Secondary Sexual Characteristics in Boys

Estimates From the National Health and Nutrition Examination Survey III, 1988-1994

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Background: Descriptive data on pubertal stages for a representative population of racially and ethnically diverse boys in the United States have not been published to our knowledge.

Objective: To determine at what ages boys in the United States reach each of the 5 sexual maturity stages for genital and pubic hair growth.


Participants: A population-based sample of 2114 boys aged 8 to 19 years representing 16,575,753 boys according to NHANES III sampling strategies. The sample included white, African American, and Mexican American boys.

Main Outcome Measures: Sexual maturity stages for genital maturation and pubic hair growth.

Results: The median (equivalent mean) ages at stage 2 for pubic hair development of white, African American, and Mexican American boys were 12.0 (95% confidence interval [CI], 11.7-12.3), 11.2 (95% CI, 10.9-11.4), and 12.3 (95% CI, 12.1-12.6) years, respectively, and at stage 2 for genital growth were 10.1 (95% CI, 9.6-10.6), 9.5 (95% CI, 9.0-10.0), and 10.4 (95% CI, 9.6-11.1) years, respectively. All 3 groups were significantly taller and heavier than boys in previous NHANES reports and showed earlier genital maturation and pubic hair growth than previous studies based on Tanner staging. Statistically significant differences among the 3 racial/ethnic groups were found in the median ages of onset of pubic hair growth and genital development at stage 5 with and without controlling for height and weight, indicating an earlier age of attainment for the African American boys.

Conclusions: The median (mean) ages at the onset of genital and pubic hair growth were younger than in past studies. Additional studies are required to further evaluate these findings and to explore the public health implications.


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Descriptive data on the pubertal development stages of racially and ethnically diverse boys selected to be representative of the US population have not been published to our knowledge. In 1997, a study on girls found significant differences in the age of onset of pubertal characteristics by race and also found that the mean age of onset was younger compared with findings from the last 30 to 40 years.1 Specifically, white girls were found to begin puberty 6 months to 1 year earlier than girls in past studies, and African American girls were found to begin puberty approximately 1 to 1.5 years earlier than white girls and to begin menses approximately 8.5 months earlier. Numerous studies worldwide have shown that the onset of pubertal characteristics varies with race and ethnicity, environmental conditions, geographical location, and nutrition1,2; thus, current geographically representative data on boys in the United States are needed. The findings of earlier studies regarding racial differences in pubertal timing between African American and white boys are conflicting.3,4 To our knowledge, the only study assessing the development of Mexican American boys, the NHANES II study of boys aged 10 to 17 years, concluded that pubertal events in this population occurred a few months later than in white boys, but noted that comparable data were lacking.5

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METHODS

STUDY DESIGN AND SAMPLE

The Centers for Disease Control and Prevention (Atlanta, Ga), through the National Center for Health Statistics (Hyattsville, Md), conducted NHANES III to collect data during two 3-year phases from 1988 through 1991 and 1991 through 1994. This cross-sectional survey had a stratified, multistage probability design. Although the survey was conducted in 2 phases, it was designed so that the total sample was representative of boys in the United States. Non-Hispanic African American and Mexican American boys were oversampled to ensure reliable weighted population estimates for these racial/ethnic minorities. The sample of 2495 boys aged 8 through 19 years represented 20674622 boys through the respective sampling weights. This survey did not collect data on gynecomastia, voice change, undescended testes, or facial hair growth. The NHANES III design and methodology has been described in detail previously.4-7

All training and assessment followed the protocol detailed below, used in previous NHANES surveys from which prior pubertal studies have been published.3,5 Interviewers, many of whom were Hispanic or bilingual in Spanish and English, attended yearly training sessions to ensure adequate and stable skills. In a similar manner, the 8 primary physicians and the back-up physicians who examined the children were trained in conducting sexual maturity ratings by an expert in adolescent medicine using discussion, text, and visual aids. Sexual maturity was defined according to the 5 stages of genital and pubic hair development, assessed by visual inspection as described by Marshall and Tanner.8 The stages of genital maturity were graded separately from pubic hair growth as follows:

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SECONDARY SEXUAL CHARACTERISTICS

Figures 1 and 2 show the prevalences of pubic hair and genital development, respectively, at Tanner stage 2 or later by age for whites, African Americans, and Mexican Americans. Corresponding 95% CIs are presented in Table 1. At age 8 years, that is, between the eighth and ninth birthday, no white boys had pubic hair; however, 5.3% of African American boys and 2.7% of Mexican American boys were at least at Tanner stage 2 for pubic hair growth. The percentages of white, African American, and Mexican American boys who had begun genital development were 29.3%, 37.8%, and 27.3%, respectively. At age 9 years, the proportions showing at least Tanner stage 2 pubic hair growth were 4.3%, 21%, and 3.3% for white, African American, and Mexican American boys, respectively and 35.7%, 58.2%, and 31.6% for genital development.

MEDIAN AGES OF ONSET OF DEVELOPMENT OF SECONDARY SEXUAL CHARACTERISTICS

Estimates of median (or equivalent mean) ages for attainment of sexual maturity at stages 2 through 5 for pu-
The 2495 boys were examined by the participating physicians in a mobile examination center designed for the survey. Their genitalia and pubic hair were inspected and classified separately according to the 5 Tanner stages. The 381 boys with missing values for any of age, race, pubic hair development stage, or genitalia development stage were excluded; therefore, the final sample for analysis included 2114 boys representing 16375753 boys in the general population.

STATISTICAL DESIGN

All statistical analyses were conducted using SUDAAN software for sample surveys and accounted for the sampling weights and the primary sampling units in the multistage probability design of the NHANES III. For descriptive purposes, race/ethnicity by age tabulations were produced for the estimated percentages (and corresponding 95% confidence intervals [CIs]) with attainment of stage 2 or later for pubic hair and genital development. Mean heights and mean weights were provided for additional description of each racial/ethnic group by age (eg, age 8 years is 8.00-8.99). We used logistic regression models to assess the relationship of age (as a linear variable) and race/ethnicity with the presence or absence of a particular secondary sexual characteristic. Medians (equivalent mean ages for the underlying logistic distributions) were separately estimated for pubic hair growth and genital development at stage 2 or later, stage 3 or later, stage 4 or later, and stage 5 (with corresponding 95% CIs) for each ethnic group by corresponding logistic regression models. We evaluated departures from linearity in the relationships between presence of a characteristic and age by adding a quadratic term to the logistic model. In cases in which the departures from linearity were noteworthy, we used a logistic model with linear age in a data structure that excluded either the youngest ages with 0% prevalences and/or the oldest ages with 100% prevalences. We did not report the estimates for median (mean) ages from those more complicated analyses since they were similar to those from the logistic models with linear age, ie, the reported estimates from the logistic models with linear age tended to depart from linearity.

Heights and weights from NHANES III were compared with those from the first and second NHANES for white boys and for African American boys by a method that controlled for age. For this purpose we used subtraction to compute deviations of the height (or weight) of each boy in NHANES III from a corresponding standardized estimate for the same age and ethnic group from the first NHANES survey; the resulting mean deviations were compared with 0 (relative to the corresponding SEs from SUDAAN) using an approximately normally distributed statistic. The first and second NHANES did not provide standardized estimates for Mexican American boys and so, for these boys, the method was modified to incorporate the standardized estimates for white boys.

Comparisons between the ethnic groups for the percentages of boys with development of a secondary sexual characteristic were made with logistic regression models that simultaneously included age as both a linear variable and a categorical variable by year (so as to account for any departures from linearity). The influence of height and weight on these comparisons was addressed by adding both of these explanatory variables to the logistic regression models. Also, models that additionally included interactions of linear age with height and weight were evaluated. Comparisons between the ethnic groups for height and weight were made similarly with multiple linear regression models. All analyses were carried out with PC-SAS and SUDAAN software.

Bovic hair and genital development are presented with their 95% CIs in Table 2. Pubic hair development began at a mean age of 12.0 (95% CI, 11.7-12.3) years for white boys, 11.2 (95% CI, 10.9-11.4) years for African American boys, and 12.3 (95% CI, 12.1-12.6) years for Mexican American boys. Genital maturity (ie, Tanner stage 5) was reached at age 15.9 (95% CI, 15.3-16.4) years for white boys, 14.9 (95% CI 14.4-15.5) years for African American boys, and 15.7 (95% CI, 15.3-16.2) years for Mexican American boys. Stage 5 pubic hair was reached at age 15.7 (95% CI, 15.3-16.0), 15.4 (95% CI, 14.9-15.9), and 15.8 (95% CI, 15.5-16.2) years, respectively, for white, African American, and Mexican American boys. Boys began genital development at a mean age of 10.1 (95% CI, 9.6-10.6) years if they were white, 9.5 (95% CI, 8.9-10.0) years if African American, and 10.4 (95% CI, 9.6-11.1) years if Mexican American. The differences in median ages for the various stages of secondary sexual characteristics among white, African American, and Mexican American boys were significant (P<.05) for pubic hair at Tanner stage 2 and genital development at Tanner stage 5 regardless of whether height and weight were controlled. These differences mainly corresponded to earlier ages of attainment for the African American boys than the white boys. Without controlling for height and weight, Mexican American boys were significantly (P<.05) older at stages 3 and 4 for pubic hair than African American and white boys. After controlling for height and weight, these differences were no longer apparent.

HEIGHTS AND WEIGHTS

Heights, weights, and population estimates by age from all 3 racial/ethnic groups in the current NHANES analysis are shown in Table 3. These boys were significantly taller and heavier than the boys in the previous NHANES analyses (data not shown). Within the current NHANES sample, African American and Mexican American boys tended to be somewhat heavier than white boys until ages 12 and 13 years when the trend reversed. African American boys were taller than white or Mexican American boys until age 12 years. From age 12 years on, the African American boys were shorter than the white boys but taller than the Mexican American boys. Differences in height (controlling for age) between whites and African Americans were not significant; differences in height between Mexican American boys and white and African American boys were significant (P<.001). Comparisons be-
between boys with stage 1 and those with stage 2 genital and/or pubic hair development, controlling for race/ethnicity and age, were significant for differences in height (P < .02) but not for weight (P = .93).

**COMMENT**

According to these NHANES III data, a significant number of boys are experiencing development of 1 or more secondary sexual characteristics, particularly genital maturity, at very young ages. African American boys exhibited growth of pubic hair and sexual maturity significantly earlier than white and Mexican American boys.

The common reference for norms, Marshall and Tanner’s 1969 study of institutionalized white boys, found that the mean age of onset of genital development was 11.6 years—1½ years later than the current findings. Using their mean age for the onset of pubic hair growth (13.4 years), is not useful for our comparison because, according to the authors, the age “was not accurately determined” because of the use of photographs for staging. Earlier studies in the United States found that the mean age of onset for pubic hair growth ranged from age 12.2 to 12.5 years for white boys, up to a half year later than boys in this study. Mean ages from the latter studies for onset of genital maturation were similar to those of Marshall and Tanner.
Longitudinal pubertal studies have found an increase in the rate of maturation rather than final height.22 Because of a lack of a secular trend for increasing height among the 15- to 17-year-old children in the study, the authors suggest that there has been an increase in the rate of maturation rather than final height.22 (Longitudinal pubertal studies have found that boys at their peak growth velocity are at approximately Tanner stages 3 to 4.)

These NHANES III data indicate significant differences among white, African American, and Mexican American boys in the age of onset of pubertal characteristics; African American boys showed pubic hair growth approximately 9 months earlier than white boys and more than 1 year earlier than Mexican American boys. The analysis by Villarreal et al23 of differences in pubertal onset between Mexican American and white boys based on NHANES II data found that Mexican American boys entered puberty later than white boys, a finding consistent with this study.

These racial/ethnic differences changed somewhat when examining the end of puberty; ie, the attainment of Tanner stage 5. All 3 racial/ethnic groups were within 5 months of each other between their 15th and 16th years for pubic hair growth. However, there was a difference of 1 year between white or Mexican American boys and African American boys in the age at completion of genital development, with the latter being younger. When compared with earlier studies, ages for completion of genital development and pubic hair growth are not markedly younger,3,5,7,8,24 indicating earlier onset with a longer time to completion, a finding also described in a recent study on pubertal development in girls in the United States.1

We cannot explain the racial/ethnic differences. Studies have found that African American boys have higher levels of testosterone4 and estradiol19 but whether this correlates with earlier development is not known. The latter study19 did not find higher levels of testosterone in African American boys but did find lower levels of androstendione. There may be racial differences in the interactions between insulin, glucose, and androgens and hyperinsulinemia19,23 that influence pubertal characteristics in ways that are not clearly understood. In addition, we can speculate that differences in diet, lifestyle, and exposure to environmental factors and contaminants could play a role.

### DATA QUALITY ISSUES

Several data quality issues need to be considered in interpreting these data because of the degree of disparity between these results and those of earlier studies that used Tanner ratings for sexual development. There are several reasons to believe that these ratings are accurate. The methods used by NHANES for training physicians in assessing sexual maturity and for collecting and processing data have been in place for many years and are subject to quality-control protocols as well as interrater reliability checks. A Westat (Rockville, Md) medical consultant conducted site visits and observed the Tanner staging used by participating physicians at least 3 times per year, comparing their ratings with his own (e-mail communication, Brian Dolan, MD, MPH, Westat, February 1, 2000). Proportions of boys showing characteristics of sexual development by age and race/ethnicity are consistent both in the yearly increases in the number of boys with a given characteristic and also across racial/ethnic groups. In addition, the boys in our survey were taller and heavier at earlier ages than those in the past; therefore, earlier sexual development would also be expected. Finally, there were significant differences in height for all 3 racial/ethnic groups between boys at stage 2 and boys who were not. If the clinicians were making errors in their assessment of stage 2 puberty, we would not expect this consistent finding. Several pubertal studies on boys have documented genital growth in boys as young as 9 years.5,7,17,19,24,26 It is interesting to note that 20 years ago the mean age for the attainment of genital stage 2 for Egyptian boys from the highest social class was 10.1 years,20 while the mean age for boys from other parts of the world has been as young as 9.1 years.3

On the other hand, Tanner staging (by observation) of male genital development, as with female breast

| Table 2. Median Age of Transition to Tanner Stages 2, 3, 4, and 5 by Race/Ethnicity* |
|---------------------------------|-----|-----|-----|
| **Mean Age, y** | **Lower CI** | **Upper CI** |
| **Pubic Hair Growth** | | |
| Stage 2 | | |
| White | 12.0 | 11.7 | 12.3 |
| African American | 11.2 | 10.9 | 11.4 |
| Mexican American | 12.3 | 12.1 | 12.6 |
| Stage 3 | | |
| White | 12.6 | 12.3 | 13.0 |
| African American | 12.5 | 12.3 | 12.8 |
| Mexican American | 13.1 | 12.9 | 13.3 |
| Stage 4 | | |
| White | 13.5 | 13.2 | 13.8 |
| African American | 13.7 | 13.5 | 13.9 |
| Mexican American | 14.1 | 13.8 | 14.4 |
| Stage 5 | | |
| White | 15.7 | 15.3 | 16.0 |
| African American | 15.4 | 14.9 | 15.9 |
| Mexican American | 15.8 | 15.5 | 16.2 |

**Genital Development**

| Stage 2 | | |
| White | 10.1 | 9.6 | 10.6 |
| African American | 9.5 | 8.9 | 10.0 |
| Mexican American | 10.4 | 9.6 | 11.1 |
| Stage 3 | | |
| White | 12.4 | 12.0 | 12.7 |
| African American | 11.8 | 11.3 | 12.3 |
| Mexican American | 12.5 | 12.2 | 12.8 |
| Stage 4 | | |
| White | 13.5 | 13.2 | 13.8 |
| African American | 13.4 | 13.1 | 13.6 |
| Mexican American | 13.7 | 13.4 | 14.1 |
| Stage 5 | | |
| White | 15.9 | 15.3 | 16.4 |
| African American | 14.9 | 14.4 | 15.5 |
| Mexican American | 15.7 | 15.3 | 16.2 |

*CI indicates confidence interval.
Given the importance of obtaining accurate pubertal data from a population-based sample that is generalizable to the US population as a whole, this change in their survey design is disappointing. Should future NHANES surveys again include sexual maturity staging, collection of pubertal data on much younger children is needed to recognize those who mature very early. Additionally, the examination should be performed by clinicians with extensive experience with the pediatric population and in a setting as comfortable and noninvasive as possible, a goal that would likely require a complete physical examination.

Second, these data do support significant racial and ethnic differences in sexual maturation, especially in the development of pubic hair. Third, the data suggest that boys in the United States are experiencing the onset of pubic hair growth earlier than in the past and may be experiencing earlier genital development, a finding that demands further study. Finally, earlier onset of puberty raises important clinical and public health implications, especially for boys who are not white. The data also suggest that onset of puberty in boys may be earlier than in the past, that there are racial and ethnic differences, and that additional studies are required to confirm or refute the NHANES results.

The findings suggest that the norms from Marshall and Tanner’s 1970 study may no longer be appropriate, especially for boys who are not white. The data also suggest that onset of puberty in boys may be earlier than in the past, that there are racial and ethnic differences, and that additional studies are required to confirm or refute the NHANES results.

These data have other limitations. While statistical methods allow the calculation of median or mean ages of attaining various characteristics with cross-sectional data, other aspects of pubertal growth such as duration, peak height velocity, or examining the relationship between duration and timing of stages can only be examined in longitudinal studies. Also, this NHANES did not collect data on gynecomastia, a common problem for adolescent boys, voice change, or axillary and facial hair growth. Finally, data on boys younger than 8 years were not collected even though a sizable proportion between ages 8 and 9 years had already begun genital growth according to the findings.

There are several conclusions that may be drawn from this analysis. First, it is clear that additional studies need to be done to either confirm or refute these findings. Given the importance of obtaining accurate pubertal data for medical, sociological, and psychological use, as well as assessing environmental influences, it is unfortunate that the NHANES survey currently being used in the field does not include collection of pubertal data and that the inclusion of such data is not planned for the future. Given the ability of NHANES to study a population-based sample that is generalizable to the US population as a whole, this change in their survey design is disappointing. Should future NHANES surveys again include sexual maturity staging, collection of pubertal data on much younger children is needed to recognize those who mature very early. Additionally, the examination should be performed by clinicians with extensive experience with the pediatric population and in a setting as comfortable and noninvasive as possible, a goal that would likely require a complete physical examination.

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cially regarding the effect of diet and endocrine disrupters on pubertal development as has been indicated by a sample of articles following the outcome of the recent study on girls.1-27-31 Issues that need addressing and further study include possible revision of sex education programs, anticipatory guidance, and clinical standards; the need to research causes that may be related to diet, culture, lifestyle, and environment; and understanding whether earlier puberty onset may have any long-term effects on health.

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