



Original article

Trends in Body Mass Index in Adolescence and Young Adulthood in the United States: 1959–2002

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 A B S T R A C T

Purpose: This study examined trends in body mass index (BMI) during the transition from adolescence to young adulthood by gender and race, using national data from the United States spanning for >40 years from 1959 and 2002. Although past research has investigated BMI trends separately in childhood/adolescence and adulthood, this study uniquely focused on the transition to adulthood (12–26 years) to identify the emergence of the obesity epidemic during this critical life-stage.

Methods: Longitudinal and cross-sectional data were obtained from four nationally representative surveys: National Health and Nutrition Examination Survey, National Longitudinal Study of Adolescent Health, National Health Interview Survey, and National Longitudinal Surveys of Youth (NLSY79 and NLSY97). The analysis tracked age trends in BMI by time, which allowed for the examination of how BMI changed during the transition to adulthood and whether the patterns of change varied by period. Data best suited for trend analysis were identified. Age trends in BMI by gender and race were graphed and regression analysis was used to test for significant differences in the trends using the National Health and Nutrition Examination Survey and National Longitudinal Study of Adolescent Health.

Results: BMI increased sharply in the adolescent ages, beginning in the 1990s and among young adults around 2000. This age pattern of BMI increase was more dramatic among females and blacks, particularly black females.

Conclusions: BMI increased during the transition to adulthood and these increases have grown larger over time. Obesity prevention efforts should focus on this high-risk transition period, particularly among minority populations.

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The public health crisis of increasing body mass index (BMI) among adolescents has captured the attention of researchers and policymakers alike. Since the late 1960s, the prevalence of obesity among adolescents (age: 12–19 years) has quadrupled to about 18% [1,2]. Increasing concerns about the high levels of BMI among youth is evidence that obesity in adolescence tracks into adulthood [3]. Moreover, risk of obesity increases in adolescence and early adulthood [4] because their levels of physical

activity decrease and energy/caloric intake increase, which perhaps are related to social and behavioral changes that occur as individuals transition into adulthood [5]. The transition to adulthood is a life-stage when young people move from being financially dependent on their family to completing their education, entering the labor force, moving out of the family home, forming cohabiting/marital unions, and having children. Because obesity is associated with negative social, economic, and health consequences, such as poor physical health, lower levels of education and income, and a lower likelihood of marriage [6], and because longer duration of obesity increases the severity of these negative consequences [7,8], experiencing obesity during this period could seriously impair successful transitions into adulthood.

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Although the transition to young adulthood is a critical period for the study of BMI change, little research has used national data to examine BMI change during this life-stage. Past research has documented trends in BMI and obesity for adults separately from children and adolescents [4,8–15], usually lumping adolescence into childhood and young adulthood with adults of all ages, with little attention to patterns during this transitional stage in the life course. Focusing on the transition to adulthood as an important risk period for the incidence of obesity will inform obesity prevention efforts to reduce overall prevalence of obesity in both adolescence and adulthood.

The objective of this article was to examine trends in BMI during the transition from adolescence to young adulthood (age: 12–26 years) using multiple national datasets between 1959 and 2002. We examined age trends in BMI by time period, allowing us to examine how BMI changes during the transition to adulthood and whether the pattern of change varies by period, and we did so for different gender and race groups across a period of >40 years.

Background

The increase in BMI during the transition to adulthood is associated with several concomitant social trends that have redefined this life-stage in the United States. Over the past few decades, there has been a lengthening of the adolescent transition to adulthood because young people spend more years in education, thereby delaying job entry, marriage, and childbearing to later ages [16]. An important consequence of the lengthening of the transition to adulthood has been to extend the period of time after young people have left the parental home and tend to have poor diets, less access to healthy food, poor sleep patterns, lack of healthcare or regular doctor visits, and continue to engage in risky health behaviors [5]. For example, inactivity historically increases with age [17]; however, over the past decade, the decrease in physical activity has migrated into the adolescent and young adult ages [18]. These health habits increase the risk of weight gain during the transition to adulthood.

At the same time that the developmental stage involving the transition to adulthood has shifted up in age to occupy the third decade of life, disease onset and prevalence has shifted down the age spectrum for several crucial health conditions, largely because of the increase in obesity among the young. Young adults are at increased risk of metabolic syndrome, high blood pressure, and premature coronary artery disease [19,20].

There are known disparities in BMI by various demographic factors such as race, gender [2], and socioeconomic status [9,14]. Among girls, blacks have the highest prevalence of obesity [21]. Similar patterns are found within the adult population, with black females experiencing the highest prevalence of obesity as compared with all other race/gender subgroups [2,22]. Although previous studies have documented disparities in BMI during either childhood or adulthood, there has been little research investigating how these disparities have unfolded during the transition to adulthood. Our research fills this gap. By focusing on this stage in the life course as a risk period for obesity incidence and examining age and time patterns by race and gender, we will identify vulnerable ages and populations for whom interventions may be especially effective in reducing the obesity burden before it worsens or becomes intractable throughout the adult years [23].

Data and Methods

Sample

Data were obtained from the following four nationally representative surveys: National Health and Nutrition Examination Survey (NHANES) [24], National Longitudinal Study of Adolescent Health (Add Health) [25], National Health Interview Survey (NHIS) [26], and National Longitudinal Surveys of Youth (NLSY79/NLSY97) [27]. For this analysis, we identified national datasets that either covered a wide time span (e.g., NHANES, NHIS) or were longitudinal (e.g., NLSY, Add Health) and that were often used by interdisciplinary researchers interested in child/adolescent health.

National health and nutrition examination survey

Data included six of the NHANES cross-sectional surveys: NHES I (1959–1962), NHES III (1966–1970), NHANES I (1971–1975), NHANES II (1976–1980), NHANES III (1988–1994), and NHANES (1999–2000 and 2001–2002). Each NHANES survey was collected during the entire period indicated using a complex, stratified, multistage probability cluster sampling design to select a nationally representative sample of the United States civilian noninstitutionalized population. Anthropometric measurements were administered by trained health technicians at all the waves, using standardized procedures and equipment. The age range for NHES I was 18–79 years and for NHES III only 12–18 years. All other NHANES samples contain information on individuals aged ≥ 1 year, and some have data on infants aged <1 year.

Add Health

Add Health is a longitudinal school-based study of U.S. adolescents studying in grades 7–12 (age: 12–19 years) beginning in 1994–1995. In 1994, a sample of 132 schools was selected using a stratified cluster design. From school rosters, an adolescent and a parent were selected for an in-home interview in 1995. This study used data from wave I (WI) in 1994–1995, and follow-up waves II (1996) and III (2001–2002) [28]. Height and weight were self-reported at WI, but measured by trained interviewers using standardized protocols and equipment in following waves.

National health interview survey

Data included six NHIS cross-sectional surveys: 1980, 1990, 2000, 2001, 2002, and 2003. Each NHIS survey was collected using a multistage area probability design that allowed the representative sampling of households and noninstitutional group quarters. A sample adult and a sample child were randomly selected from each household. Adult respondents self-reported their height and weight through personal interview. The nonrestricted NHIS data contain information for individuals aged ≥ 17 years.

National longitudinal surveys of youth 79

NLSY79 is a longitudinal sample of individuals who were first surveyed in 1979 when they were 14–21-years-old. The NLSY consists of three independent probability samples that represent the entire population of youth aged 14–21 years as of December 31, 1978. Between 1979 and 1986, interviews were administered

in person. Although height questions were asked in 1981–1983, and 1985, weight questions appear in the 1981–1982, 1985–1986, 1988–1990, and 1992–2004 waves. Therefore, we used the 1981–1982, 1985 waves of the NLSY79. In these years, height and weight were self-reported.

National longitudinal surveys of youth 97

NLSY97 is a longitudinal sample of individuals aged 12–16 years as of December 31, 1996. In 1997, the eligible youth and one of the youth's parents both received personal interviews. Respondents self-reported their height and weight. This analysis used data collected in 1997 and 2001 for period comparability with other datasets used in this study. Similar to the NLSY79, the NLSY97 is a complex survey composed of multiple nationally representative samples.

For all data, we limited our analysis to non-Hispanic black, non-Hispanic white, and Hispanic respondents (with the exception of Add Health, which included Asians, and NHIS, which included an "other" race category) who were between the ages of 12–26 years and had valid measures of height and weight (pregnant females were excluded). Analytical sample sizes varied by dataset. The total combined sample size was 28,818 for NHANES and 18,858 for Add Health. The sample sizes for NHIS and NLSY samples ranged from 7,600 to 18,000 respondents. Sampling weights were calculated to take into consideration the unequal probabilities of inclusion resulting from sampling design and nonresponse.

This study was approved by the University of North Carolina at Chapel Hill Public Health Nursing IRB number 05-1164.

Measures

BMI was computed by dividing body weight in kilograms by the square of height in meters (kg/m^2). It is defined differently for children and adults. In childhood and adolescence, percentiles are used because BMI increases due to normal growth [29]. We used raw BMI score because we needed a consistent measure across both adolescence and young adulthood and percentiles do not exist in adulthood. However, to account for this, we adjusted for age.

Our analysis focused on three demographic measures: gender, age, and race. Datasets differed somewhat in their collection of demographic information. We emphasize these differences and explain our efforts to standardize the measures across the datasets later in the text. In addition to these measures, the effect of calendar year periods was also explored [4].

Race/ethnicity categories differed by study and year of survey collection. Given Hispanic ethnicity and "other" race were not measured or labeled consistently across studies and study years, these racial/ethnic groups were only included in descriptive graphs of aggregate trends in BMI by age and gender. Trends by race were only shown for non-Hispanic blacks and whites.

For our concatenated NHANES dataset series, we created period indicators for regression analysis. We created narrow and wide interval period indicators. The narrow interval period indicators included the following: 1959–1962 (reference category), 1966–1970, 1971–1975, 1976–1980, 1988–1994, and 1999–2002. The wide interval period indicators included: 1959–1980 (reference category), 1988–1994, and 1999–2002.

Analytic strategy

We plotted the trends in BMI by age across total samples, and gender-, race-, and gender/race-specific samples in a series of graphs. In our examination of aggregate trends in BMI by age and period, we compared the data using self-reported height and weight with that using measured height and weight in order to determine the data best suited for trend analysis. Numerous studies have assessed the validity of self-reported height and weight in the United States, indicating an underestimation of BMI [30,31], but, to our knowledge, none have examined the trends.

Panel 1 in Figure 1 shows that around the year 1980, self-reported BMIs among adolescents and young adults in NHIS were only slightly lower than the measured BMIs from NHANES. The self-reports of BMI seemed to be markedly downwardly biased 10 years later. Panel 2 in Figure 1 shows that self-reported adolescent and young adult BMI in NHIS 1990 were considerably lower than the measured BMI in NHANES III (1988–1994) and Add Health WI (1994–1995). A sharper contrast between self-reported and measured BMI appears in studies that were carried out around the year 2000. Self-reported BMI from NHIS 2000–2003 and NLSY 1997–2001 were markedly lower than measured BMI in NHANES 1999–2002 and Add Health VIII (2001–2002).

Thus, there seems to be a dramatic increase in the downward bias in self-reported BMI relative to measured BMI over a 20-year period between 1980 and 2000. Researchers that use self-reported height and weight data such as the NLSY and NHIS should use correction approaches to account for this bias [32]; however, it should be noted that such adjustments increase error that may vary over time in trend analyses. Based on these findings, we only used NHANES and Add Health data in subsequent analysis of BMI trends for the years spanning between 1959 and 2002.

Regression analysis was then used to test whether the age trends in BMI shown in graphs were statistically significant. For the NHANES data, multiple regression models were estimated with pooled cross-sectional data [33]. For the Add Health data, which have repeated measures of BMI for each respondent, we used growth curve models [34] to evaluate changes in BMI over time (i.e., age). The model fits a developmental trajectory for changes in BMI as youth age into young adulthood by gender and race.

Results

BMI trends

Panel 1 in Figure 2 (BMI by age) shows the trends in BMI in adolescents and young adults using NHANES (1959–2002). Over this period, average BMI increased by about $2 \text{ kg}/\text{m}^2$ in early adolescence and by about $3 \text{ kg}/\text{m}^2$ in young adulthood. The increase in BMI over the period was not gradual. Hardly any increase was noticeable in the first four studies ranging from 1959 to 1980. Large increases in early adolescence appeared around 1990 in NHANES III (1988–1994). However, dramatic increases among young adults did not take place until around 2000 in NHANES (1999–2002). For example, 18-year-old adolescents had an average BMI of about $22 \text{ kg}/\text{m}^2$ between 1959 and 1980, which was stable during this period. This increased to about $23 \text{ kg}/\text{m}^2$ in 1990 and to about $25 \text{ kg}/\text{m}^2$ in 2000. Similarly, average BMI for 12-year-olds be-

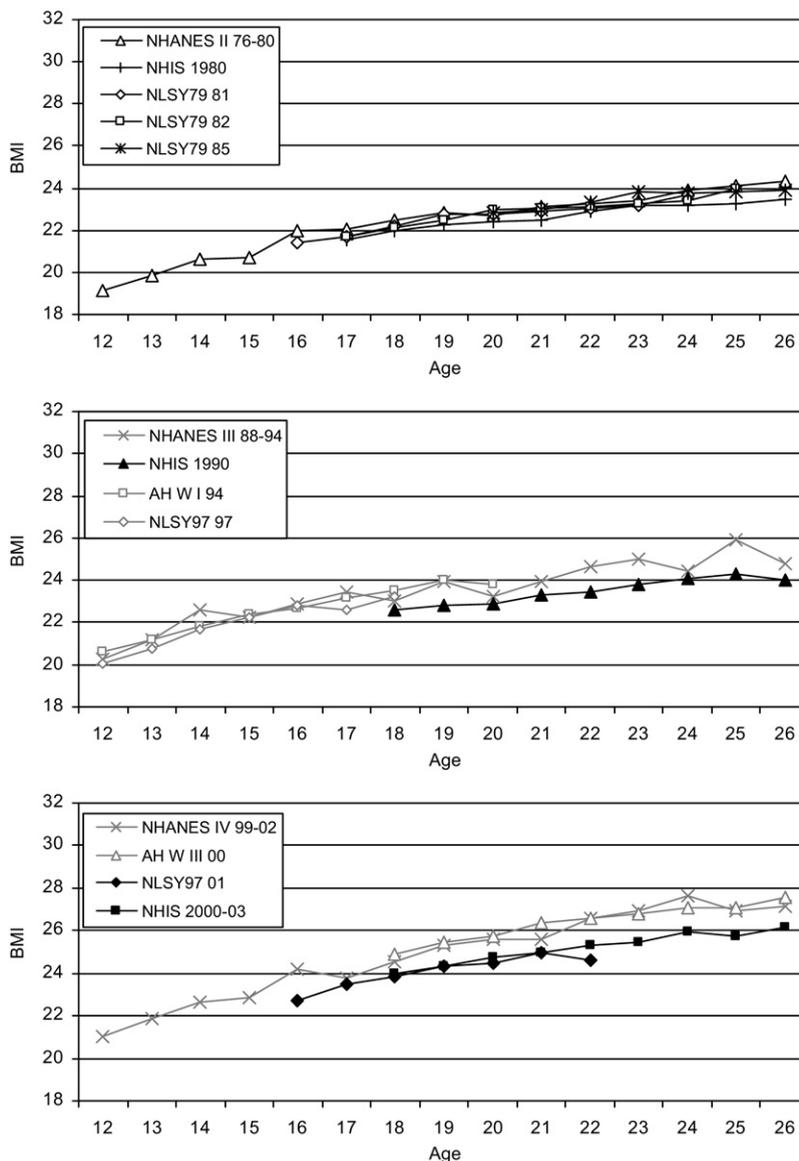


Figure 1. Comparing national datasets: body mass index (BMI), 1975–2003. Panel 1. Comparing national datasets: BMI, 1978–1985. Panel 2. Comparing national datasets: BMI, 1990s. Panel 3. Comparing national datasets: BMI, 1999–2003.

tween 1966 and 1980 was stable during this period at about 19 kg/m². This increased to about 20 kg/m² in 1990 and to about 21 kg/m² in 2000.

Panel 2 in Figure 2 (BMI by gender) explores gender differences in the trends of BMI increase. Although increases in BMI were present among males and females, there were significant differences between the genders. As compared with male young adults, BMI increases among female young adults were larger and started earlier, appearing first in NHANES III (1988–1994). Panel 3 in Figure 2 (BMI by race) investigates differences in the trends between whites and blacks. The increase in BMI among blacks was larger than the increase in BMI among whites and started earlier. Around the year 1990 (as shown in NHANES III), BMI among blacks was already 2–3 kg/m² higher than BMI around 1980. In contrast, the large increase in BMI among white young adults did not appear until around 2000.

Panel 4 in Figure 2 (BMI by gender and race) investigates the interactions between gender and race. Although the general trends in the increase of BMI over the decades were similar across the four gender/race groups, increases for black females were the most dramatic throughout adolescence and young adulthood, especially in young adulthood in the late 1990s. These findings were supported by both NHANES and Add Health.

Regression analysis

The regression models shown in Table 1 were designed to replicate the findings described in Figure 2. To simplify the NHANES regression models, the periods up to 1980 were collapsed into a single period because the findings in panel 1 in Figure 2 suggested little changes in levels of BMI before 1980.

Figure 2. Trends in BMI by age, gender, and race. Panel 1. Trends in BMI by age. Panel 2. Trends in BMI by gender. Panel 3. Trends in BMI by race. Panel 4. Trends in BMI by gender and race.

Column 1: In [Table 1](#), BMI by age shows a marked upward trend in BMI since the reference period of 1959–1980, relative to which the BMI in the period of 1988–1994 increased by 1.09 kg/m² and the BMI in 1999–2002 increased by 2.43 kg/m².

Column 2: In [Table 1](#), BMI by gender investigates the role of gender in the upward trend in BMI. The results indicate that although females on average had a lower BMI than males (–.54 kg/m²), the increase in BMI in the period of 1999–2002 relative

Table 1
Trends in BMI in the United States: linear regression results, 1959–2002 (confirming Figure 2)

Age, gender, race and period measures	NHANES				Add Health
	1: BMI by age	2: BMI by gender	3: BMI by race	4: BMI by gender and race	5: BMI by gender and race
1959–1980 (Reference)					
1988–1994	1.089*** (.132)	.902*** (.191)	.884*** (.156)	.726** (.225)	
1999–2002	2.428*** (.143)	1.981*** (.193)	2.200*** (.164)	1.915*** (.225)	
Age	1.134*** (.090)	1.145*** (.089)	1.136*** (.090)	1.154*** (.089)	.936*** (.045)
Age (squared)	-.020*** (.002)	-.021*** (.002)	-.020*** (.002)	-.021*** (.002)	-.010*** (.001)
Female		-.538*** (.080)		-.721*** (.086)	-.363*** (.093)
White (reference)					
Black			.314** (.118)	-.394* (.151)	.193 (.122)
Black female				1.369*** (.234)	1.504*** (.170)
Interaction with period					
Gender × period					
Female × 1959–1980					
Female × 1988–1994		.369 (.264)		.312 (.312)	
Female × 1999–2002		.891** (.286)		.564 (.328)	
Race × period					
Black × 1959–1980					
Black × 1988–1994			1.058*** (.238)	1.129** (.328)	
Black × 1999–2002			1.154*** (.308)	.488 (.381)	
Race × gender × period					
Black female × 1959–1980					
Black female × 1988–1994				-.146 (.474)	
Black female × 1999–2002				1.342* (.604)	
N	23,687	23,687	23,687	23,687	48,701

NHANES: only whites and blacks included, sample size reduces from 28,818 to 23,687 when Hispanics are excluded; Add Health: Hispanics and Asians also included, coefficients are not shown; the N represents person-wave observations. SE included in parentheses. Data are weighted.

BMI = body mass index; NHANES = National Health and Nutrition Examination Survey; SE = standard error.

* $p < .05$, ** $p < .01$, *** $p < .001$ (two-tailed test).

to the period of 1959–1980 was larger (.89 kg/m²) for female than for male adolescents.

Column 3: In Table 1, BMI by race investigates the role of race. Relative to whites, blacks on average had a higher BMI (.31 kg/m²). In addition, the BMI among blacks increased at a faster rate than whites in both the period of 1988–1994 (1.06 kg/m²) and 1999–2002 (1.15 kg/m²). Column 4: In Table 1, BMI by gender and race attempts to replicate the upward swing in BMI among black females detected in Panel 4 in Figure 2. Black females on average had the highest BMI (1.37 kg/m²) and the BMI among black females also increased at the fastest rate (1.34 kg/m²) in the period 1999–2002. Unlike NHANES data, Add Health data were restricted to the period 1994–2002; thus, the analysis was designed to examine the roles of gender and race in this period. The regression findings from Add Health (Column 5: BMI by gender and race) were similar to those based on NHANES. Because Add Health data are longitudinal and follow the same individuals over time, we gain confidence that the patterns found in the NHANES data are not simply because of the birth cohort differences.

In summary, findings from regression-based models of trends in BMI using NHANES and Add Health were consistent with our descriptive graphical findings. The increase in BMI during the transition to young adulthood has grown larger over time. Increases were larger for females and blacks, with black women being the most vulnerable, especially during 1999–2002.

Discussion

This study examined trends in race/ethnic and gender disparities in BMI during the transition from adolescence to young adulthood using nationally representative data that spanned the

period from 1959 to 2002. We tested for significant differences in age trends in BMI by period, and found that the widely documented recent increase in BMI occurred during the adolescent ages in the 1990s, followed by an increase in BMI in the young adulthood ages a decade later in 2000. This pattern suggests that when BMI increased in the 1990s, that increase was greater for adolescents, and they carried a higher BMI with them into young adulthood 10 years later. However, we cannot sort out how much of the increase in BMI among young adults beginning in 2000 was because of higher BMI among adolescents moving into the young adult ages or increasing BMI among young adults, but it is likely that both processes were operating over time.

Our findings further indicated that the age pattern of increasing BMI in the adolescent ages beginning in the 1990s and in the young adult ages in 2000 was more dramatic for females and blacks, particularly black females. Thus, these groups were especially important in driving the increase in BMI/obesity over the past several decades. Black females, in particular, experienced the greatest increase in BMI since the 1990s. Why BMI would increase so dramatically for black females is not clear, but these findings portend adverse health consequences for black females if this trend persists across the life course and across birth cohorts into the future.

From a historical perspective, our trend analysis implies that the recent and dramatic increase in obesity among black females cannot be solely due to biological factors. It is more likely that recent changes in the physical and social environments in which black females reside are important causes of obesity. Perhaps race- and gender-specific social forces, also increasing during this period, such as increasing unemployment, neighborhood and school segregation and crime, single motherhood, increasingly disadvantaged childhood conditions (e.g., absent fathers

because of the increase in mass incarceration) have served to increase stress and poor health behaviors related to obesity such as overeating and physical inactivity among this group [35–37]. Interventions and clinical care for these populations need to be tailored to reflect these circumstances, such as the work being done in the Bayview Child Health Center, as highlighted in the New Yorker magazine [37].

This study contributes to the research on BMI by examining age and period trends in BMI during an increasingly vulnerable stage in the life course when adolescents transition to young adulthood. Recent research has identified this life-stage when young people leave the parental home and begin to establish their own health habits and behaviors in early adulthood as a period of poor health habits and behavioral choices, and a time in which individuals are more likely to be uninsured or underinsured with less access to primary and preventive care [5]. Weight gain during this transition can set trajectories of BMI into adulthood with negative consequences for metabolic processes and cardiovascular health [20,38]. Increasing BMI at any age is a serious health concern, but it is especially alarming early in life because of earlier and longer exposure to these health-threatening conditions and their associated morbidity and disability [6–8,20].

Future research needs to focus on this early part of the life course to identify the factors that initiate trajectories of BMI increase among young people, an aspect our research did not address. Although obesity is a consequence of complex factors, the prevalence and rapid increase in BMI among young people over these decades is likely due to changes in the social and physical environment, including reduced funding for physical activity programs in public schools, changes in food advertising for children and adolescents, urban sprawl and lower neighborhood walk-ability, and increasing income inequality, and race-specific factors discussed earlier in the text, as well as reduced access to grocery stores in poor and minority neighborhoods [39]. National studies such as Add Health with rich environmental data will provide key insights into the obesity epidemic of the past few decades among young people [40].

Our results align well with other research that has combined multiple years of cross-sectional data to examine trends in obesity and BMI across the age spectrum [4,8,11,12,15,41]. Also, by incorporating longitudinal data from Add Health, our results represent new findings on changes in BMI for the same individual during their transition to adulthood. Our results bring important attention to adolescence as a critical period for the development of obesity. Our findings help inform public health programs designed to curb this epidemic with interventions focused on the young, when BMI changes begin to emerge, rather than in later adulthood when health habits have been established and physical health is already compromised.

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obtain the Add Health data files is available on the Add Health website (<http://www.cpc.unc.edu/addhealth>).

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