Links between Weight, Age at Menarche, and Height in a Cohort of American Women

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Abstract

Three fairly new, and potentially related, trends exist in the United States today: relative decline in height, increasing weight, and decreasing age at menarche. This paper examines the links between weight, age at menarche, and height using data from the National Longitudinal Study of Adolescent Health. It undertakes a regression analysis of the determinants of height after age 20 in females. Determinants include age at menarche, body mass index, socioeconomic status, diet, exercise, and ethnicity. We examine whether the trends in relative decline in height in the U.S. can be explained by decreasing age at maturational timing, instigated by increasing weight, by using the coefficients resulting from these equations with indicators of change over time in BMI and age at menarche, to determine the potential role of each variable in determining trends in height in young adulthood. Linear regression analyses shows that heavier BMI is related to earlier age at menarche, and that earlier age at menarche, in turn, is related to shorter final height at age 20.

Introduction

Three fairly new trends exist in the United States today: relatively declining height, increasing weight, and decreasing age at menarche. Considerable attention has been paid to the relationship between obesity and age at menarche, but height has been relatively overlooked. This paper seeks to understand how these three trends may be related by examining the links between weight, age at menarche, and height in a cohort of American women. The results are applied to determine if relative decline in height in the U.S. can be explained by decreasing age at maturational timing instigated by increasing weight.

The United States was the tallest country in the world for two centuries leading up to the mid 1900s. However, in the 1950s adult height stabilized in the United States, while it continued to increase in other countries, causing Americans to fall behind and stay behind other industrialized European countries (Komlos and Lauderdale, 2007). The Dutch are now the tallest population in the world, a considerable change from the mid-1800s when Americans were 6.5 centimeters taller than the Dutch (Komlos and Breitfelder, 2007). At the same time, a trend of increasing weight has been observed across the United States and has resulted in an increasing proportion of overweight Americans (Reynolds and Himes, 2007; Troiano and Flegal, 1998). Many researchers have linked the increase in weight and obesity to an increase in chronic diseases and an adverse impact on the health of adult Americans; however, it is also possible that increases in weight affect the development of younger people. A third trend that is occurring is a decreasing age at menarche. There is consensus that age at menarche has decreased, but the rate and amount of decrease are debatable. Most researchers estimate that it has dropped from 16 or 17 years to about 12 years over the past 150 years (Wu, Mendola, and Buck, 2002; Ong, Ahmed, and Dunger, 2006). The trend toward decreasing age at menarche has been linked to increasing weight or BMI, which could be related to both more nutritional input and less infection. Some researchers have shown age at menarche to be reduced by increases in weight starting as young as age 3 (Lee et al., 2007). However, few researchers have looked at how height fits into this equation. Adult height may also be impacted by increasing weight and decreasing age at menarche. This paper seeks to elucidate this relationship by addressing the question: Can decline in age at maturational timing explain the relative decline in height in the United States?

Height is determined by many factors, including nutritional status, socioeconomic conditions, health care, illness, work, ethnicity, genetic factors and conditions in utero and in young adulthood. The relative decline in height in the United States is a concern for some demographers because height is seen as an indicator of health and is one predictor of life expectancy. It is negatively correlated with all-cause mortality risk up to the oldest ages (Komlos and Lauderdale, 2007). Thus, the stabilization and relative decline of height in the United States could reflect poorer lifetime health of Americans. Komlos and Lauderdale (2007) have suggested the relative decline of height in the U.S. may be related to a poorer diet and poorer health care compared to the welfare states of Europe. Determining the relationship between height, weight or body mass index, and age at menarche may provide insight into the relative health of Americans and encourage policy changes that promote healthy living in the United States.

Background

Height

Few researchers have paid attention to the stability in absolute height and the decline in relative height of Americans, as this trend has been overshadowed by the more prominent issue of increasing weight. However, Komlos and Lauderdale (2007) recently compared the height of black and white Americans to the height of Western and Northern Europeans between 1958 and 2004 using data from the National Health Examination Survey (NHES) and National Health and Nutritional Examination Survey (NHANES). The authors explain that Americans had been the tallest population in the world for two centuries, until the Depression, when height began to stabilize. Stabilization was followed by decreasing height during World War II and then stagnation for nearly 20 years, for the birth cohorts of 1955-74. At the same time, people in Northern and Western Europe were experiencing rapid increases in height. Despite recent minimal gains in adult height for whites in the birth cohorts of 1975-83, the U.S. still trails behind Europe. Komlos and Lauderdale have postulated that because the height-income and height-educational attainment relationships have remained steady for men and women, relatively declining height may be a result of the U.S. health care system and a weak welfare safety net. That is, comprehensive universal healthcare, intact social safety nets, less socio-economic inequality, as well as a healthier diet in Europe may be causing Europeans to grow taller than Americans.

The biological argument for this hypothesis is that height is determined by energy balance or net nutritional status. Energy balance is energy intake minus energy expenditure. Energy and nutrient intake are affected by many factors such as dietary habits, income and food prices, while expenditure of energy is affected by such factors as work, exercise and illness. Access to affordable, nutritious food and affordable, quality medical care, can directly impact individual energy balance and therefore height. This paper seeks to add to this research by determining whether declining age at menarche, which also may be affected by American diet, could be related to the relative decline in height.

Maturational Timing

There is consensus among researchers that age at menarche has declined in the United States, and throughout the world, since the mid-1800s and early 1900s. Some researchers approximate that in the United States it has decreased by about 4 years from about 16 to 12 (Wyshack as cited in Freedman et al., 2002). In Denmark the mean age at menarche in the 1800s was about 17 years of age (it is now 13-13.5) (Juul et al., 2006). The decrease may be due to improved nutrition and socioeconomic status, as well as the reduction in infection that is related to the long-term increases in life expectancy. There is less consensus about more recent menarcheal trends. Most researchers have found some decline in age at menarche over the last thirty to forty years, but disagree on whether these changes are significant and what the possible causes could be. Researchers do agree that in the United States there are clear racial differences in age at menarche that have been present for decades. Blacks reach puberty first, followed by Hispanics, and then whites, although the differences between Hispanics and non-Hispanic whites are sometimes not significant. Recent estimates of current age at menarche and comparisons to earlier findings are discussed below.

Using data from 7 cross-sectional examinations of Louisiana school-aged children from the Bogalusa Heart Study to perform both longitudinal and cross-sectional analyses, Freedman et al. (2002) found that the median menarcheal age between 1973 and 1994 decreased by 9.5 months among black girls and 2 months among white girls in this sample. Cross-sectional analyses showed the trend among blacks was consistent, decreasing from 12.9 to 12.1 years over the time period. The trend was less consistent among whites as age at menarche initially increased from 12.7 to 12.9 years between 1973 and 1976, but then decreased to 12.5 years by 1994. They also found that an increasing proportion of girls had undergone menarche at a young age, by 11 years of age, in 1994 than was the case in 1973 (17% vs. 5% of blacks and 10% vs. 7% of whites, respectively). Longitudinal analyses concluded that blacks go through menarche about 3 months earlier than whites on average, as the median age of menarche was 12.3 years among blacks and 12.6 years among whites. Anthropometric measures indicated that 5-9 year old black girls were taller and weighed more than white girls of the same age, and that both height and weight were associated with early menarche (<11 years). However, the authors also found that the racial differences in age at menarche are not due to anthropometric characteristics, as the rate of early menarche among black females is still 1.4 times greater than among whites even with controls (Freedman et al., 2002).

Interestingly, another study found that although girls were entering puberty earlier than previously thought (enough to elicit recommendations for revisions to pediatric handbooks), the age at menarche had remained relatively stable over the last 45 years. The study, known as the American Academy of Pediatrics' Pediatric Research in Office Settings (PROS), is a large cross-sectional study conducted by 225 clinicians in pediatric practices of girls aged 3-12 (N=17,077 girls) (Herman-Giddens et al., 1997). Data from this study were used to conclude that the average age of menarche in African American girls is 12.16 years and in white girls it is 12.88 years. After comparing these ages to HANES data (1963-70) they conclude that although age at menarche appears to have decreased, especially among African Americans (from 12.52 years to 12.16), it can be considered relatively stable. However, other characteristics of puberty, such as onset of breast development and pubic hair, occurred much earlier than expected. Blacks experienced these developments at 8.87 and 8.78 years respectively and whites at 9.96 and 10.51 years respectively. Additionally, at 7 years of age 27.2 percent of blacks and 6.7 percent of whites had evidence of breast development or pubic hair and by 8 years of age the numbers were 48.3 percent and 14.7 percent respectively. At 11 years of age 27.9 percent of African Americans had begun their period versus 13.4 percent of whites and by 12 years the numbers were 62.1 percent and 35.2 percent respectively. This led the authors to conclude that girls are entering puberty at younger ages than expected, blacks by 8-9 years and whites by 10 years, and recommended that practitioners revise their definitions of early puberty. In accordance with other studies, the authors found that African American girls were more developed than whites at every age and for every characteristic: they enter puberty 1-1.5 years earlier and begin menstruating 8 months earlier than whites. Not only are they more developed, they are also larger and heavier at each age. One drawback of this study is that the sample is taken from girls in pediatric practices, so it is not representative of the entire U.S. population; however this is also an advantage as the subjects should be in better health.

In another study that compared two nationally representative surveys conducted 25 years apart, the National Health Examination Survey (NHES cycles II and III, 1963-70) and the Third National Health and Nutrition Examination Survey (NHANES, 1988-1994), researchers found that the national average age at menarche dropped by about 2.5 months between the two time periods, from 12.75 to 12.54 years (Anderson, Dallal, and Must, 2003). Broken down by race, this is a change in average age at menarche from 12.48 to 12.14 years for blacks and from 12.8 to 12.6 years for whites in a period that averages about 16 years. Again, blacks had an earlier age at menarche. As in the previously discussed studies, the researchers also found that the percent of girls at each age who had reached menarche was greater in the more recent study (Anderson et al., 2003). At the same time the decrease in age at menarche was occurring, BMI was increasing in adolescent girls: between the two time periods the percent of girls between 10 and 15 years whose BMI was defined as at risk of overweight (BMI≥85^{th} percentile) increased from 16 to 27 percent. Blacks and Hispanics tended to be more overweight than whites. Higher BMI was strongly associated with an increased likelihood of having reached menarche even after race and age were controlled for. Thus, the earlier age at menarche found in black girls is not due to their higher likelihood of being overweight. Additionally, in both surveys, girls who had achieved menarche had a higher BMI than those who not.

Other studies using NHANES III have found similar results. A study of ethnic differences in the presence of secondary sex characteristics and age at menarche found that black and Mexican American girls experienced onset of pubic hair, breast development, and onset of menarche at younger ages than whites (Wu et al., 2002). The mean age of menarche among blacks was 12.1 years, among Mexican Americans 12.2 years, and among whites 12.7 years. These differences were still significant even when BMI and social and economic factors were controlled for (Wu et al., 2002). Additionally, 35.1 percent of blacks, 22 percent of Mexican Americans, and 11.8 percent of whites had attained menarche by 11 years of age.

In a similar study conducted to estimate the average national timing of sexual maturation and the differences among the races using NHANES III, researchers concluded that blacks and Mexican Americans developed pubic hair and breasts earlier than whites, but the differences between Mexican Americans and whites were often not significant (Sun et al., 2002). They also found that although children began puberty at different ages, they tended to complete it around the same age, and almost all were mature by 16.5 years. The earlier maturing children were found to have a greater BMI than the later maturing ones (Sun et al., 2002).

Finally, in another study using NHANES III of 2,510 girls aged 8-20, researchers found the median age of menarche to be 12.43 years, which they find to be not significantly different from 12.77 years reported in 1973, leading them to conclude age at menarche is not significantly earlier than in the past (Chumlea et al., 2003). They find that 80 percent of girls start to menstruate between 11 years and 13.75 years, with less than 1 percent starting before 11 years and about 25 percent starting after 13. They find age at menarche among black girls (12.06 years) to be significantly earlier than among Mexican American (12.25 years) or white girls (12.55 years) (Chumlea et al., 2003). Thus, the most recent trend in age at menarche is somewhat controversial, but these studies all find declining ages of menarche; the decrease, however, is not always significant.

The age of menarche among American girls in not only decreasing in comparison to American adolescents of the past, but it is decreasing relative to European countries as well. In a comparison of pubertal development of Danish and American girls, researchers show that Danish girls experience menarche significantly later (mean age of 13.42) than American girls (Juul et al., 2006). They also experience breast development later (10.88 years) than Americans. Unlike American girls, the age of puberty in Danish children has not changed since 1964. However, as in the U.S., a relationship between BMI and age at menarche was found. Danish girls with a BMI greater than the median BMI experienced breast development and menarche significantly earlier than girls with a BMI less than the median, 10.4 years and 13.2 years versus 11.24 years and 13.7 years respectively (Juul et al., 2006).

Weight

A trend that has been well-publicized in recent years is the increasing prevalence of overweight persons. In an examination of adult obesity (≥18 years) using the National Health Interview Survey (NHIS, 1982-2002), researchers created 16 five-year birth cohorts based on the years 1899 to 1974 and analyzed cohort obesity over the time period 1982-2002 (Reynolds and Himes, 2007). They determined that with each successive birth cohort there is an increase in the probability of being obese at a given age. The 1974 birth cohort of white women was 20 times more likely to be obese than the 1909 birth cohort, and the 1974 birth cohort of black women was 6.5 time more likely to be obese than the 1939 birth cohort. The authors conclude that being born in each successive birth cohort increases the odds of being obese by 21.3 percent; however, whites have lower obesity rates than blacks at all ages (Reynolds and Himes, 2007).

Children and adolescents have been gaining weight at the same time as adults. In another study that examined the change in weight of male and female adolescents (13-20 years) over a five year period (1996-2001) during which they transitioned into adulthood (19-26 years), researchers found that the percent of obese (BMI>30) in the study population increased from 10.9 to 22.1 percent over the time period (Gordon-Larsen et al., 2004a). The rate of obesity was especially high in black females. Of interest is the fact that this study used data from the National Longitudinal Study of Adolescent Health (Add Health) the same dataset used in our study and compared Waves II and III. The researchers noted that the upward shift in BMI was at the upper end of the distribution, conveying not only an increase in obesity but an increase in the severity of obesity. The percent of extreme obesity (BMI>40) by Wave III was 4.3 percent (Gordon-Larsen et al., 2004a).

Flegal and Troiano (2000) found that for every age-sex group studied, the mean and median BMI and prevalence of overweight and obesity were greater in NHANES III (1988-84) than in NHANES II (1976-80) or NHES II or III (1963-65;1966-70). Thus, there has been an increase in BMI across the population. However, for children, the lower end of the distribution of BMI showed almost no change whereas the upper end showed increased difference. Thus, the heaviest children are getting heavier, while the lower end has not changed much.

Correlates of Overweight

Socioeconomic circumstances (income and education), race/ethnicity, physical activity, sedentary behavior, built and social environments, and diet and fast food have all been associated with weight status (Gordon-Larsen et al., 2003, Gordon-Larsen et al., 2002, Boone et al., 2007, Nelson et al., 2006a, Nelson et al., 2006b). In determining the relationship between BMI, height, and age at menarche, many of these factors will be controlled for.

Race

In the United States, weight is correlated with race/ethnicity. The prevalence of overweight tends to be highest in African American females, followed by Hispanics of both sexes, and then white males. There is an inverse relationship between obesity and SES for whites, but not for African Americans or Mexican Americans.

Eating Habits, Nutrition, and Socioeconomic Status

Over the past 20 years there have been changes in eating habits, including what people eat, where they eat, and when they eat, that may be contributing to increased obesity. Most notable is the fact that the number of calories consumed has increased over the last 20 years (Nielsen et al., 2002) and is increasing among all age, race, gender, and SES groups (Popkin et al., 2005). Americans have shifted from consuming meals to energy-dense snacks and from eating at home to away from home, in restaurants, particularly those offering fast food. This has led to large increases in energy intake from foods such as salty snacks, sugary soft drinks, and pizza as well as cheeseburgers, French fries, and Mexican food (Nielsen et al., 2002; Popkin et al., 2005) in combination with a decrease in fruit and vegetable consumption (particularly in low income families and men aged 18-39) (Popkin et al., 2005). These dietary changes were found to be similar in all age groups in a study of energy intake trends between 1977 and 1999 using nationally representative data from the Nationwide Food Consumption Survey. The study showed that for all age groups the decline in energy intake from foods eaten at home was between 11.1 and 20.8 percent, and the increase in energy intake from restaurant or fast food was between 91.2 and 208 percent. The average American previously consumed 76.9 percent of all energy in the home; this has declined to 64.5 percent. However, these changes were proportional across age groups, leading the authors to conclude that widespread social and environmental changes are leading to increasing obesity across the population, rather than adverse choices among only a select group of people (Nielsen et al., 2002).

In a review article of the environmental influences on food choice, physical activity and energy balance, Popkin, Duffey, and Gordon-Larsen (2005) conclude that environmental factors (which they define as consisting of physical, legal, and policy factors) have a significant influence on diet, physical activity, and obesity. Not only have dietary habits changed, but food production, processing, and distribution patterns have changed. These may contribute to changing dietary habits because of different shopping options. The authors state that the neighborhood environment, such as location in relation to a food or health food store, matters in dietary options and choices. They report that residents of higher SES neighborhoods have better access to supermarkets, convenience stores, and a variety of foods, and are also more likely to meet recommendations for healthy living regardless of their individual SES. Race has also been shown to be a factor in availability of foods, as white neighborhoods tend to have greater access to low-cost quality foods than black neighborhoods of equal SES. Price is another factor that affects dietary habits, leading to less consumption of fruits and vegetables among people of lower SES (Popkin et al, 2005).

Physical Activity

The built environment also affects healthy living as it shapes the amount of physical activity undertaken. Physical activity is directly related to weight. Several studies have shown that accessibility of resources, convenience, and aesthetics directly influence physical activity (Popkin et al., 2005). Some neighborhoods are more conducive to walking and biking, and this is especially true in more densely packed and populated cities. In children specifically, access to facilities and opportunities to exercise are predictors of physical activity. For instance, participation in physical education and community recreation center use were shown to have a significant effect on the likelihood that children engaged in moderate to vigorous physical activity (Popkin et al., 2005). Popkin et al.'s study (2005) shows that Black and Hispanic adolescents in the Add Health sample have lower physical education participation rates (which decrease with age) and obtain less moderate to vigorous physical activity than do whites. Additionally, children living in lower SES neighborhoods are less likely to have an activity facility than those living in higher SES neighborhoods and children living in neighborhoods with higher crime rates are less likely to engage in moderate to vigorous physical activity (Popkin et al., 2005).

In a study of the change in physical activity during the transition from adolescence to adulthood based on Add Health data, Gordon-Larsen, Nelson, and Popkin (2004b) found that the majority of adolescents do not achieve 5 or more sessions of moderate physical activity per week and continue to fail to achieve this amount into adulthood. They also found that white adolescent females are more likely to attain this desired level of activity level than black or Hispanic females.

The biological link between weight and puberty may have to do with body fat. One hypothesis is that there is a threshold of weight below which the reproductive system does not function (Frisch and Revelle, 1971). Above this threshold, levels of body fat and an associated hormone, leptin, may allow development to occur. Leptin is positively related to puberty onset and body size and may play a permissive role in menarche (Kaplowitz, 2008). Height may be involved in this process because people who go through earlier puberty may not have reached their full childhood height before maturation ends their growth. This is because estrogen promotes the closure of long bones. Heavier girls may have more estrogen, and while low levels of estrogen encourage puberty, high levels stop the growth of long bones (Turner, Rigges, and Spelsberg, 1994; Cutler Jr., 1997).

BMI and Menarche

A number of researchers have addressed a possible correlation between increased BMI and decreasing age at menarche. First, there is not total agreement in the field about whether increased BMI is related to decreasing age at menarche; and second, among those who feel there is a relationship, there is lack of consensus as to whether the relationship is causal as well as the direction of causation.

A few studies have found that increased BMI is related to age at menarche. Using Add Health data, Adair and Gordon-Larsen (2001) found that early maturing girls were two times more likely than girls maturing at an average age to be overweight. They reported that overweight was significantly higher in early maturing girls and significantly lower in later maturing girls in all race/ethnic groups. Overweight was especially high in blacks, where 57.7 percent of early maturing girls had a BMI greater than the 85^{th} percentile. Another study showed that girls with a higher percentage of body fat at age 5, and girls with larger increases in the percentage of body fat between ages 5 and 9 were more likely to have begun maturation by age 9 (Davison, Susman, and Birch, 2003). Building on this study, Lee et al. (2007) looked at weight before 5 years of age, using data from the National Institute of Child Health and Human Development Study of Early Child Care and Youth Development, and found that a higher rate of change in BMI between 36 months and grade 1 was positively correlated with earlier onset of puberty.

Other studies find contrasting results. Some conclude that BMI and age at menarche are not related, while another study finds causation in the opposite direction, with age at menarche influencing BMI. Demerath et al. (2004b) found that BMI and age at menarche were not related in a study of 371 white girls born in 6 10-year birth cohorts (between 1929-1990) whose mean BMI was measured cross-sectionally at selected ages from 3-35 in the Fels Longitudinal Study. The Fels Longitudinal Study began in 1929 in Ohio and is one of the oldest and largest studies of growth, maturation, and outcomes. Participants attended study examinations every 6 months from age 2-18, and hence the majority of participants were residents of Ohio or nearby. The study finds that although girls born in the 1980s had a mean age of menarche 3-6 months earlier than girls born before, mean BMI in childhood and adolescence remained constant across birth cohorts. Thus, the authors concluded that the trends are independent trends that may be occurring simultaneously. Similarly, in a review of evidence from large population studies dealing with the timing of puberty and increase in obesity since 1960, only one study found changes in age at menarche that were consistent with changes in obesity (Himes, 2006). The author did find a decrease in age of menarche by about 3 months in American white girls and 5.5 months in American black girls between the late 1960s and 1990. In a different study conducted by Demerath et al. (2004a), researchers found that BMI and the rate of increase in BMI for girls born after 1965 were significantly greater than those of girls of earlier birth cohorts in the Fels Longitudinal Study (Demerath et al., 2004b). However, they also found that the increases in weight are a consequence of early age at menarche, rather than a cause (or they may be unrelated). Although they found that girls with earlier ages at menarche were significantly more likely to have higher BMIs than those with average or late menarche, the differences did not appear until 4 to 6 years after menarche (Demerath et al., 2004). Thus, there is some debate over the relationship between BMI and age at menarche. The consensus seems to be that earlier maturers have heavier BMIs, but not all studies have found this relationship.

Height, BMI, and Age at Menarche

Although numerous studies have looked at the relationship of BMI to age at menarche, only a couple have taken height into consideration and examined its relationship to the other 2 factors. Komlos and Breitdelder (2007) conducted a study comparing BMI and height of U.S. and Dutch children, and concluded that differences may lead to and be a result of earlier menarche, respectively. Dutch children were selected as the comparison population because the Dutch are the tallest population in the world and are often used as examples of "ideal development." The authors concluded that U.S. children are shorter and heavier than Dutch children. When adult height stagnated in America, during the birth cohorts of 1955-75, so did the height of American children. Their study shows that at birth American children are actually longer than Dutch children, but by 6 months Dutch children catch up to American children, surpass them, and remain taller for the duration. Specifically looking at girls, the mean height of U.S. children at age two is slightly above the 25th percentile of Dutch children. By age 11 U.S. girls even come within 1 centimeter of the median height of Dutch girls, but by the late teenage years American girls are well below the height of Dutch girls.

Not only are American girls shorter than Dutch girls, but they are also heavier: the median BMI of Dutch girls continually falls below that of American girls and after 8 years it is significantly lower, with a maximum difference of 2.8 units at age 13. The authors believe that the heavier American BMI is related to American girls' earlier age at menarche and, in turn, shorter final height. They explain that American girls experience an earlier growth spurt, with their peak growth occurring between about 9.5 to 10.5 years. Among Dutch girls the majority of growth tends to occur about one year later, as fewer girls experience early menarche in Denmark and more experience menarche after 12 years. This delay gives Dutch girls about one more year of growth before they move into adolescence, probably leading to the taller final height of Dutch women, who on average are about 6 centimeters taller. Additionally, although Dutch girls get their period later, they grow for a longer period of time during adolescence and thus have a higher rate of growth than Americans between the ages of 11 and 16.

Qing He and Johan Karlberg (2000) conducted a study on BMI in childhood and its association with height gain, timing of puberty, and final height, using data from a Swedish population-based longitudinal study of growth. Unlike Komlos and Breitfelder they found that age at menarche does not affect final height. They focused on how overnutrition (increase in childhood BMI) influenced these factors. They found that a greater BMI in childhood was related to an earlier onset of puberty for both boys and girls. In girls, the timing of puberty was 0.7 years earlier. Additionally, BMI gain in childhood was associated with an increased height gain in childhood (increase of 1 BMI unit associated with increase in height of .29 cm. in girls), but a reduced height gain in adolescence (increase of 1 BMI unit associated with reduced height gain by .51 cm. for girls). However, they found no direct correlation between childhood BMI gain and final height, leading them to conclude that overnutrition between 2 and 8 years of age leads to a height gain in childhood, but it is only temporary, as it also causes earlier puberty and a decreased height gain in adolescence, which washes out the earlier height advantage in childhood. This study was conducted on a Swedish sample. Our paper seeks to add to this field by focusing solely on an American sample that is representative of the United States population, an area of research we feel is lacking.

Two additional studies have looked at height and age at menarche, but have left out BMI. Barbara Vizmanos et al. (2001) looked at how age at onset of puberty impacts the intensity and duration of pubertal growth and final height using data from a longitudinal clinical follow-up that began in 1987 and was conducted in children between the ages of 10 and 20 years (N=251). The researchers looked at intensity and duration of growth during puberty because they believe those to be the two factors that influence height gain during puberty. They found that there were significant differences in height at the age of onset of puberty, with later maturers being taller than early maturers. However, earlier onset of puberty in girls was also associated with more height gain during puberty and a longer period of growth during puberty, and later onset of puberty was associated with less height gain and a shorter period of growth, leading to no significant difference in final height by age at pubertal maturation. Thus, like He and Karlberg (and unlike Komlos and Breitfelder), they find that the age of onset of puberty does not affect final height. This is because early maturers are smaller when they enter puberty but grow more and for a longer time during puberty; later maturers are larger at puberty but grow less and for a shorter time. Thus there seems to be a phenomenon that cancels out the anthropometric differences that are present at maturation. One drawback of this study is the sample size was relatively small and was not representative of the United States population.

Karlberg (2002) also conducted a literature review of cross-sectional, longitudinal, and twin studies in an attempt to describe the relationship between the trend of earlier pubertal development and increased final height. In his other studies he has found that earlier puberty impacts final height negatively, while late puberty impacts it positively (like Komlos and Breitfelder). He states that pubertal growth does not contribute as much growth to final height as is popularly believed. He estimates that 7% of female final height is due to pubertal growth during adolescence and thus, individuals who hypothetically do not experience puberty could theoretically obtain a final height around the mean value. Instead, he looks at puberty as a "regulator of the cessation of growth" so that early puberty would lead to decreased final height and the absence of puberty would not be as detrimental as believed. He examines the trends in height and age at menarche and finds that the final height of most European and some western countries has increased 1-3 centimeters per decade over the past 100 years. At the same time age at menarche has decreased by 6 months to 1 year (settling around 12.5 years in Europe). However, he claims that age at menarche has stabilized, while height continues to increase, and thus they are mostly independent trends that are occurring at the same time. He adds that the majority of height gain over the last 100 years has come in the first two years of life, considerably before puberty.

Thus, few researchers have looked at the possibility of a connection between stabilizing height and decreasing age at menarche, instigated by increasing BMI. It is rare to find all three factors considered together. It is also rare to find such a study conducted among an American sample representative of the United States population. This study seeks to do this and therefore further the scientific literature on this subject.

Hypotheses

The primary hypothesis this paper addresses is that age at menarche is positively related to final height. That is, earlier maturers, or girls with a younger age at menarche, will reach a shorter final height than girls who experience menarche at a later age. We expect this to be the case because girls who mature earlier may prematurely stop their childhood growth as they transition into adolescence. A secondary hypothesis, that we expect may help to explain the primary hypothesis, is that body mass index and age at menarche are negatively associated. That is, we expect that girls with a heavier BMI will experience an earlier age at menarche. Thus, we are seeking to elucidate a path of relationships, where heavier BMI leads to earlier age at menarche and earlier age at menarche, in turn, leads to shorter height (Figure 1). Ultimately, this paper will address whether decreasing age at menarche could be leading to a relative decline in height in the United States, and if this is found to be true, if increasing obesity could be leading to an earlier age at menarche. One possible pathway to relative decline in height is increasing BMI resulting in earlier age at menarche.

[Figure 1 about here]

Data

Data for our analysis comes from The National Longitudinal Study of Adolescent Health (Add Health), a longitudinal study of a nationally representative sample of adolescents (Udry, 2003). It consists of three waves of data collection that span the period 1994 to 2002 and tracks a core group of adolescents into young adulthood. It was designed to study the health and well-being of American adolescents. Health and health-related behaviors are captured by variables such as diet/nutrition, physical exercise, access and use of health services, violence, injury, substance abuse, sexual behavior, contraception, sexually transmitted infections, pregnancy, suicide, and mental health (Harris et al., 2003).

Wave I, conducted between September 1994 and December 1995, gathered data on students in grades 7 through 12, from 132 schools representing 80 different communities. Wave I consisted of in-school questionnaires given to every student present on the day of data collection. From these students, as well as ones who did not complete the in-school questionnaire, another random core sample was selected, and administered a 90 minute in-home, more detailed interview. The in-home interviews provide a nationally representative sample of 12,105 American adolescents in grades 7 through 12 and this group is the core group that is studied in follow-up surveys. A parent-interview was also conducted for most of the children who completed the in-home interview. In addition, there are special subsamples such as genetic, ethnic, disabled, and saturation samples from 16 high schools.

Wave II (N= 14,738) was conducted one year later, from April through August 1996, and re-interviewed all the in-home questionnaire respondents from Wave I who were in grades 7 through 11 at Wave I. Twelfth graders at Wave I who were part of the genetic or adopted sample were also included in the Wave II in-home interview; other twelfth graders at Wave I were not included (Harris et al., 2003).

Wave III (N=14,979), conducted six years after Wave II, from August 2001 to April 2002, captured the adolescents as they transitioned to adulthood, with all respondents being between 18 and 26 at the time of Wave III. The merged Wave I, II, and III public use in-home sample used in this paper begins with data from 6,504 respondents of both sexes, not including an over-sample of high-education black students. Thus, only the nationally representative sample was used. The longitudinal aspect of the survey (with Wave III coming six years after Wave I) allows inspection of the relationship and relative changes in height and BMI from adolescence to adulthood in relationship to age at menarche.

The analytic sample for this paper includes female members of the core merged sample (n=2,442), who were age 20 or older at Wave III (n=2,132). Age is limited to those 20 and older because females are assumed to reach adult height by this age (Komlos and Lauderdale, 2007). Only respondents with data on height and weight at Wave I and III and age at menarche at Wave I or Wave III were included. Of the 2,132, 176 cases were missing on BMI at Wave I (8.0%), 148 cases were missing on BMI at Wave III (6.9%), and 4 cases were missing on age at menarche at Wave III (0.2%). This resulted in a final sample size of 1,899.

Measurement

Dependent Variable

Height is the dependent variable. It is measured in inches and partial inches. While height at Wave I was self-reported, at Wave II and III it was measured by interviewers in the field.

Independent Variables

Age at menarche is one of the major independent variables. Age at menarche is self-reported at each Wave. While age at menarche is reported at multiple waves, we use data from Wave I, the Wave closest to the time of menarche for most women and therefore the time at which menarche is likely to be recalled most accurately. Average age at menarche in the sample is about 12 years old and girls in Wave I are generally between 11 and 17 years old. In Wave III almost all are 20 years old or older, making them substantially further from first age at menarche, and perhaps leading to more inaccurate recall with memory failure. However, as not all respondents have experienced menarche by Wave I, we use data from Wave III for those who experienced menarche after Wave I. While average reported mean age at menarche does not change significantly from Waves I to III, it increases slightly, as would be expected with more respondents experiencing menarche at older ages by Wave III. Report at Wave II will not be used, as many subjects were not included in Wave II due to graduation from high school. These subjects were followed up in Wave III but not in II. (See Table 1 for a complete list of variables).

[Table 1 about here].

Weight is also available at each interview; like height, weight was measured at Waves II and III, and self-reported at Wave I. Weight (to the nearest pound) and height (in inches and partial inches) were used to construct the variable BMI at each Wave (BMI I, BMI II, BMI III) by dividing weight in pounds by height in inches squared and multiplying by 703 (weight (lb) / $[\text{height (in)}]^2$ x 703) (Centers for Disease Control and Prevention). BMI at Wave I is based on self-reports and BMI at the next two waves on measurement.

One issue encountered in constructing BMI was that the scale did not register weights over 330 pounds. Therefore, for measured weights in Waves II and III, some weights are reported as missing simply because the scale would not measure those weights. In these instances, self-reported weight is used (which could be reported over 330) as a proxy for measured weight. In Wave III there were nine people with weights over 330 pounds, and for eight of them self-reported weights are provided. While some of these self-report slightly less than 330 pounds, they are all above 300 and are used. It is important to keep these subjects in the data set, rather than lose them altogether, because they represent the heaviest subjects. A similar procedure was followed in Gordon-Larsen, Adair, Nelson, and Popkin (2004a).

Age at menarche and weight are attributes at adolescence that may impact final height. Numerous additional independent variables are used to control for variables that might be related to height and weight. These additional independent variables can be categorized as capturing demographic attributes of the adolescent (age and race), mediating behaviors (diet and exercise), and the adolescent's family attributes (structure and socioeconomic status).

Adolescent's age and race constitute the demographic attributes. Age is calculated as age to the nearest year at the time of the Wave III interview. Race is determined from self-reported race and ethnicity and is categorized into four mutually exclusive categories: white, black, Hispanic, and other. A positive answer to Hispanic ethnicity placed the subject in the category Hispanic irrespective of reported race. The category Black includes people who report themselves as black or report being of multiple races including black, i.e. white and black. The "Other" category consists of Asian, American Indian, and self-reported others, who did not report Hispanic ethnicity. People who reported multiple races including white and one of the "Other" races are categorized as other. Thus, "White" does not include people of multiple races of which one is white, but only those who report only white race.

Mediating behaviors considered consisted of eating patterns and exercise patterns measured over the past week. Nutrition and diet were indicated by intake of fast food and breakfast consumption in the past week. These variables are measured at Wave II, because they were not asked at Wave I. We assume that because Wave II came only 1 year after Wave I, they should be a good approximation of behaviors before or around the time of menarche. These questions were only asked regarding the prior week ("Last week, how many days did you eat in a fast food restaurant?" and "Last week, how many days did you eat breakfast?"). Thus, they may not be representative of the adolescent's typical behavior. For both questions, answers ranged from 0 to 7 days; we used the categories 1 day, 2, 3, 4, and 5 plus days as categories for analysis. It is assumed that adolescents who consume less fast food and more breakfast will have a healthier diet. In fact, it has been shown that those who eat breakfast have significantly lower BMIs than those who skip it (although, people who eat meat and eggs for breakfast have higher BMIs) (Cho et al., 2003). Physical activity is indexed by reports of level of exercise respondents engaged in in the past week. This was determined by two variables, both reported at Wave I: number of times exercised last week and number of times played an active sport in the past week. This question was asked only of the prior week, and thus responses may not reflect an average week for the adolescent. Answers were reported as 0, 1-2 times, 3-4 times, or 5+ times per week.

Finally, attributes of the adolescent's family, such as family structure and socioeconomic status (SES), could potentially affect many of the variables of interest. Family structure could impact childhood development as it could be a possible stressor or support, thus it will be considered in the analysis. Family structure while the adolescent was growing up was determined at Wave I based on answers from the parent-interview to the questions, "What is you relationship to the adolescent?" and "Does the adolescent's biological mother/father live in the household?" If the adolescent lived with both her biological mother and father she was coded as living in an intact household with both biological parents. If the adolescent lived in any other arrangement, she was coded as living in an "other" arrangement. Other arrangements could include single parent families, step families, adoptive families, as well as many other situations. Living with both biological parents is assumed to be the most supportive situation.

We additionally control for family socioeconomic status. Available measures include maternal and paternal education as well as total household income (at Wave 1). Parental education is measured by maternal education, as adolescents are more likely to live with their mothers, whether parents are married or not. There is also more missing data on fathers, as some students appear not to know about their fathers. Information from two study questions was used to determine maternal education – one question was addressed to the mother in the parental interview at Wave I and the other was addressed to the female adolescent in the in-school interview at Wave I. Mothers reported their own level of education. Female adolescents reported level of school completed by their mother in response to the question "How far did mother go in school?" (never went, eighth grade or less, some high school, high school graduate, some college, college graduate, professional training after college, etc). If a mother reported on her own level of education her answer was given precedence over the female adolescent's report of her mother's education. If the mother failed to report her education level, the female adolescent's report was used. For both questions, answers were recoded into one of four levels of schooling: less than high school, high school graduate, some college, or college graduate or more. Subjects who reported that their parents went to school, but did not know what level was attained were coded as high school graduate because that was the modal category. If they did not know whether their mother went to school, they were coded as less than high school, a fairly low level of education. A dummy variable for missing information on education was also constructed to account for those who provided no information (9.2% of the sample). Parent's report of total annual household income (in thousands of dollars) at Wave I was also used to determine household socioeconomic status. Missing responses include those with no parent information as well as parents who did not answer the question; 23.9 percent of the sample had missing responses.

Methods

This study explores the factors affecting age at menarche, and subsequent height at age 20, using two sets of linear regression analyses. The regression analyses rely on Ordinary Least Squares (OLS) regression of the continuous dependent variables. Statistical analysis was performed using SPSS version 15.0 (Statistical Package for the Social Sciences). The first regression analysis examines factors affecting age at menarche and does so through a series of models. The first model examines age at menarche in relation to attributes at adolescence (BMI), the second model adds demographic attributes (race/ethnicity), the third mediating behaviors, and the fourth and final model controls for family attributes. We then move on to explore height using regressions including measures of age at menarche and BMI to adjudicate the relationship proposed. The analysis of the factors affecting height implements similar models to those used to examine age at menarche: attributes at adolescence (age at menarche and BMI), demographic attributes (race/ethnicity), mediating behaviors, and family characteristics. The regressions are used to determine the potential impact of change in age at menarche, weight, and social and demographic characteristics on height. Core weights with post-stratification adjustment for Wave I were applied.

Results

Sample Description

The sample ranges in age at Wave III from 20 to 27 years with a mean age of 22 (See Table 2). In the final sample 66.7% are white, 15.7% Black, 10.9% Hispanic, and 6.7% other. On average, mothers have 13 years of schooling. Mean total annual household income is $48,500. Over half (57.5%) of the sample lives with both biological parents (this does not necessarily mean the parents are married).

[Table 2 about here].

Average height at Wave III is 64.5 inches, which is slightly higher than the 64.3 inches at Wave I. The correlation between height at Wave I and III is .814. Figure 2 shows the distribution of height at Wave III in inches. The modal category is 5 feet 4 inches and the distribution is relatively normal around that value. There is one outlier of 7 feet. The shortest person is 4 feet 6.5 inches.

[Figure 2 about here]

Mean BMI increases from 22.3 to 26.5 between Wave I and III. At Wave I, 20 percent of the girls are overweight (BMI≥25) and 5.9 percent are obese (BMI≥30). By Wave III, about half are overweight (46.9%) and nearly one-quarter are obese (23.5%).

The average age at menarche is 12.2 years. At Wave I the average reported age of menarche is 12.14 years and at Wave III it is 12.65 years. A distribution of age at menarche is shown in Figure 3. The range is 7 years to 20 years old; all of the respondents have experienced menarche by 20 years of age.

[Figure 3 about here].

Bivariate Relationships

Preliminary results show that both height and BMI are related to age at menarche (Figures 4 and 5 respectively). Females at extreme ages at onset of menarche were grouped together in the figures so as to preserve the trend. Those experiencing menarche at 9 years of age or earlier were grouped (N=67) as were those who experienced menarche at age 16 or later (N=30). In the 9 and younger group, 6 girls reported experiencing menarche by 7 years of age, 4 at 8 years of age, and 57 at 9 years of age. In the older grouping, 21 experienced menarche at 16 years, 6 at 17 years, 2 at 18, and 1 at 20.

[Figures 4 and 5 about here]

As hypothesized, females with later age of menarche are taller on average at Wave III. Similarly, females with higher BMIs tend to experience menarche earlier. This is especially true for females in the more "normal" age range of menarche (9-15 years). The graph tails slightly upward for females experiencing menarche after 15 years, showing that these women tend to have slightly higher, although still relatively low BMIs. This may be because by 16 plus years of age the women are taller and larger (leading to higher BMIs), than girls in the more normal range, because of development that occurs by that age regardless of the onset of menarche. Similarly, females experiencing menarche before age 9 have a relatively low BMI. This may be because they are young and have gone through relatively less development. Outliers withstanding, this relationship seems to lend support to the view that early age at menarche is associated with a higher BMI. The relationship between age at menarche and BMI at Wave I and BMI at Wave III are similar (Figure 6). The value of BMI for each age group increases between the time periods (as would be expected with maturation) but the trend remains the same.

[Figure 6 about here]

The influence of race/ethnicity on the primary variables (BMI, age at menarche, height) is examined in Table 3. The primary variables are broken down by race/ethnicity category. As the table shows, blacks have a higher BMI than whites at both Wave I and III. This difference is significant at each wave. Hispanics and Other are not significantly different from Whites in BMI at either wave. Hispanics and Other are significantly shorter than whites at Wave III, but blacks are not. This is an interesting change from Wave I, when all races were significantly shorter than whites. Additionally, Hispanic age at menarche is significantly lower than that for whites; this is not true for Black or Other (although both of these groups have a younger mean age at menarche than that of white as well). Thus, Hispanics have a significantly lower age at menarche than whites and are significantly shorter than whites at Wave III.

[Table 3 about here]

Regression Analysis

Two sets of linear regression analyses are run to examine the relationships between the hypothesized variables: one with age at menarche as the dependent variable and one with final height as the dependent variable. The first regression analysis examines factors that may effect age at menarche, because we hypothesize that decreasing age at menarche may be related to relative decline in height. Therefore, we want to determine what impacts age at menarche, and then see how these factors may impact height.

Within each analysis, several models are run sequentially to examine the relationships between different sets of potential explanatory factors. The first model examines the most basic relationship between the primary independent and dependent variable alone. The second model incorporates the demographic attribute of race and ethnicity. The third model includes possible individual mediating behaviors, such as eating and exercise patterns; and the fourth and final model adds family attributes and indicators of socioeconomic status.

Model 1 in Table 4 on age at menarche shows that BMI at Wave I is related to age at menarche. The relationship is highly significant in the inverse direction ($b = -0.051$, $p \leq .01$). Therefore, a higher BMI in adolescence is associated with an earlier age at menarche.

[Table 4 about here]

Model 2 added the demographic attribute of race and ethnicity to the analyses with white as the reference category. BMI at Wave I remained highly significant with the same coefficient as in Model 1. Hispanics have significantly earlier menarche than whites ($b = -0.226$, $p < .05$). The coefficients for black race and other race are also negative in comparison to whites, but are non-significant. Hispanics also differ significantly from blacks ($p \leq 0.10$) in their age at menarche. The relationship, obtained by running the regression including white and using black as the reference category, is negative (b = -.218). The "other" category does not differ significantly in age at menarche from either whites or blacks.

Model 3 examined how individual behaviors, such as eating patterns and exercise patterns, may mediate relationships with age at menarche. BMI at Wave I and Hispanic ethnicity remained significant when controls for individual behaviors were added in this model. The effect of eating fast food two days a week was related to a significantly later age at menarche (b = 0.242, $p<.05$). Girls who did not report their fast food consumption or for whom no data are available have a somewhat later age at menarche (b = .198, $p\leq.10$). All the categories of fast food consumption greater than zero had weak positive coefficients indicating that eating fast food tended to delay menarche in comparison to not eating it, but most of these relationships did not attain statistical significance.[1] This is somewhat surprising given the high caloric density and fat content of fast food and that heavier BMI is associated with earlier menarche. It could be that reports of fast food consumption in the past week are not typical for the adolescent, as she usually eats more or less fast food per week than reported. Still it must be remembered that most of these relationships did not attain significance. Age at menarche for those playing sports five plus times in the past week was significantly different from the age for those playing sports zero times in the past week, and was the only category that was significantly different from the reference category. The relationship was in the positive direction (b = 0.249, $p<.05$), with more sports activity being associated with later menarche, in comparison to those who did not participate in sports in the last week. High performance

[1] A control for breakfast consumption in the past week was also initially included, but was subsequently dropped because it never attained significance in its relationship to height, and was very inconsistently related to age at menarche.

athletes experience menarche later, perhaps due to lower body fat content (the critical body mass hypothesis). The coefficients for participating in active sports 1-2 and 3-4 times in the past week were not significant.[2]

Finally, family structure and family socioeconomic status, which may affect childhood nutrition, health, and living conditions, were added in the fourth and final model. Family structure, maternal education, and family income were all incorporated. Even with these controls, BMI at Wave I remained highly significant. The impact of Hispanic ethnicity was attenuated, with the coefficient declining both in size and significance. While Hispanics still reach age at menarche earlier than do whites, accounting for family factors reduces this effect, and it is now only weakly significant. So part of the earlier age at menarche for Hispanics is a result of their family structure, maternal education, and household income. In terms of the impact of family structure, it did not have a significant effect on age at menarche. We also used proxies to control for familial socioeconomic status. In comparison to having a mother with a high school education, adolescents with more or less educated mothers were not significantly different in age at menarche. When some college was made the reference category instead of high school degree, missing on education became weakly significant with a negative coefficient ($b = -.245$, $p \leq .10$). It is reasonable to assume that those who fail to report their education are of lower socioeconomic status. If this is the case, it seems that adolescents in less well-off families tend to reach menarche earlier than the better-off. None of the family income categories (less than or equal to the 25 percentile, greater than or equal to the 75^{th} percentile, and no response) were significantly different from the

[2] A control for number of times adolescent exercised in the past week was also initially included, but was subsequently dropped because it never attained significance in its relationship to height, and was very inconsistently related to age at menarche.

reference category of family income between the 25th and 75th percentile in their relationship to age at menarche. When the highest income category, the 75th percentile or greater, was made the reference category, there still were no significant differences between high income and the other income categories in their relationship to age at menarche.

What is striking in the regressions on age at menarche is that BMI at Wave I remains highly significant in all four models with a stable coefficient, even as mediating variables are added. Race/ethnicity seems to have a somewhat significant relationship too, particularly for Hispanics (although it is attenuated upon controlling for family social class, and becomes only weakly significant). On the other hand, individual behaviors and family socioeconomic status seem to have little effect on age at menarche. This seems to indicate that biological factors may be most important in determining age at menarche.

The same models were run in the regression on final height, with the addition of age at menarche in every model as well as age (year of birth) (Table 5). Model 1 examines the main relationships: BMI, age at menarche, and final height. The first regression analysis showed that BMI was strongly significantly related to age at menarche, as hypothesized. Now we examine our primary hypothesis that age at menarche is related to height. Since this may be mediated by BMI, we attempt to determine whether BMI and age at menarche are significantly related to height in this regression. Linear regression analysis shows that age at menarche is related to final height (Model 1). The relationship is strong and highly significant in the positive direction ($b = 0.224$, $p \leq .01$), meaning that later menarche is associated with greater height, as hypothesized. BMI at Wave I was not significantly related to final height with age at menarche controlled, even though it was related to age at menarche in the first regression analysis. The coefficient is extremely small (b = 0.001).

[Table 5 about here]

Again Model 2 incorporates the demographic variables; these include age and race/ethnicity. Age at menarche remained highly significant in this model, while BMI at Wave I remained non-significant. The demographic attribute of age was not significantly related to final height. Race/ethnicity however, did tend to be related to final height. Hispanics and girls of "other" race were significantly different from whites in their final height. The coefficients are highly negative (b = -1.797 and -1.530, respectively, $p \leq .01$), meaning that in comparison with whites, Hispanics and others tend to reach shorter final heights. In fact, Hispanics are nearly 2 inches shorter than non-Hispanic whites. Blacks also had a negative coefficient, but were not significantly different from whites. Hispanics and "others" were also significantly different from blacks in final height. Again, both coefficients were strongly negative (b = -1.640 and -1.373, respectively, $p \leq .01$).

Model 3 in the regression on final height incorporates the mediating behaviors of eating and exercise. The addition of mediating variables did not change the significance of the attributes at adolescence or the demographic attributes. Among the attributes at adolescence, age at menarche remained highly significant, with the coefficient decreasing somewhat (b = .192), while BMI at Wave I remained non-significant. Among the demographic attributes, age also remained non-significant, while Hispanic and other race, in comparison to White race, remained highly significant. Those reporting eating fast food one day a week (b = .572, $p \leq .01$), five days a week (b = .541, $p < .05$), or not reporting ($b = .523$, $p < .05$) attain a taller final height than those with no fast food consumption in the prior week. Again the associations for the other fast food categories were positive, although not significant. Participation in active sports five or more times a week was significantly different from zero times a week in its association with final height. The difference was large and highly significant in the positive direction, so that exercising more relative to zero times a week was related to taller final height ($b = .646$, $p \leq .01$). This may be reflecting a selection factor rather than a causal relationship, as taller girls may be selected into and recruited for sports where height is an advantage, such as basketball and volleyball.

The fourth and final model analyzed the possible mediating behavior of family factors on final height. Despite the addition of these controls, age at menarche, Hispanic and other race, and exercising 5 times or more in the past week remain highly significant in this final regression ($p \leq .01$). Thus the significance of attributes at adolescence and demographic attributes remain unchanged (BMI at Wave I and age remain non-significant respectively). The significant differences between the fast food categories stay the same. In analyzing the effects of family structure, the final height of girls from non-intact families and girls from families that did not respond was not significantly different from girls growing up with both biological parents present. In terms of the effects of maternal education, young women whose mothers were college graduates were significantly taller than girls whose mothers had less education ($b = 0.347$, $p < .05$). Of interest is the finding that for mothers with less than a high school education and for mothers who did not respond the coefficient is negative (for mothers with some college education it is positive). Thus, there appears to be an almost linear association between maternal education and final height as the coefficient gets more positive and more significant as education increases. This implies that compared to mothers who graduated from high school, those with less education and those who failed to respond have daughters of shorter final height. It could be the case that mothers who failed to respond are also less educated. If this is so, the relationship may reflect the impact of lower socioeconomic status on height (which is found below). College graduates are also significantly different (at the $\leq .10$ level) from mothers with some college education, highlighting the importance of degree completion (b = .324). Finally, in terms of the effects of family income on height, we found that those whose parents failed to report their family income are significantly different from those whose family income is between the 25^{th} and 75^{th} percentile, in their relationship to height. The difference is weakly significant but large in the negative direction (b = -0.372, $p \leq .10$), so that parental failure to report income is associated with shorter final height of the child. Additionally, families with income less than the 25^{th} percentile also have a negative coefficient, but the relationship is not significantly different from those between the 25^{th} and 75^{th} percentiles. For those above the 75^{th} percentile, the coefficient is positive, although not significant. When the 75^{th} percentile or greater was made the omitted category, missing on income was significantly different from those in the 75^{th} percentile. Thus, those not reporting income are significantly shorter than young women from the most economically established families.

The most important finding for our study from the regression analysis on final height, is that age at menarche is strongly significantly related to final height, with later age at menarche being associated with taller final height, as hypothesized. This relationship remains highly significant and stable throughout, even as mediating variables are added. Race/ethnicity is also related to height. With these variables included, 6.7% of the variance in height is explained. Adding the behavioral and socioeconomic factors increases the variance explained to 7.9%. Some categories of maternal education, family income, fast food consumption, and exercise were significantly related to final height. Thus, it appears that final height is somewhat influenced by environmental factors. This does not appear to be as true for age at menarche (a primarily biological characteristic). Race/ethnicity also appears to have an important effect on both age at menarche and height.

We find two important relationships: heavier BMI is associated with earlier menarche, and earlier menarche, in turn, is associated with shorter final height.[3] In neither set of regressions do we explain a large amount of the variance in the outcome. In the analysis of age at menarche, the adjusted r^2 is 2.4 to 2.8 percent. In the analysis of height, age at menarche only explains 1.3% of the variance. When the race/ethnicity indicators are added, the adjusted variance explained jumps to 6.7% and with the addition of all the other variables it only increases to 7.9%. Thus, while we have found significant variables, the amount of variance explained by these variables is not large.

Discussion and Conclusions

Inspired by trends of increasing body mass index, decreasing age at menarche, and relatively declining height in the United States, this study explored the relationships between these three factors in females age 20 and over in an attempt to discover whether

[3] An analysis of the 138 girls who had not yet experienced menarche at Wave I (late maturers), found a similar, but slightly stronger (by almost 50%) effect of BMI on age at menarche, but essentially no effect of age at menarche on final height.

decreasing age at maturation could be contributing to the relative decline in height of Americans. We hypothesized that such a result could come about through two interrelated relationships: increasing body mass index leading to decreasing age at menarche, and decreasing age at menarche then leading to shorter final height. Our regression analyses supported the existence of these relationships and the relationships were highly significant throughout, remaining so even after controls for demographic attributes, mediating behaviors, and family attributes were implemented. Body mass index was inversely related to age at menarche, so that heavier females tended to mature earlier. Age at menarche was positively related to height, so that later maturers tended to be taller. We did not however, find a direct relationship between body mass index and height; body mass index seems only to operate through age at menarche.

Looking more specifically at the relationship between BMI and age at menarche, we found the relationship to be strong and remain consistent even after accounting for family social class (or mediating behaviors). In fact, controls for family socioeconomic status did not have a significant relationship with age at menarche. Ethnic differences were only weakly significant after accounting for all controls. Thus, it seems that age at menarche is mostly biologically determined and affected minimally by social and environmental circumstances. This is somewhat different from height, which seems to have more associations with non-biological variables than age at menarche.

Final height is very significantly and consistently related to age at menarche, and remains so with all controls. Interesting social class effects, in terms of maternal education and income, affect height. Adolescents with mothers who are college graduates are taller than those with less educated mothers. Additionally, adolescents whose families are economically disadvantaged are shorter than those from better-off families, although not significantly so. This tends to imply that although height is primarily biologically determined, it may be more influenced by social and environmental factors, particularly family socioeconomic status, than age at menarche is. Of course, it is possible that parental height is related to parental SES and the observed link between parental SES and height could be a link between height of parent and height of child.

There are also interesting ethnic effects on height that deserve further comment. In the final regression, Hispanics and others are significantly shorter at age 20 than whites and blacks, even after accounting for differences in age at menarche. The above social class factors explain part of the height differential between whites, Hispanics and others (primarily Asians), but not all the difference, as the coefficients remain highly significant. This implies that even if Hispanics and others had the same levels of maternal education and family income, they would still be shorter than non-Hispanic whites. Nonetheless, accounting for these factors does moderate the negative effects of being Hispanic or of "other" race, so it is possible that the height disadvantage is due to foreign birth or genetics. In fact many of the present studies of height in America focus on white and black height, selecting out immigrants and children of immigrants, in order to control for this problem. However, Asians and Hispanics constitute a large and growing portion of our society, so we considered them essential to the research question.

The explanatory value of the equations predicting age at menarche and height was also tested within the three largest race-ethnic groups (Tables 6 and 7, respectively). For whites (the largest group measured, N=1,266), the results of the equations are very similar to those reported above. The effect of BMI on age at menarche and age at menarche on height are very significant and similar in size and in the same direction as those reported previously. For blacks, although the coefficients are in the same direction, the effects lose some significance probably due to the fact that the sample size is fairly small (N=297). Age at menarche was still positively related to height, but with weak significance among blacks. BMI is not significantly related to age at menarche in this group. The small sample size was also a problem among Hispanics (N=205), as the relationships tended to lose significance. BMI was negatively and weakly significantly related to age at menarche among Hispanics, but the significant relationship between age at menarche and height disappeared. Interestingly, BMI is weakly significantly related to final height within Hispanics.

[Tables 6 and 7 about here]

We may not have found large environmental influences on menarche and height because the United States may be at such a high level of development (with above adequate nutrition) that even the poorest and least educated are no longer nutritionally deprived. This could mean that increases in income are not as important as they were in the past. Some researchers have explored a possible biological minimum below which age at menarche cannot decrease (Ong et al., 2006). Additionally, some believe age at menarche has stabilized around 13 years in Europe (Cole, 2003). However, our paper finds a relatively low mean age at menarche (12.2) among American adolescents and a clear impact of young age at menarche on height.

We found a clear link between increased BMI and decreased age at menarche, and decreased age at menarche and shorter height. The relative decline in American height is worrisome because height is a good predictor of life expectancy. Thus, it may be that Americans are becoming less healthy. Shorter height is correlated with increased all-cause mortality, increased risk of stroke (both ischemic and hemorrhagic), increased risk of cardiovascular disease, increased coronary heart disease, and increased respiratory disease (the risk of cancers unrelated to smoking is variable but tends to increase with height, except for stomach cancer which has a negative association) (Crimmins et al., 2005; Davey Smith et al., 2000; McCarron et al., 2000; 2001). Additional studies of why Americans are relatively declining in height are clearly needed. This paper is a beginning in addressing that need.

It must be remembered however, that American height is stabilizing. It is not declining absolutely, but only relative to other countries, particularly those of Northern Europe. Thus, the trends result from the fact that Northern Europeans continue to grow while Americans do not. Some researchers have suggested this trend may not be that worrisome as there may be genetic differences between Americans and Northern Europeans resulting from genetic isolation and the homogeneity in Northern Europe (Haas and Campirano, 2006). Thus, it is not certain that all populations can achieve the height of the Northern Europeans under ideal environmental conditions. It is still possible however, that different environmental and dietary factors in Northern Europe could also contribute to their sustained growth (Haas and Campirano, 2006).

Limitations and Future Directions

As with all studies, this one has several limitations. First, the Add Health sample was drawn from a school-based population, which inherently omits those adolescents who dropped out of school before the first interview, and who are also likely to be the most disadvantaged. Thus, the most disadvantaged or early maturers may not be well represented in our sample. This may partially explain why we do not find the earliest age at menarche among blacks, as previous literature has. We do find an earlier age at menarche among Hispanics compared to whites, which is supported by other literature. We also do not find that black girls experience earlier menarche, when weight is controlled (a race effect suggesting some sort of biological factor different in blacks) as other studies have found, although we do find that heavier BMI is associated with earlier menarche, even when race is controlled, in accordance with findings of other studies. We may differ in our findings regarding black girls because these studies are somewhat older and weight has increased markedly in the last 10 years. It has increased disproportionately among ethnic groups, making the differences smaller than in the past, as whites have gained relative to blacks (National Center for Health Statistics, 2006). We should note that the mean age at menarche we find for blacks is similar to that reported in recent literature. It is the age of menarche for whites that seems somewhat earlier than previously reported. It may be that recent reductions in age at menarche have been larger among whites and resulted in no difference between blacks and whites in this sample.

The data we use are representative of the United States population at the beginning, but they are longitudinal data and we analyze data for women who are interviewed at Wave I and Wave III. It is possible that differential dropout could affect our results. Further investigation of this effect will be important.

Additionally, the use of the body mass index measurement is somewhat problematic, especially in children. It does not differentiate between different body compositions, for example between fat and muscle mass. For this reason it is only moderately correlated with adiposity or body fatness (Kuczmarski and Flegal, 2000). Additionally, BMI may be affected by maturational stage as substantial growth, often disproportional growth, takes place during puberty. However, Add Health does not gather data on body fat; it only measures weight, so we were limited to using BMI. We could have employed age and sex-specific cut off points for body mass index in childhood, using specific centiles linked to adult cut off points and based on international data, which may be more accurate (Cole et al., 2000). However, we deemed traditional absolute BMI to be more appropriate to analyzing change in BMI over time as had been done in past studies. Using consistent measures was necessary for comparison with these studies in order to explain change in height over time and its relationship to age at menarche.

Another data limitation of the study is using self-reported age at menarche. The correlation between the report of age at menarche at Wave I and Wave III was 0.51. Recall of age at menarche may be inaccurate particularly at older ages that are farther from menarche, thus reports at Wave III when adolescents in the study were between 20 and 27 years are likely to be more inaccurate than Wave I reports. In order to counteract memory failure, we use reported age of menarche at Wave I if the data are available, because it is closer to when the adolescent would have begun their periods. If the data are not available we use the Wave III report, because some subjects have not achieved menarche by Wave I. In a data set that does not inquire about menarche annually, recall will always be a limitation. The low correlation found in our data seems to indicate that menarche recall is not as accurate as previously thought. More prospective studies would be needed to solve this problem. Although Add Health is a prospective study, it does not begin collecting data at young enough ages.

Another limitation is that when analyzing data for participation in sports, for athletic female adolescents, particularly high-level athletes, selection factors may be operating. For example, taller height may be associated with being highly active because tall women are recruited into sports (particularly basketball and volleyball). Thus, taller women may experience later menarche because high levels of activity are associated with later menarche (perhaps through the critical body mass theory or stress of training).

How Do These Results Help to Explain Change in Relative Height of Americans?

Finally, our study focuses on young women coming of age at the end of the 20th century. It is hard to fully answer the question of what is causing the stabilization of American height with data for such a brief and specific time period; however, we can use our results to see what the implications are for understanding links between time trends in weight, age at menarche, and height. If BMI increased by 4 points for girls between the ages of 12 and 17 as it was reported to do from 1963-5 to 1999-2000 (between NHES and NHANES) (Ogden et al., 2004), our results would indicate that this would lead to a decrease in age at menarche of .2 years (-.051 x 4). This is 2.4 months which is very close to the estimate of the NCHS for the period from 1963-70 to 1988-94. This reduction in age at menarche would, in turn, lead to a decrease of .04 inches in height (0.224 x .2). This is a very small decrease but it could be one factors related to the stability in American height. Future research with data that is not currently available will be needed to fully understand trends in American height.

Figure 1. Model Linking Major Variables

Table 1: Variable Descriptions

Variable Name	Description
Biological Sex	Self- reported as male or female (Wave III).
Calculated Age	Calculated by recorder based on birth date (Wave III).
Height I	Reported current height in inches and partial inches at Wave I
Height II	Measured height in inches and partial inches at Wave II
Height III	Measured height in inches and partial inches at Wave III
BMI 1	Calculated BMI based on reported current height and weight at Wave I.
BMI 2	Calculated BMI based on measured height and weight at Wave II.
BMI 3	Calculated BMI based on measured height and weight at Wave III.
Menstruation – Age first period	Self-reported at Wave I, or at Wave III for those whose age at first period was after Wave 1
Weight I	Self-reported current weight at Wave I.
Weight II	Measured weight at Wave II.
Weight III	Measured current weight at Wave III.
Race/Ethnicity	Self-reported as Non-Hispanic White, Non-Hispanic Black, Hispanic, other category.
Total household income	Reported at Wave I by parent.
Maternal Education	Based on Mother's report if available or students response to question "How far did mother go in school?"
Times exercise last week	Reported at Wave I as 0, 1-2, 3-4, or 5+.
Times play an active sport past week	Reported at Wave I as 0, 1-2, 3-4, or 5+.
Last week, how many days eat in fast food restaurant?	Reported at Wave II. (Range 0-7)
Last week, how many days eat breakfast?	Reported at Wave II. (Range 0-7)
Family Structure	Reported by respondent to the parental-interview at Wave I. Based on questions "What is your relationship to the adolescent?" and "Does the adolescents' biological mother/father live in the household?" Coded as adolescent lives with both biological parents or lives in "other" situation (which includes all other relationships – single parent, step parent, adoptive parent, etc.).

Table 2. Means and Standard Deviations of Variables Used in Analysis

Variables		Mean	S.D.	All Subjects
Height Wave I (in.)		64.3	2.92	
Height Wave III (in.)		64.5	2.73	
ATTRIBUTES AT ADOLESCENCE				
Age at Menarche				
Combined Age at Menarche from Wave I and III		12.24	1.45	
Age at Menarche Wave I (n = 1762)		12.14	1.34	
Age at Menarche Wave III (n = 1883)		12.65	1.89	
BMI				
BMI Wave I		22.3	4.43	
BMI Wave III		26.5	6.83	
DEMOGRAPHIC ATTRIBUTES				
Age at Wave III		22.07	1.56	
Range 20-27 years				
Race/Ethnicity				
Non-Hispanic White		66.7%		
Non-Hispanic Black		15.7		
Hispanic		10.9		
Other		6.7		
MEDIATING BEHAVIORS				
Nutrition (at Wave II) (of those reporting)				
# days eat in fast food restaurant last week		2.14	1.78	
	0	17.2%		13.5%
	1	25.9		20.3
	2	22.6		17.7
	3	15.0		11.8
	4	8.2		6.4
	5+	11.0		8.6
No response				21.8%
# days eat breakfast in last week		4.02	2.63	
	0	15.7%		12.2%
	1-2	17.6		13.8
	3-4	19.4		15.1
	5-6	14.9		11.7
	7	32.4		25.3
No response				21.9%
Exercise (at Wave I)				
# of times exercised last week		2.91	2.07	
	0	13.5%		
	1-2	36.1		
	3-4	26.0		
	5+	24.4		
# of times played active sport last week		1.99	2.10	

0	36.7%		
1-2	30.9		
3-4	16.8		
5+	15.6		
FAMILY ATTRIBUTES			
Family Structure (at Wave I)			
(of those reporting)			
Intact Family (biological parents)	57.5%		50.6%
Other family (single mother, step parent, other)	42.5		37.4
No response (n = 227)			12.0%
Socioeconomic Status measures (SES)			
Maternal Education (Years)	13.2 yrs	2.61	
(of those reporting)			
Less than high school	15.8%		14.3%
High school degree	34.0		30.8
Some college	24.8		22.5
BA or more	25.4		23.0
No response (n = 176)			9.2%
Family Income ($1,000s)	48.5	54.01	
(of those reporting)			
25th percentile	$23.0		19.8%
Median	40.0		35.3
75th percentile	60.0		21.1
No response (n = 452)			23.8%
N=1,899			

Figure 2: Distribution of Height at Wave IIII

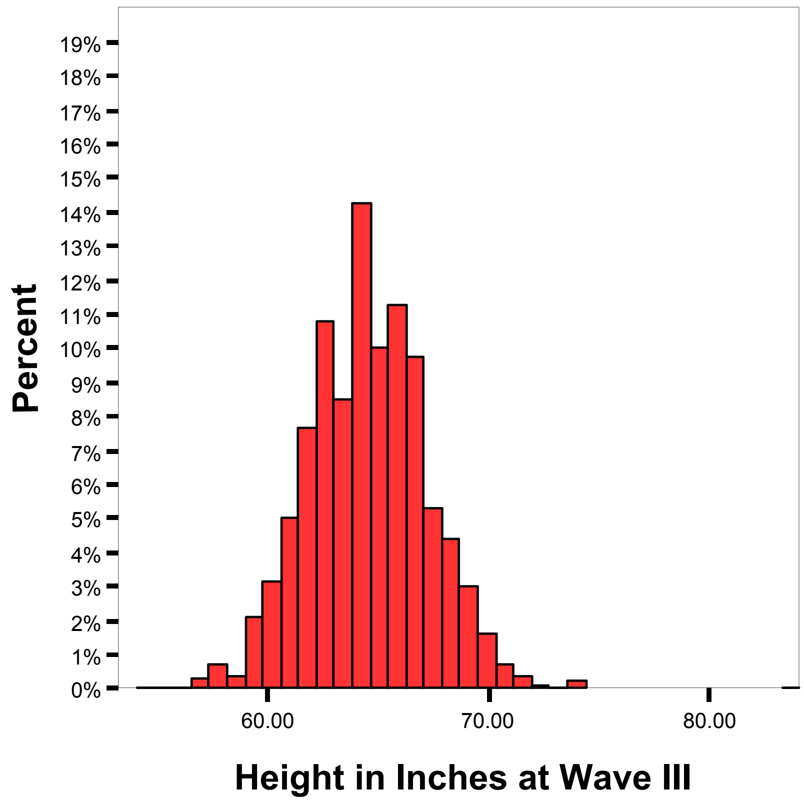

Figure 3: Distribution of Age at Menarche

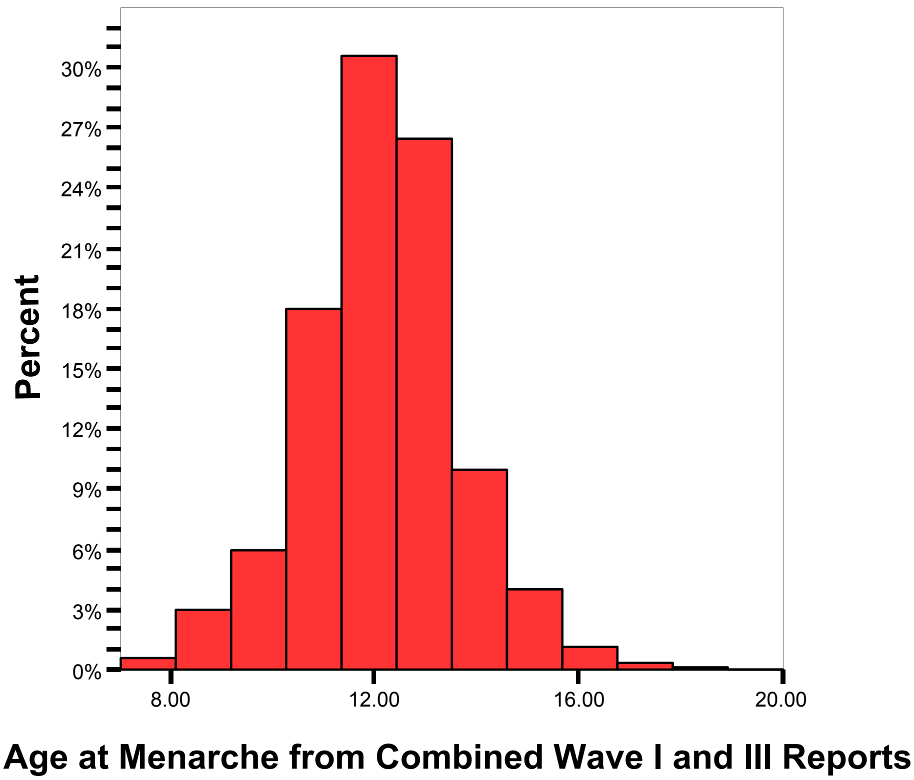

Figure 4: Mean Height at Wave III by Age at Menarche

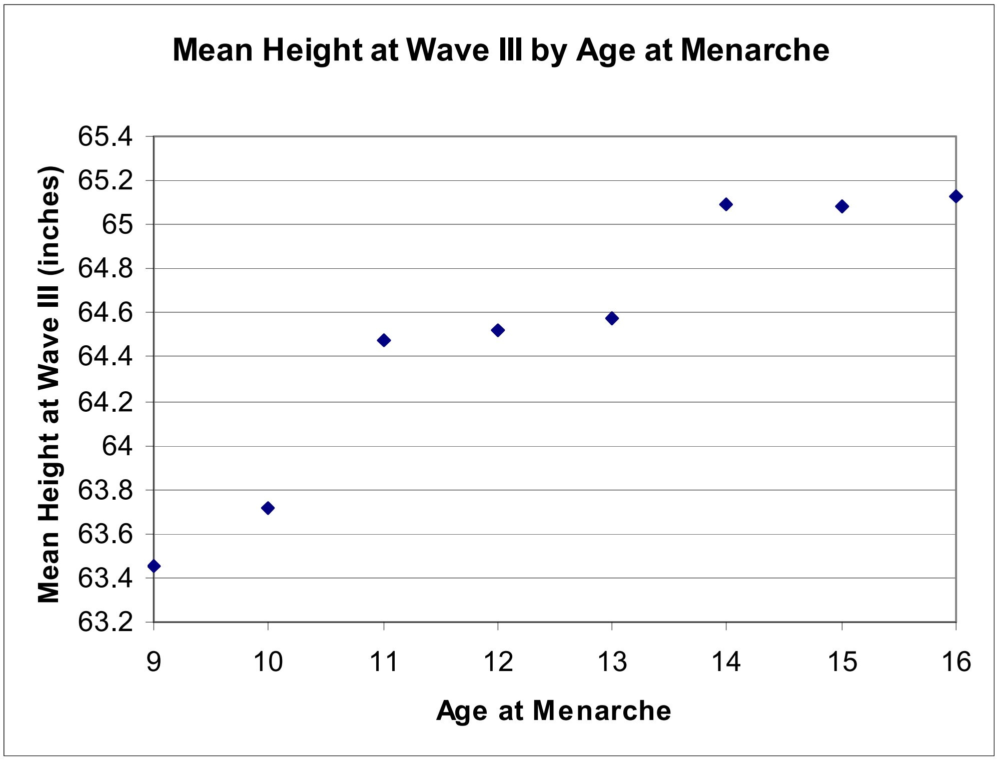

Figure 5: Mean BMI at Wave I by Age at Menarche

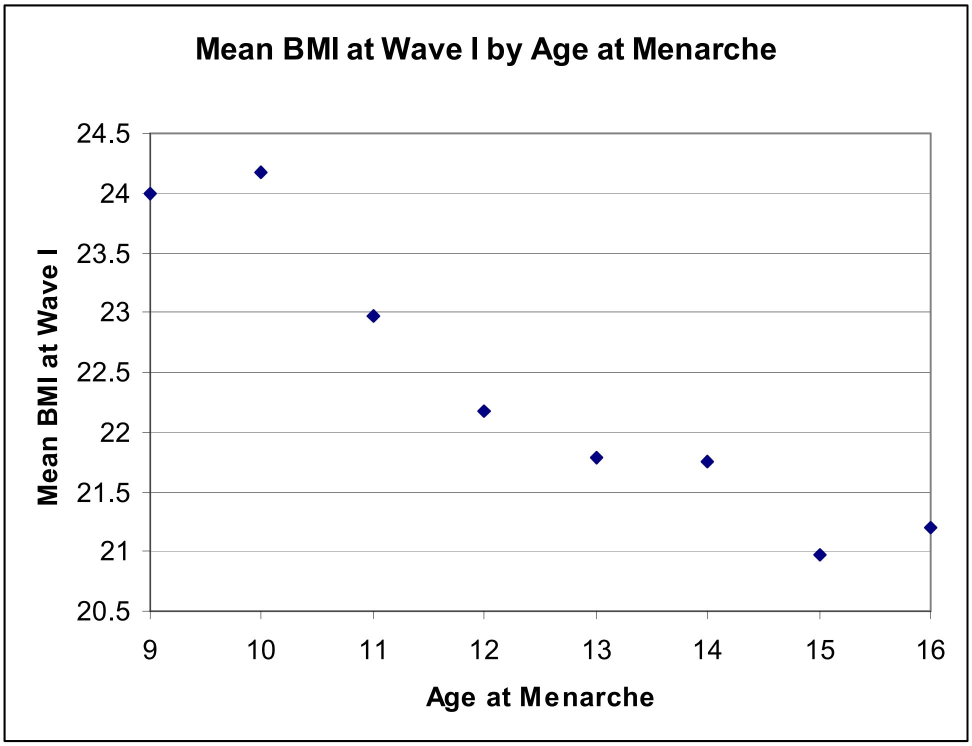

Figure 6: Mean BMI at Wave III by Age at Menarche

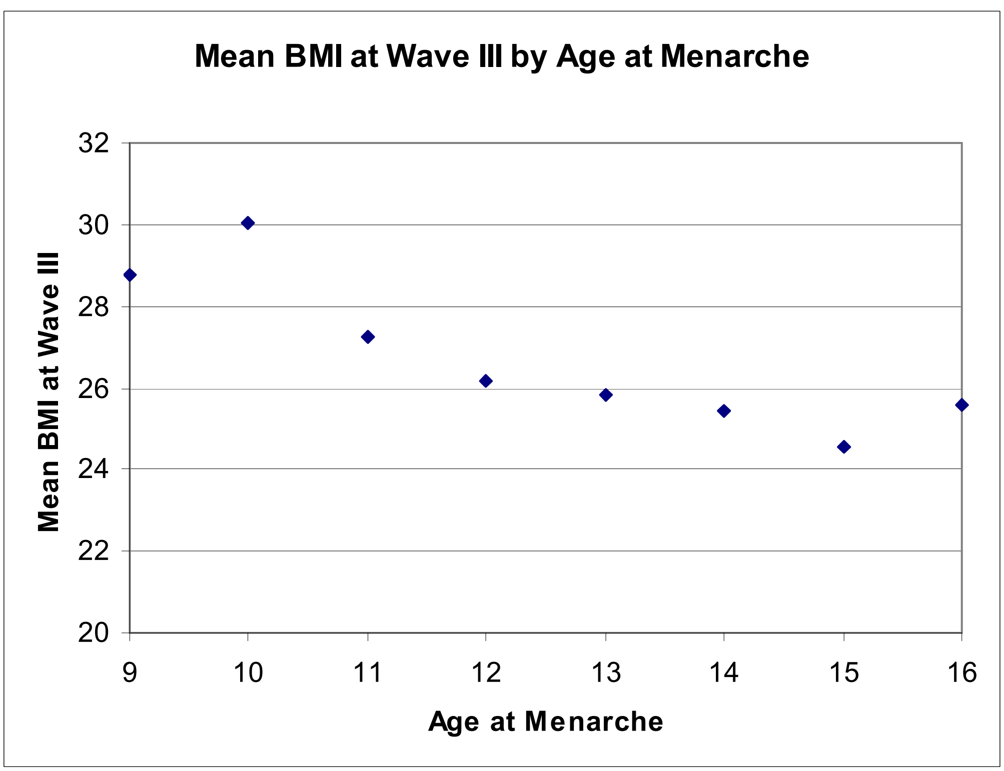

Table 3: Primary Variables by Race/Ethnicity

	WHITES (N=1267)	BLACKS (N=298)	HISPANICS (N=206)	OTHERS (N=127)
BMI I	21.97	23.81*	22.53	21.77
BMI III	26.04	28.43*	26.37	26.22
Height at Wave I (In.)	64.66	64.28*	62.89*	63.29*
Height at Wave III (In.)	64.87	64.69	63.02*	63.29*
Age at Menarche	12.29	12.19	12.04*	12.09
Mother's Education (Yrs.)	13.62	12.89	11.14	13.3

*Significant difference compared to Whites

Table 4. Main Effects on Age at Menarche

	Model 1		Model 2		Model 3		Model 4	
ATTRIBUTES AT ADOLESCENCE	b	sig	b	sig	b	sig	b	sig
BMI at Wave I	-0.051	**	-0.051	**	-0.050	**	-0.050	**
DEMOGRAPHIC ATTRIBUTES								
Race/Ethnicity								
White (reference)								
Black			-0.008		-0.007		0.004	
Hispanic			-0.226	*	-0.218	*	-0.196	+
Other			-0.203		-0.179		-0.172	
MEDIATING BEHAVIORS								
Eating Patterns Past Week								
Fast food consumption								
0 days (reference)								
1 day					0.182		0.192	+
2 days					0.242	*	0.231	+
3 days					0.137		0.130	
4 days					0.019		0.003	
5+ days					0.154		0.145	
No Response					0.198	+	0.167	
Exercise Patterns Past Week								
Played active sport								
0 times (reference)								
1-2 times					0.001		0.000	
3-4 times					-0.013		-0.024	
5+ times					0.249	*	0.242	*
FAMILY ATTRIBUTES								
Family Structure								
Intact (reference)								
Other							-0.111	
No response							0.111	
Maternal Education								
Less than HS							-0.051	
High school (reference)								
Some college							0.126	
BA or more							0.013	
No response							-0.119	
Family Income								
≤ 25th percentile							0.092	
25th-75th percentile (ref)								
≥ 75th percentile							0.056	
No response							0.093	
Constant	13.38		13.422		13.189		13.177	
F	48.02		13.605		5.207		3.518	
Adjusted R-Square	0.024		0.026		0.028		0.028	
N	1,899		1,899		1,899		1,899	

**p≤.01, *p<.05, +p≤.10

Table 5. Main Effects on Height at Wave III

	Model 1		Model 2		Model 3		Model 4	
ATTRIBUTES AT ADOLESCENCE	b	sig	b	sig	b	sig	b	sig
Age at Menarche	0.224	**	0.207	**	0.192	**	0.190	**
BMI at Wave I	0.001		0.004		0.006		0.012	
DEMOGRAPHIC ATTRIBUTES								
Age			-0.051		-0.043		-0.034	
Race/Ethnicity								
White (reference)								
Black			-0.157		-0.100		0.043	
Hispanic			-1.797	**	-1.765	**	-1.593	**
Other			-1.530	**	-1.477	**	-1.443	**
MEDIATING BEHAVIORS								
Eating Patterns Past Week: Fast food consumption								
0 days (reference)								
1 day					0.572	**	0.526	*
2 days					0.312		0.291	
3 days					0.312		0.305	
4 days					0.033		-0.004	
5+ days					0.541	*	0.582	*
No Response					0.523	*	0.506	*
Exercise Patterns Past Week: Played active sport								
0 times (reference)								
1-2 times					0.211		0.232	
3-4 times					0.289		0.254	
5+ times					0.646	**	0.546	**
FAMILY ATTRIBUTES								
Family Structure								
Intact (reference)								
Other							-0.060	
No response							0.136	
Maternal Education								
Less than HS							-0.075	
High school (reference)								
Some college							0.023	
BA or more							0.347	*
No response							-0.307	
Family Income								
≤ 25th percentile							-0.157	
25th-75th percentile (ref)								
≥ 75th percentile							0.105	
No response							-0.372	+
Constant	61.756		63.358		62.735		62.462	
F	13.544		23.774		11.146		7.809	
Adjusted R-Square	0.013		0.067		0.074		0.079	
N	1,899		1,899		1,899		1,899	

**p≤.01, *p<.05, +p≤.10

Table 6. Main Effects on Age at Menarche within Race/Ethnic Subgroups

	White		Black		Hispanic	
ATTRIBUTES AT ADOLESCENCE	b	sig	b	sig	b	sig
BMI at Wave I	-0.058	**	-0.025		-0.048	+
MEDIATING BEHAVIORS						
Eating Patterns Past Week						
Fast food consumption						
0 days (reference)						
1 day	0.103		0.086		1.078	**
2 days	0.121		0.456		1.011	**
3 days	0.095		0.270		0.634	
4 days	-0.111		0.672		0.140	
5+ days	0.182		0.059		0.442	
No Response	0.176		0.210		0.470	
Exercise Patterns Past Week						
Played active sport						
0 times (reference)						
1-2 times	-0.025		-0.168		-0.113	
3-4 times	-0.118		-0.140		-0.154	
5+ times	0.077		0.903	**	0.421	
FAMILY ATTRIBUTES						
Family Structure						
Intact (reference)						
Other	-0.106		0.232		-0.784	**
No response	0.166		0.418		0.171	
Maternal Education						
Less than HS	-0.180		0.535	*	-0.043	
High school (reference)						
Some college	0.056		0.426	+	-0.397	
BA or more	0.031		-0.133		-0.282	
No response	0.050		-0.335		-0.272	
Family Income						
≤ 25th percentile	-0.115		0.473	*	0.151	
25th-75th percentile (reference)						
≥ 75th percentile	-0.104		0.756	*	0.439	
No response	-0.005		0.208		0.423	
Constant	13.545		11.899		12.648	
F	2.947		2.585		2.520	
Adjusted R-Square	0.028		0.092		0.123	
N	1266		297		205	

**p≤.01, *p<.05, +p≤.10

Table 7. Main Effects on Height at Wave III within Race/Ethnic Subgroups

	White		Black		Hispanic	
ATTRIBUTES AT ADOLESCENCE	b	sig	b	sig	b	sig
Age at Menarche	0.249	**	0.234	+	0.007	
BMI at Wave I	0.009		-0.023		0.081	+
DEMOGRAPHIC ATTRIBUTES						
Age	-0.045		0.072		-0.017	
MEDIATING BEHAVIORS						
Eating Patterns Past Week						
Fast food consumption						
0 days (reference)						
1 day	0.533	*	0.290		0.893	
2 days	0.093		0.249		0.967	
3 days	0.390		-0.190		-0.139	
4 days	-0.085		0.578		0.165	
5+ days	0.584	+	1.072		-0.465	
No Response	0.387		0.580		0.369	
Exercise Patterns Past Week						
Played active sport						
0 times (reference)						
1-2 times	0.368	*	-0.018		0.391	
3-4 times	0.488	*	0.752		-0.593	
5+ times	0.750	**	0.359		-0.001	
FAMILY ATTRIBUTES						
Family Structure						
Intact (reference)						
Other	-0.18		-0.353		0.179	
No response	-0.092		0.534		0.697	
Maternal Education						
Less than HS	-0.245		0.814		-0.251	
High school (reference)						
Some college	0.044		-0.317		0.931	
BA or more	0.213		0.709		1.321	+
No response	0.017		-0.708		-0.402	
Family Income						
≤ 25th percentile	-0.009		-1.069	*	0.245	
25th-75th percentile (reference)						
≥ 75th percentile	0.281		-1.172	+	0.213	
No response	-0.163		-1.068	+	-0.155	
Constant	61.942		61.245		60.752	
F	3.121		1.254		1.366	
Adjusted R-Square	0.034		0.018		0.036	
N	1266		297		205	

**p≤.01, *p<.05, +p≤.10

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