

Adolescent health brief

Early Markers of Pubertal Onset: Height and Foot Size

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Abstract

This longitudinal study compared the timing of foot and height velocities with pubertal onset in girls. There was no difference between ages of increased foot and height growth velocities; both occurred before onset of secondary sexual characteristics. Change in foot size may represent an early marker for transition to puberty. © 2009 Society for Adolescent Medicine. All rights reserved.

Keywords:

Puberty; Pubertal onset; Growth velocity

The biologic and physiologic changes during the teen years are more strongly correlated with pubertal maturation than chronologic age. Common markers of pubertal onset include self or parental report of menarche, height velocity, and breast development. Difficulties in determining breast stage development in obese girls [1] and teen inaccuracies in self-report [2] limit the use of such methods.

The availability of an easy, cost-effective, reliable, noninvasive method to assess the onset of puberty may be useful in both clinical and research settings. The primary purpose of this project was to determine whether change in foot size may be used as a marker for the onset of puberty. We compared the age at which the foot size increased, with the age when secondary sexual characteristics were observed and the age at which height velocity increased.

Methods

The subjects in this study were girls currently enrolled in the Cincinnati site of the Breast Cancer and Environmental Research Centers. Girls in the Cincinnati project, "Growing Up Female," were 6–7 years old at the time of recruitment. They were recruited from public and parochial schools in the greater Cincinnati area and through the Breast Cancer Registry of Greater Cincinnati. Parental consent and participant assent were obtained on all participants. Girls were seen

every 6 months and were included in this analysis if there had been at least one visit with secondary sexual characteristics. Girls were excluded from inclusion if they had secondary sexual characteristics at first visit, if they did not enter puberty in the first 24 months of the study, or if they had visits without foot measurements. The final analysis was completed on 86 eligible girls. The study was approved by the Internal Review Board of our institution.

Height, weight, foot size, and maturation ratings were obtained every 6 months. We used the Brannock foot deviceTM Junior European model to determine foot length. Each girl's bare, right foot was measured one time while standing. A subset of 48 participants had repeated foot length measures. Of these, 38 of 48 had identical foot lengths, an additional seven of 48 had repeated measures within .33 cm, and three of 48 had repeated measures within .66 cm. The intraclass correlation for foot length in these 48 participants was .992. Height measurements were made three times; a third measurement was obtained if the first two measures differed by a preset amount (.5 cm). We used mean values for analysis. Trained healthcare providers performed sexual maturity ratings for breast development and pubic hair. Breast and pubic hair staging were done by inspection and palpation based on the Tanner Stages of sexual maturity. Onset of puberty was defined as either Tanner Breast Stage 2 or Pubic Hair 2. Height velocity and foot size velocity were calculated by taking the difference in value between consecutive visits divided by the number of days between these visits, to provide annualized data. A mixed model approach was used to examine the relationship between age of increase of height velocity, increase in foot size velocity, and appearance of secondary sexual

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Table 1
Results comparing age (in years) of onset of secondary sexual characteristics with increase in height velocity and increase in foot size velocity

Parameter	Mean age (SD)	p Value
Onset of secondary sexual characteristics	8.79 (.92)	Reference
Increase in height velocity	8.27 (.89)	.0005
Increase in foot size velocity	8.40 (.95)	.007

SD = standard deviation.

characteristics. This method was also used to test for the interaction of race, and subsequent overall race effect. SAS version 9.1 software was used to manage and analyze the data.

Results

There were 86 girls eligible for this study. The sample was 73% white and 27% African American. The mean age of onset of secondary sexual characteristics was 8.79 years in this sample (SD = .92), as shown in Table 1. The mean age for foot velocity increase was 8.40 years (SD = .95), and the mean age for height velocity increase was 8.27 years (SD = .89).

There was a statistically significant difference between age at onset of secondary sexual characteristics and age of foot velocity increase ($p = .007$), as well as age at onset of secondary sexual characteristics and age of increase in height velocity ($p = .0005$). There was no significant difference in age of foot velocity increase and height velocity increase ($p = .39$) (Figure 1). The relationships between age at onset of secondary sexual characteristics with height velocity and foot velocity were similar when using age at onset of breast development (data not shown). There was no significant race interaction ($p = .92$), but there was an overall race effect ($p = .0006$). African-American girls in this study started all markers an average of .42 year (SD = 1.30) before their white American peers (Figure 2).

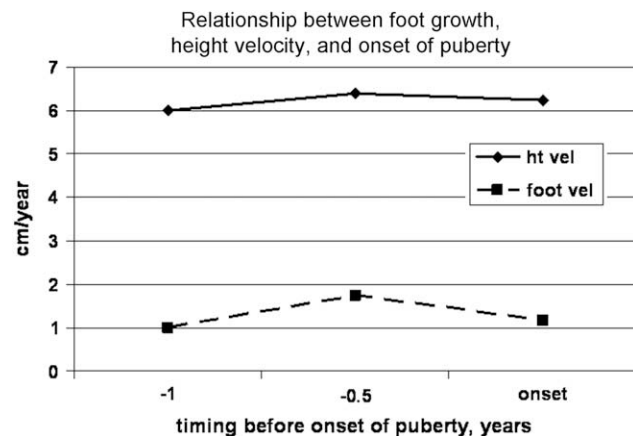


Figure 1. Relationship between foot growth, height velocity, and onset of puberty.

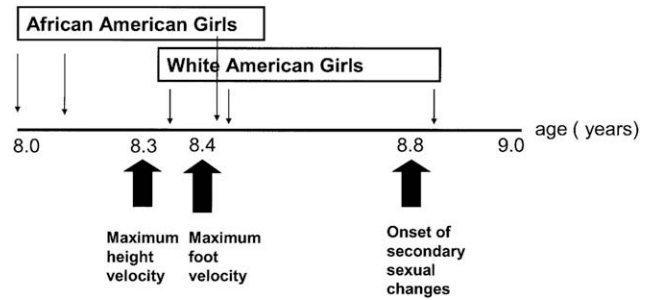


Figure 2. Race has an effect on the timing/initiation of events, not the sequence. Race effect = .006, race by sequence interaction = .92.

Discussion

Recognizing the exact onset of puberty provides researchers and clinicians with a method to categorize patients for teaching or therapy. For example, the age at onset of puberty is associated with adult body mass index [3] as well as social and psychological issues in adulthood [4,5]. In this study sample, the age at which there was increase in both foot size and height was younger than the age of pubertal onset (defined as the onset of secondary sexual characteristics). There was no statistically significant difference between the age when height velocity increased and age when foot size velocity increased. This project demonstrated no statistical difference in sequence of events among races, although African-American girls reached each marker earlier than white American girls. Parents and children may easily recall a change in footwear, necessitating new shoes versus remembering when the onset of breast development or appearance of pubic hair began. Therefore, using the change in a prepubertal child’s foot size could be an early, viable, noninvasive marker to document the onset of puberty.

Acknowledgments

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