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Puberty Onset Among Boys in Riyadh, Saudi Arabia

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Abstract

Background: The ages of onset of pubertal characteristics are influenced by genetic, geographic, dietary and socioeconomic factors; however, due to lack of country-specific norms, clinicians in Saudi Arabia use Western estimates as standards of reference for local children.

Aims: The aim of the Riyadh Puberty Study was to provide data on pubertal development to determine the average age of onset of pubertal characteristics among Saudi boys.

Methods: Cross-sectional study among male school children in Riyadh, Saudi Arabia, in 2006, 542 schoolboys, aged 6 to 16 years old, from diverse socioeconomic levels were selected into the sample using a cluster sample design. Tanner stages were ascertained during physical examination by pediatric endocrine consultants, and also trained pediatric residents and fellows.

Results: The mean age (standard deviation) at Tanner Stages 2, 3, 4, and 5 for pubic hair development of Saudi boys was 11.4 (1.6), 13.3 (1.3), 14.4 (1.0) and 15.1 (0.8) years old, respectively. For gonadal development, the mean age (standard deviation) at stages 2, 3, 4, and 5 were 11.4 (1.5), 13.3 (1.2), 14.3 (1.1) and 15.0 (0.9) years old, respectively.

Conclusion: The ages of onset of pubertal characteristics, based on gonadal development, among Saudi boys are comparable to those reported in Western populations.

Keywords: adolescence, boys, pubertal characteristics, puberty onset, Riyadh, Saudi Arabia

Clinical Medicine Insights: Pediatrics 2010:4 19–24

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Introduction

Puberty is the period of transition between childhood and adulthood during which the growth spurt occurs, secondary sexual characteristics appear, fertility begins and profound psychological changes take place in the individual. The changes occurring during puberty are substantial, yet subtle, causing it to be difficult to ascertain when the first changes occur. The easiest sign to determine is the growth of pubic hair. The initial presentation, as light, fine and straight hair (Tanner Stage 2) may be confused with hypertrichosis, so long, curly dark hair (Stage 3) may be a more accurate indicator of the onset of pubertal androgen production.¹ However, the criterion that most accurately reflects gonadal activity in boys is testicular enlargement, and this is ordinarily the first sign of puberty.^{2,3}

The age of onset of puberty is influenced by racial, ethnic, genetic, geographical, nutritional and socioeconomic factors.^{4–11} In developed countries, the onset of puberty seemed to stabilize during the 1990s. However, two subsequent studies reported earlier pubertal development in US children, both boys and girls,^{12,13} although this has been disputed.¹ In developing countries, variations in the onset of puberty may be affected by differences within and between countries due to socioeconomic inequalities, urban and rural lifestyles, and the gap between affluent and poor families.⁸

The definition of appropriate pubertal age limits is crucial to restrict diagnostic evaluation and possible therapeutic intervention to children with an average onset of pubertal development.¹⁴

With the exception of a study among boys in a rural area of Southern Saudi Arabia,¹⁵ the average age of onset of pubertal characteristics among Saudi children has not been explored. Due to a lack of national measures, clinicians in Saudi Arabia use Western estimates as standards of reference on the local children, in spite of the recent questions raised by US studies and the facts supporting variations in the onset of puberty in developing countries.

Aims

The Riyadh Puberty Study was designed to establish the local standard age of onset of pubertal characteristics among children in Riyadh, Saudi Arabia.

Methods

Population and sampling technique

The study was cross-sectional in design, carried out among school children in Riyadh, Saudi Arabia. A total of 542 male children were selected for the study using a cluster sampling strategy. Out of 650 students invited to participate, the final sample size was 542 and the response rate was 84%. Schools (clusters) were sampled from the Riyadh region using information from the Ministry of Education and Ministry of Planning to construct our sampling frame. Schools were selected from affluent areas of Riyadh as well as those of a low economic status. The North and East geographical areas of Riyadh include high socioeconomic status residents, whereas the West and South regions include low socioeconomic residents. In our study, we sampled from private and public schools from the four regions to cover a representative sample. The sampling protocol was as follows: from each area, a K-12 school was randomly selected and all students in the class were invited to participate in the study. Data were collected in each boy's school by a team of male pediatric endocrinology consultants and fellows. One week prior to data collection, each student received an envelope containing an informational brochure about the study, an informed assent and consent form, and a self-administered child's health and other demographic information to be completed by the student's parent or guardian. Only students with signed consent forms were allowed to participate in the study. The study protocol was approved by the Research and Ethics Subcommittee at the King Abdullah International Medical Research Centre in Riyadh.

Data collection

The study was conducted between January and June 2006. Each boy was examined by the data collection team in his school clinic or a specifically designated area. A systematic data collection protocol was followed to collect data on the following variables:

Systematic examination

A general and systematic examination was done, paying particular attention to the presence of physical or endocrinological symptoms that were exclusionary criteria.



Maturation

The boys' sexual maturity stages were assessed using Tanner's criteria. In addition, the gonadal stage was assessed by direct testes palpation and testicular volume was measured using a Prader Orchidometer.^{16,17} Orchidometry sizing was used, but data were entered as Tanner gonadal stages, with the equivalent of 1–3 ml as Stage 1, 4–8 ml as Stage 2, 8–12 ml as Stage 3, 12–15 ml as Stage 4 and >15 ml as Stage 5.^{18,19} All components of Tanner staging were ascertained for each Riyadh Puberty Study participant by a pediatric endocrinology consultant in addition to trained pediatric residents and fellows.

Growth parameters

Height was measured using a wall-mounted stadiometer and measurement was recorded to the nearest 0.1 cm. Weight was measured to the nearest 0.1 kg with a beam-balance scale. All measurements were collected by a nurse member of the data collection team in the child's school clinic.

Statistical analyses

Descriptive analyses were carried out by calculating the number and percent for categorical variables, and the mean and standard deviation for continuous variables. Stratified analyses by age for height, weight, and body mass index (BMI) were also carried out. Moreover, the mean, standard deviation and 95% confidence intervals of age by stage for pubic hair and genital development were also calculated. Data management and analyses were carried out using SPSS software (version 15).

Results

Out of the 542 male children who were selected for the study, 28 students were excluded due to the presence of chronic illness. The 5th percentile for the onset of gonadal enlargement was approximately 9.0 years and 95% of boys had achieved G2 by 13 years. The 5th percentile for the appearance of Stage 3 pubic hair was about 11.0 years and 95% of boys had reached this stage by 15 years.

Table 1 summarizes the number and percent of boys for ages from 6 to 16 years. Table 1 also shows the mean and standard deviation for height, weight and BMI for each of the different ages, as well as the percentage of children who attained gonadal enlargement (G2), sexual pubic hair (P2) and sexual pubic hair (P3) at each age. We found that in general, BMI increased with age.

Table 2 shows the mean and standard deviation of age of onset of development of secondary sexual characteristics (pubic hair development and gonadal development) for boys 6 to 16 years of age along with the 95% confidence interval and 5th and 95th percentiles of age for each stage. The mean ages at Tanner Stages 2, 3, 4, and 5 for pubic hair development of Saudi Arabian boys was 11.4, 13.3, 14.4 and 15.1 years old, respectively. For gonadal development, the mean ages at Stages 2, 3, 4, and 5 were 11.4, 13.3, 14.3 and 15.0 years old, respectively. Thus, the onset of gonadal development (G2) and pubic hair development (P2) coincided.

We have assessed the correlation between pubic hair and gonadal development, and a correlation efficient of 0.96 (*P*-value < 0.0001) was found,

Table 1. Age, number of boys and percentages with their mean heights, weights and percentage to attain gonads (G2), pubic hair (P2) and pubic hair (P3) during each age. Age indicates 6.00 through 6.99 and so on.

Age yr	Number (%)	Height cm mean (sd)	Weight kg mean (sd)	BMI mean (sd)	Gonads G2%	Pubic hair P2%	Pubic hair P3%
6	33 (6.4)	122.3 (7.2)	24.5 (6.5)	16.2 (3.0)	0	0	0
7	52 (10.1)	124.5 (7.2)	28.5 (15.8)	17.9 (5.9)	09	2.0	0
8	49 (9.5)	130.9 (6.5)	30.1 (7.3)	17.4 (3.1)	3.6	5.0	0
9	48 (9.3)	134.2 (5.9)	32.6 (8.0)	17.9 (3.3)	10.9	12.9	0
10	53 (10.3)	137.5 (8.1)	39.2 (19.7)	20.6 (10.7)	21.8	25.7	0
11	69 (13.4)	142.2 (8.4)	38.9 (12.1)	18.9 (4.3)	49.1	47.5	11.4
12	50 (9.7)	148.6 (8.3)	49.5 (16.9)	22.0 (6.2)	76.4	73.3	22.7
13	46 (8.9)	154.5 (8.5)	51.0 (13.7)	21.4 (5.2)	95.5	94.1	54.5
14	42 (8.2)	162.6(10.1)	60.7 (18.4)	22.6 (5.1)	99.1	98.0	79.5
15	51 (9.9)	166.0 (8.7)	70.0 (22.4)	25.1 (6.6)	100	100	97.7
16	21 (4.1)	167.2 (7.5)	63.0 (17.7)	22.4 (5.3)	100	100	100



Table 2. Mean and standard deviation of age of onset of development of secondary sexual characteristics for boys 6 to 16 years of age along with the 95% Confidence Interval and 5th and 95th percentile of age per year for each stage. TV is denoted testicular volume.

Stage	Number (%)	Age, yr mean, sd	95% CI	5th percentile	95th percentile
Pubic hair growth					
Stage 2	101 (20)	11.4 (1.6)	(11.1–11.7)	8.1	14.0
Stage 3	44 (8.7)	13.3 (1.3)	(13.0–13.7)	11.0	15.0
Stage 4	40 (7.9)	14.4 (1.0)	(14.1–14.7)	12.1	16.0
Stage 5	51 (10.1)	15.1 (0.8)	(14.8–15.3)	13.0	16.0
Genital development					
Stage 2	110 (21.8)	11.4 (1.5)	(11.2–11.7)	9.0	13.5
TV (4–8 ml)					
Stage 3	40 (7.9)	13.3 (1.2)	(12.9–13.7)	11.0	15.0
TV (9–12 ml)					
Stage 4	43 (8.5)	14.3 (1.1)	(14.0–14.7)	12.0	16.0
TV (12–15 ml)					
Stage 5	54 (10.7)	15.0 (0.9)	(14.7–15.2)	13.0	16.0
TV (>15 ml)					

indicating a high correlation between both pubertal characteristics.

Discussion

Our study showed the mean age of onset of both genital development G2 and pubic hair stage 2 developments was 11.4 years. The genital development is similar to most published data in Western Europe.

In boys, the earliest stage of maturation is an increase in testicular volume (more than 3 ml), followed by thinning of the scrotum, penile growth, pubic hair development and, lastly, a linear growth spurt. The duration of secondary sexual development is about 3 to 4 years.³ Testicular volume is typically measured using the Prader Orchidometer, a series of plastic ellipsoids with a volume from 1 to 25 mL.¹⁷

It is hard to compare different studies about pubertal onset in different ethnic groups. This is due to several reasons.^{8–20} First, some studies used a cross-sectional methodology, whereas others were longitudinal; second, different age groups were used in different studies; third, differences in assessment of onset of puberty, (pubic hair, growth spurt and age at peak height velocity, or testes size); and, finally, methods of assessment being either inspection or photography, measurements of the testes by diameter or orchidometry, or self-assessment.^{16,19,21}

A secular trend showing a consistent and remarkable decline of age of onset of puberty in the United States and some western European countries was

noted in the mid-19th and early 20th centuries. This trend was attributed mostly to improvements in general health, nutrition and other living conditions during this time frame.⁸ In 1970, Marshall and Tanner provided age references for male pubertal development; the mean age for G2 stage was found to be 11.6 years in the United Kingdom, which is considered a common international reference for norms.¹⁶ Very similar findings have been reported in Switzerland (11.2 years) in 1983,²² the United States (11.5 years) in 1985,²³ Sweden (11.6 years) in 1996²⁴ and the Netherlands (11.5 years) in 2001.²⁵ These studies showed stabilization of onset of puberty in developed countries.

On the other hand, a subsequent study has challenged the acceptance of this as an international reference standard by suggesting a secular trend. Herman-Giddens et al¹³ published data from the National Health and Nutrition Examination Survey III (NHANES) 1988 to 1994, involving 2114 boys aged 8 to 19 years. The report showed a decline of 1½ years in the age of genital development G2 compared to Marshall and Tanner data, and a decline in the mean age for the onset of pubic hair growth compared to earlier studies in the United States. The data were based on visual inspection without palpation of testicular volume or assessment of testicular size, and revealed the surprisingly long interval of two years between G2 and P2 stages, whereas this interval was found to be one year by others.



This report of considerably earlier onset of puberty in boys is the subject of ongoing debate internationally. An expert international panel was established to evaluate data from 1940 to 1994 to determine the evidence of secular changes over time in US children. It was concluded that there were insufficient data to evaluate secular trends in male pubertal development.²¹ This debate supports both re-evaluating the reliability of the published data concerning the age of puberty onset in boys and re-studying puberty maturation in boys using a reliable methodology.^{3,26}

Several international studies have been. Defining the age of pubertal onset based on pubic hair development, Kanbur-Öksüz et al found Turkish boys entered puberty (P2) by a mean age of 11.53 years.²⁷ More appropriately defining the age of pubertal onset by G2, Pantziotou et al²⁸ carried out a prospective study to evaluate pubertal development in Greek boys. They included 204 pre-pubertal boys between the age of 8 and 10 years who were followed over an average of 7.5 years in duration. The mean age onset of puberty was 10.3 years for G2 and 10.8 years for P2. Despite this earlier onset of puberty, the attainment of sexual maturity was not accelerated, with a pubertal duration of 6.2 years, measured by the mean time interval of progression from G2 to attaining final height. In Egypt, on the other hand, boys had their onset of puberty at a mean age of 10.56 years (G2) and 11.86 years (P2), with a pubertal duration of about 4 years, measured from the beginning of testicular enlargement to a testicular volume of 15 ml (G5).¹⁹ The limitation of both studies is that they were undertaken in urban cities on middle- to upper-class children. Lee et al reported median ages of G2 11.9 and P2 12.7 years in Russian boys, which correspond to the commonly accepted age of puberty onset.²⁹

There are only two Saudi Arabian studies focused on male onset of puberty. Abofotouh³⁰ studied special students from institutes for the deaf and blind in Abha, Saudi Arabia, aged between 10 and 20 years. Up to 21% and 30% of blind and deaf boys, respectively, did not attain puberty by the age of 16 years. It was concluded that in both groups, there was significant delay in pubertal completion.

Sengupta et al¹⁵ carried out a cross-sectional study of 368 boys in a rural area in Gizan, Saudi Arabia, in 1983. The onset of puberty, by measurement of testicular volume, was reported only by percentage; the median of their students was 13 years old. This is considerably

later than the mean for G2 of our population. It may be related to their students' mean weight being significantly lower than our students' mean weight, across all ages, although the average height was similar to that in our study.

In spite of similarity of our mean age of onset of gonadal puberty with recent Western data, our data showed an early pubarcheal age and concomitant of mean ages for all stages of pubic hair growth with their corresponding gonadal stages. Five percent of our healthy, non-obese children reached Stage 2 of pubic hair at 8.1 years; based on NHANES III data, Herman-Giddens et al found 5.3% of African American and 2.7% of Mexican Americans boys exhibited growth of pubic hair at 8 years.¹³ In contrast to our findings, Biro et al found 95% of boys had an increase in testicular volume (≥ 3 mL) prior to the appearance of pubic hair, and only 4% of boys had concomitant growth of both pubic hair and gonadal development.²

Our study has some limitations. First, cross-sectional data were used and, as a result, the data can neither tell us how much individuals vary in the rate at which they pass through puberty, nor how the development of the secondary sex characteristics is related to the adolescent growth spurt. Second, Riyadh is home to only one-third of the Saudi population; therefore, descriptive data may not be generalized to the entire Saudi population. Another limitation is the sample size, which was small, especially for the stratification by age analysis.

Despite these limitations, we think that our data further ignites the debate about the age of onset of pubertal characteristics in Saudi Arabia, and may pave the way for more studies to understand the age of onset of pubertal characteristics. We believe that a larger study with better matching of different provinces may give us more insight into the real age of onset of pubertal characteristics in Saudi Arabia.

Conclusion

There are recommendations that may be drawn from this analysis. First, it is clear that additional national studies need to be done to establish normative references for sexual maturity levels of Saudi boys. Second, with the current findings, no change in the average limits for puberty in boys is proposed at this time. Third, pubic hair development does not reflect the true stage of puberty in Saudi boys.



Acknowledgment

The authors would like to thank Dr. Robert Rosenfield at The University of Chicago Pritzker School of Medicine for his invaluable feedback and review of this paper. The authors would like to thank King Abdullah International Research Center for supporting this study.

Disclosure

This manuscript has been read and approved by all authors. This paper is unique and is not under consideration by any other publication and has not been published elsewhere. The authors and peer reviewers of this paper report no conflicts of interest. The authors confirm that they have permission to reproduce any copyrighted material.

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