclusive of the normal increase in BMI with age, we plotted the BMI values of Add Health wave II and wave III respondents relative to age-matched, age-standardized data from NHANES I. The comparison of the



**FIGURE 1.** Distribution frequency of BMI from the National Longitudinal Study of Adolescent Health (Add Health) waves II (1996; ages 13–20 y) and III (2001; ages 19–26 y) samples compared with data (n = 5505) from the first National Health and Nutrition Examination Survey (NHANES I), 1971–1974 (17); the NHANES data were age-matched and age-standardized to the Add Health study population.

**TABLE 3**

Shifts in obesity between wave II (1996; ages 13–20 y) on the basis of International Obesity Task Force (IOTF) cutoffs and wave III (2001; ages 19–26 y) on the basis of adult cutoffs in participants of the National Longitudinal Study of Adolescent Health<sup>1</sup>

	Wave II prevalence (baseline prevalence) <sup>2</sup>	Wave II nonobese to wave III obese (became obese) <sup>3</sup>	Wave II obese to wave III obese (remained obese) <sup>4</sup>	Wave II obese to wave III nonobese (became nonobese) <sup>5</sup>	Wave II nonobese to wave III nonobese (remained nonobese) <sup>6</sup>
			%		
Total ( <i>n</i> = 9795)	10.9 (9.8, 12.1)	12.7 (11.7, 13.9)	9.4 (8.4, 10.5)	1.6 (1.3, 2.0)	76.3 (74.5, 77.9)
Males ( <i>n</i> = 4797)	11.3 (9.9, 12.7)	12.0 (10.7, 13.4)	9.2 (7.9, 10.6)	2.1 <sup>7</sup> (1.5, 2.8)	76.8 (74.9, 78.6)
White ( <i>n</i> = 2677)	11.5 (9.7, 13.3)	11.6 (10.1, 13.3)	9.2 (7.6, 11.0)	2.2 (1.5, 3.3)	77.0 (74.5, 79.2)
Black ( <i>n</i> = 914)	12.0 (9.0, 15.1)	13.6 (10.3, 17.7)	10.2 (7.5, 13.6)	1.8 (1.0, 3.2)	74.5 (70.1, 78.4)
Hispanic ( <i>n</i> = 814)	11.5 (8.3, 14.6)	11.5 (9.0, 14.7)	9.1 (7.0, 11.8)	2.2 (1.0, 4.8)	77.1 (72.5, 81.2)
Asian ( <i>n</i> = 392)	6.1 (1.6, 10.6)	13.2 (8.7, 19.7)	5.9 (2.6, 12.7)	0.1 <sup>8</sup> (0.0, 0.2)	80.8 (72.3, 87.2)
Females ( <i>n</i> = 4998)	10.6 (9.1, 12.0)	13.6 (12.1, 15.1)	9.6 (8.3, 11.1)	1.1 (0.8, 1.6)	75.7 (73.3, 77.9)
White ( <i>n</i> = 2799)	9.3 (7.6, 11.1)	12.5 (10.9, 14.4)	8.5 (6.9, 10.3)	1.1 (0.7, 1.5)	78.0 (75.2, 80.6)
Black ( <i>n</i> = 1089)	17.5 (14.4, 20.6)	18.4 <sup>9</sup> (15.2, 22.0)	16.1 <sup>8</sup> (13.4, 19.3)	1.3 (0.6, 2.8)	64.2 <sup>8</sup> (59.3, 68.8)
Hispanic ( <i>n</i> = 770)	12.0 (8.4, 15.7)	15.8 (12.1, 20.4)	10.9 (7.9, 15.0)	1.4 (0.6, 3.3)	71.9 (67.4, 75.9)
Asian ( <i>n</i> = 340)	2.5 (−0.0, 5.1)	6.5 <sup>9</sup> (3.3, 4.4)	1.2 <sup>8</sup> (0.3, 4.4)	1.2 (0.3, 4.0)	91.1 <sup>8</sup> (82.5, 95.7)
Total population by age					
13–15 y ( <i>n</i> = 3249)	10.6 (9.2, 12.0)	11.2 (9.9, 12.7)	8.9 (7.6, 10.4)	1.9 (1.3, 2.6)	78.1 (75.8, 80.2)
16–17 y ( <i>n</i> = 4201)	10.9 (9.2, 12.5)	14.1 (12.3, 16.0)	9.4 (8.0, 11.1)	1.7 (1.3, 2.3)	74.8 (72.4, 77.1)
18–20 y ( <i>n</i> = 2345)	11.8 (9.6, 14.1)	14.6 (12.7, 16.9)	11.1 (9.0, 13.6)	0.9 <sup>10</sup> (0.4, 1.7)	73.4 (70.2, 76.4)

<sup>1</sup> 95% CI in parentheses. IOTF cutoffs corresponded to a BMI  $\geq 30$  (obesity) at wave II relative to adult cutoffs corresponding to a BMI  $\geq 30$  (obesity). All results were weighted for national representation, and the SEs were corrected for multiple stages of cluster sample design and unequal probability of selection. Interaction terms were tested by using ANOVA with Bonferroni's adjustment.

<sup>2</sup> Main effect of race-ethnicity ( $P \leq 0.01$ ) and interaction terms for race-ethnicity  $\times$  sex ( $P \leq 0.05$ ) and age  $\times$  sex ( $P \leq 0.05$ ) were statistically significant; interaction term for race-ethnicity  $\times$  age  $\times$  sex was not significant.

<sup>3</sup> Main effects of race-ethnicity ( $P \leq 0.01$ ) and age ( $P \leq 0.01$ ) and interaction term for race-ethnicity  $\times$  sex ( $P \leq 0.05$ ) were statistically significant; interaction term for race-ethnicity  $\times$  age  $\times$  sex was not significant.

<sup>4</sup> Main effects of race-ethnicity ( $P \leq 0.01$ ) and sex ( $P \leq 0.01$ ) and interaction term for race-ethnicity  $\times$  sex ( $P \leq 0.05$ ) were statistically significant; interaction term for race-ethnicity  $\times$  age  $\times$  sex was not significant.

<sup>5</sup> Main effects of sex ( $P \leq 0.01$ ) and age ( $P \leq 0.05$ ) were statistically significant; interaction term for race-ethnicity  $\times$  age  $\times$  sex were not significant.

<sup>6</sup> Main effects of race-ethnicity ( $P \leq 0.01$ ) and age ( $P \leq 0.01$ ) and interaction term for race-ethnicity  $\times$  sex ( $P \leq 0.05$ ) were statistically significant; interaction term for race-ethnicity  $\times$  age  $\times$  sex was not significant.

<sup>7</sup> Significantly different from females,  $P \leq 0.05$  (*t* test with Bonferroni's adjustment).

<sup>8,9</sup> Significantly different from same-sex, non-Hispanic whites (*t* test with Bonferroni's adjustment): <sup>8</sup> $P \leq 0.01$ , <sup>9</sup> $P \leq 0.05$ .

<sup>10</sup> Significantly different from the youngest age group (13–15 y),  $P \leq 0.05$  (*t* test with Bonferroni's adjustment).

BMI distribution of Add Health participants from waves II and III with that for NHANES I (18) (all measured at the same point in time and age-standardized to the Add Health population) clearly shows the increase in body mass seen in the 5-y period between the longitudinal Add Health surveys, over and above what one would expect given a 5-y difference in age. In other words, the upward age-related shift in BMI was markedly smaller with the use of the NHANES I contemporaneous sample than was the upward shift from Add Health wave II to III. The shapes of the BMI distributions for Add Health wave II [13–20 y: ( $\bar{x}$ : 23.0; median: 21.7; variance: 25.1; skewness: 1.5; kurtosis: 5.9)] and NHANES I [13–20 y: ( $\bar{x}$ : 21.7; median: 20.9; variance: 17.9; skewness: 1.8; kurtosis: 8.6)] were not different although the mean was shifted to the right. However, there were clear differences in the shape of the BMI distributions of the Add Health wave III [19–26 y: ( $\bar{x}$ : 26.2; median: 24.7; variance: 37.4; skewness: 1.3; kurtosis: 5.0)] and NHANES I [19–26 y: ( $\bar{x}$ : 23.4; median: 22.5; variance: 21.2; skewness: 1.8; kurtosis: 8.7)]. The population shift in body mass is particularly evident in the higher BMI range, where a substantial proportion of the wave III young adults fall. Thus, there was an increase in both the prevalence and severity of excess body mass.

### Incidence of obesity in the 5-y period between 1996 and 2001

Over the 5-y period between waves II (ages 13–20 y) and III (ages 19–26 y), considerable differences in the incidence and reversal of obesity were observed (Table 3). On the basis of the IOTF reference, 9.4% of the total sample was obese as adolescents and young adults, and 12.7% of those nonobese at wave II become obese at wave III. Across all sex and ethnic groups, there was a consistently small percentage of adolescents who reversed obesity (changed from being classified as obese at wave II to being classified as nonobese at wave III). Non-Hispanic black females were significantly more likely than their non-Hispanic white counterparts to become and remain obese, whereas Asians were significantly less likely to become and remain obese. Fewer than 2% of the total sample (with little variation across sex and ethnic groups) of young adults who were obese as adolescents shifted to become nonobese. For the total sample, we found that the younger adolescents were less likely to become obese as young adults (compared with older adolescents) and were twice as likely to become nonobese as were their older counterparts.

Obesity incidence data across the 5-y study period with the use of the pediatric cutoff (95th percentile, 2000 CDC growth charts)

**TABLE 4**

Shifts in obesity between wave II (1996; ages 13–20 y) on the basis of 2000 Centers for Disease Control and Prevention (CDC) growth charts for overweight and wave III (2001; ages 19–26 y) on the basis of adult cutoffs for obesity in participants of the National Longitudinal Study of Adolescent Health<sup>1</sup>

	Wave II prevalence (baseline prevalence) <sup>2</sup>	Wave II nonoverweight to wave III obese (became obese) <sup>3</sup>	Wave II overweight to wave III obese (remained obese) <sup>4</sup>	Wave II overweight to wave III nonobese (became nonobese) <sup>5</sup>	Wave II nonoverweight to wave III nonobese (remained nonobese) <sup>6</sup>
			%		
Total (n = 9795)	12.5 (11.3, 13.7)	11.7 (10.6, 12.8)	10.4 (9.4, 11.6)	2.1 (1.7, 2.6)	75.8 (74.0, 77.4)
Males (n = 4797)	14.0 (12.4, 15.5)	10.2 <sup>7</sup> (9.0, 11.5)	11.0 (9.6, 12.6)	2.9 <sup>7</sup> (2.3, 3.8)	75.9 (74.1, 77.7)
White (n = 2677)	14.4 (12.4, 16.4)	9.7 (8.3, 11.3)	11.1 (9.3, 13.2)	3.2 (2.4, 4.3)	76.0 (73.6, 78.3)
Black (n = 914)	14.0 (10.7, 17.2)	12.1 (8.9, 16.3)	11.7 (8.9, 15.2)	2.3 (1.4, 3.9)	73.9 (69.4, 77.9)
Hispanic (n = 814)	13.4 (9.9, 16.8)	10.4 (7.9, 13.4)	10.3 (8.0, 13.2)	2.9 (1.6, 5.4)	76.4 (71.9, 80.4)
Asian (n = 392)	9.2 (4.6, 13.8)	10.2 (6.2, 16.4)	8.9 (5.2, 14.9)	0.4 <sup>8</sup> (0.1, 1.7)	80.5 (72.0, 86.8)
Females (n = 4998)	11.0 (9.5, 12.4)	13.2 (11.9, 14.9)	9.8 (8.5, 11.3)	1.2 (0.9, 1.7)	75.6 (73.2, 77.9)
White (n = 2799)	9.6 (7.8, 11.3)	12.3 (10.6, 14.2)	8.7 (7.1, 10.5)	1.0 (0.6, 1.5)	78.0 (75.2, 80.6)
Black (n = 1089)	18.3 (15.4, 21.3)	18.4 <sup>8</sup> (15.0, 22.2)	16.2 <sup>9</sup> (13.6, 19.1)	2.0 (1.1, 3.6)	63.5 <sup>9</sup> (58.5, 68.3)
Hispanic (n = 770)	13.0 (9.2, 16.8)	15.2 (11.6, 19.7)	11.5 (8.4, 15.6)	1.7 (0.8, 3.7)	71.5 (67.1, 75.6)
Asian (n = 340)	2.7 (0.6, 4.9)	6.6 (3.0, 13.8)	1.1 <sup>9</sup> (0.4, 3.0)	1.5 (0.6, 3.8)	90.8 <sup>9</sup> (82.5, 95.4)
Total population by age					
13–15 y (n = 3249)	12.7 (11.3, 14.2)	9.7 (8.3, 11.2)	9.9 (8.4, 11.3)	2.8 (2.0, 3.5)	77.6 (75.4, 79.8)
16–17 y (n = 4201)	12.5 (10.8, 14.3)	12.7 (10.8, 14.4)	9.8 (8.2, 11.4)	2.0 (1.4, 2.5)	75.6 (73.3, 78.0)
18–20 y (n = 2345)	11.9 (9.4, 14.3)	13.5 <sup>10</sup> (11.3, 15.8)	10.4 (8.3, 12.6)	1.0 <sup>10</sup> (0.3, 1.7)	75.0 (72.0, 78.0)

<sup>1</sup> 95% CI in parentheses. 2000 CDC growth chart cutoffs corresponded to age- and sex-specific BMIs ≥ 95th percentile relative to adult cutoffs corresponding to a BMI ≥ 30 (obesity). All results were weighted for national representation, and the SEs were corrected for multiple stages of cluster sample design and unequal probability of selection. Interaction terms were tested by using ANOVA with Bonferroni’s adjustment.

<sup>2</sup> Main effects of race-ethnicity and sex and interaction terms for race-ethnicity × sex were statistically significant (*P* ≤ 0.01); interaction term for race-ethnicity × age × sex was not significant.

<sup>3</sup> Main effects of race-ethnicity (*P* ≤ 0.01) and age (*P* ≤ 0.05) and interaction term for race-ethnicity × sex (*P* ≤ 0.01) were statistically significant; interaction term for race-ethnicity × age × sex was not significant.

<sup>4</sup> Main effects of race-ethnicity (*P* ≤ 0.01) and sex (*P* ≤ 0.01) and interaction term for race-ethnicity × sex (*P* ≤ 0.05) were statistically significant; interaction term for race-ethnicity × age × sex was not significant.

<sup>5</sup> No terms were statistically significant.

<sup>6</sup> Main effects of race-ethnicity and age and interaction terms for race-ethnicity × sex were statistically significant (*P* ≤ 0.01); interaction term for race-ethnicity × age × sex was not significant.

<sup>7</sup> Significantly different from females, *P* ≤ 0.01 (*t* test with Bonferroni’s adjustment).

<sup>8</sup> Significantly different from same-sex, non-Hispanic whites, *P* ≤ 0.05 (*t* test with Bonferroni’s adjustment).

<sup>9</sup> Significantly different from same-sex, non-Hispanic whites, *P* ≤ 0.01 (*t* test with Bonferroni’s adjustment).

<sup>10</sup> Significantly different from the youngest age group (13–15 y), *P* ≤ 0.01 (*t* test with Bonferroni’s adjustment).

for adolescents (wave II) and the adult cutoff (BMI ≥ 30) for young adults (wave III) are presented in **Table 4**. Although we previously argued that such comparisons are problematic, we present the data to show findings based on definitions that are widely recommended in the United States. In general, estimates of overweight prevalence at wave II were higher and thus incidence estimates were lower when the CDC growth chart 95th percentiles were used than when the IOTF percentile that corresponds to the adult BMI value of 30 was used. In a comparison of the patterns in race, ethnicity, and sex disparities obtained with the use of IOTF definitions compared with those obtained with the use of the CDC growth charts, small differences were observed; however, these slight differences potentially result in a substantial number of misclassifications of the adolescents and incorrect incidence estimates that, when multiplied across the population, may represent millions of US adolescents.

**DISCUSSION**

These data indicate a high incidence and maintenance of obesity during the transition from adolescence to young adulthood. Conversely, only a small proportion of adolescents (ages 13–20 y) moved out of the obese category as they became adults (19–26

y). Despite the rapid linear growth of males after puberty and the equally profound changes in females during this period, only 14.7% of those obese as adolescents (or 1.6% of the wave III sample) ceased to be obese as young adults. This points out the critical nature of focusing on obesity prevention before adulthood and enhancing mechanisms and demand for treatment.

The effect of our findings on the population was substantial. Our Add Health analysis sample represented ≈15.6 million 13–20-y-old students at public and private schools in the United States and indicates that >1.9 million adolescents became obese and an additional 1.5 million adolescents remained obese during the 5-y study period. Conversely, a markedly small proportion of adolescents (representing approximately one-quarter million adolescents) moved out of the obese category as they aged.

These results mirror many smaller studies that display a significant tendency for childhood and adolescent overweight to persist or track into adulthood (4–6). Childhood obesity is moderately predictive, whereas adolescent obesity is highly predictive of adult obesity (19, 20). Our findings indicate that the transition between adolescence and young adulthood appears to be a period of increased risk of development of obesity. This upward trend was evident in both males and females and in all

major US ethnic groups, particularly in non-Hispanic blacks and in older youth (a group not previously thought to be at high risk). The observed increase in BMI is greater than what is expected due to age-related changes in body shape and size. These data are the first longitudinal, nationally representative, and ethnically diverse data to capture the transition from adolescence to adulthood.


The accepted and standard classification of overweight among children and adolescents is based on age- and sex-specific percentiles of the 2000 CDC growth charts (12), which provide statistical (rather than risk-based) definitions of overweight. In contrast, the adult definitions are based on recommendations from expert panels, such as the National Heart, Lung, and Blood Institute (10) and the World Health Organization (11) and relate to health risk in addition to statistical distribution. Nonetheless, the adult definitions remain statistical definitions on the basis of population distributions and are subject to the advantages and disadvantages of all statistical definitions (21). Given the different terminology and definitions used during these distinct stages of life, comparisons that fail to properly bridge both age periods are problematic.

The approach used in this study to address the differences in definition of obesity across the 2 age periods was 3-fold. First, we compared BMI distributions in the Add Health longitudinal sample with those of an age-matched cross-sectional NHANES I sample, and this comparison shows that the increase in BMI from wave II to wave III is substantially greater than what we would expect based simply on the 5-y difference in age. Second, our analyses focused on obesity rather than on overweight, which as a more stringent criteria reduced the chance of misclassifying weight status attributable to changes in lean body mass, rather than adiposity. Third, we used the IOTF cutoff points, which link childhood BMI centiles to adult cutoff and provide a clear comparison in the transition period from adolescence to adulthood.

Our strategy of using the IOTF data are not without caveats. Comparisons of the 2000 CDC growth charts with the IOTF data indicated similarities between the 2 sets of reference values (22–25). However, the IOTF data have limitations, namely the data are designed for international comparisons and produce results similar (but not identical) to those obtained with the use of the 2000 CDC growth charts. In addition, the IOTF references provided a lower percentage of obesity and thus a higher incidence of obesity than did the 2000 CDC growth charts. However, we opted to accept these limitations in exchange for the continuity of the obesity definition across the age ranges of interest, which is essential to the determination of obesity incidence in these distinct periods of life. For comparability with other US studies, we included incidence data derived from the more commonly used 2000 CDC growth charts, which provide a completely distinct definition of overweight in the adolescent and young adult samples. Although our results show similarities in findings between the IOTF reference data and the 2000 CDC growth charts, the differences in using these 2 sets of criteria are significant in the potential for misclassification of individuals (potentially upward of several hundred thousand persons) in the incidence and resolution of obesity categories.

One need only look at Figure 1 to see that the trend toward higher BMIs is disconcerting. The shift in the distribution of BMI from adolescence to young adulthood indicates a displacement of

BMI values (ie, a long right tail) into a high-risk profile. Importantly, these shifts are greater than one would expect with age-related changes. Particularly, the high incidence and maintenance of obesity (and low proportion of adolescents who move in the opposite direction) in this period points to a critical and growing obesity problem. This pattern results in a substantial proportion of young adults with extreme obesity, with particular risk among non-Hispanic black females.

The public health implications of this upward trend in obesity prevalence are substantial. The trend foreshadows higher rates of diabetes and nutrition-related chronic degenerative diseases emerging at younger ages (26, 27). In addition, obesity reduces life expectancy, particularly among young adults (28). This trend among young adults is also alarming in light of further increases in obesity that are likely from the young adult to the middle adult years and in relation to the decline in physical activity shown to occur between adolescence and young adulthood (29–31). Although the upward trend in obesity prevalence occurs across all groups, minority adults are at particular risk (32). The upward trend and adverse health implications associated with obesity are significant and indicate the need for preventive strategies to curb this upward trend in obesity prevalence. 

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