Optimal age of sexual maturation in Egyptian children

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العمر الأمثل للنضج الجنسي في الأطفال المصريين

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الخلاصة: تم تحديد مراحل "تانر" للنضج لمعرفة العمر الأمثل للنضج الجنسي في الأطفال المصريين، وذلك في عدد من الأطفال والمراهقين (1550 فتاة و1563 فتى) تراوحت أعمارهم في ما بين 6.5 و18.5 عاماً. وكان العمر المتوسط لنمو شعر العانة (المرحلة الثانية) 10.46 عاماً (بانحراف معياري قدره 1.36) بالنسبة للفتيات و11.86 (بانحراف معياري قدره 1.45) بالنسبة للفتيان. أما شعر الإبط (المرحلة أ 2) فكان العمر المتوسط هو 11.65 عاماً (بانحراف معياري قدره 1.62) في الفتيات، و13.55 عاماً في الفتيان (بانحراف معياري قدره 1.52). وكان العمر المتوسط لبدء الإحاضة لدى الفتيات هو 12.44 عاماً ونمو الثديين 10.71 عاماً (المرحلة ب 2) (بانحراف معياري قدره 1.30)، كما دل حجم الخصيتين بالجس على أن العمر المتوسط للمرحلة التناسلية G2 للفتيان هو 10.56 عاماً (بانحراف معياري قدره 1.40). ومن شأن ما أسفرت عنه الدراسة من نتائج أن يساعد في تقييم النضج الجنسي واضطرابات البلوغ لدى المراهقين المصريين.

ABSTRACT To establish the optimal age of sexual maturation in Egyptian children, Tanner's maturity stages were determined for a sample of children and adolescents (1550 girls, 1563 boys) ranging from 6.5 to 18.5 years. The mean age for attainment of pubic hair (stage PH2) was 10.46 (SD 1.36) years for girls and 11.86 (SD 1.45) years for boys. For axillary hair (stage A2), mean age was 11.65 (SD 1.62) years for girls and 13.55 (SD 1.52) years for boys. The mean age at menarche in girls was 12.44 years and for breast development (stage B2) was 10.71 (SD 1.30) years. Testicular volume by palpation showed that the mean age of genital stage G2 for boys was 10.56 (SD 1.40) years. The study results can aid in the assessment of sexual maturation and pubertal disorders in Egyptian adolescents.

Âge optimal de la maturation sexuelle chez les enfants égyptiens

RÉSUMÉ Afin d'établir l'âge optimal de la maturation sexuelle chez les enfants égyptiens, on a déterminé les stades de maturité de Tanner pour un échantillon d'enfants et d'adolescents (1550 filles et 1563 garçons) dont l'âge s'échelonnait entre 6 ½ ans et 18 ½ ans. L'âge moyen de l'apparition de la pilosité pubienne (stade P2) était de 10,46 (écart type 1,36) ans pour les filles et de 11,86 (écart type 1,45) ans pour les garçons. En ce qui concerne la pilosité axillaire (stade A2), l'âge moyen était de 11,65 (écart type 1,62) ans pour les filles et de 13,55 (écart type 1,52) ans pour les garçons. L'âge moyen de la ménarche chez les filles était de 12,44 ans et l'âge du développement mammaire (stade S2) était de 10,71 (écart type 1,30) ans. Le volume testiculaire à la palpation montrait que l'âge moyen du stade génital G2 pour les garçons était de 10,56 (écart type 1,40) ans. Les résultats de l'étude peuvent aider à évaluer la maturation sexuelle et les troubles pubertaires chez les adolescents égyptiens.

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Introduction

Previous studies have clearly demonstrated the influence of genetic as well as environmental factors on pubertal development; these can be explained to some degree by the effect of socioeconomic level as well as the extent of physical activity [1,2].

A secular trend in the age of sexual maturation has been observed in many industrialized countries [1,3]. The age of onset of puberty has decreased dramatically over the past 150 years, at a rate of 2–3 months per decade. This has been attributed to a decline in the incidence of infectious diseases and improvements in health care, vaccination programmes, socioeconomic conditions and nutrition [4]. Racial differences across nations and even in the same country have been reported [5–8]. Therefore, the use of standards for sexual maturation from other countries is not useful. On the other hand, studies of sexual maturation in Egypt are scarce and inadequate. The aim of this study was to obtain data about the optimal age of sexual maturity in Egyptian children and adolescents, data which could be considered as a baseline for assessment of different pubertal disorders.

Methods

Sample

A total of 1563 boys and 1550 girls were assessed for sexual maturation as part of a much larger cross-sectional study to establish standard growth curves for Egyptian infants, children and adolescents. The ages of the children in this substudy ranged from 6.5 to 18.5 years. The duration of the study was from July 1997 to December 2001.

Ideally, national growth curves would be based on a representative sample of children from every governorate of Egypt. However, the great majority of Egyptians live in the Nile valley, where a geographical gradient is assumed to exist in the genetic composition of Egyptians. Moreover, the inhabitants of Cairo, the capital city, amount to one-fifth of the Egyptian population, and many are migrants from areas throughout Egypt. For these reasons, the sample was chosen from the population of Cairo.

To establish standard growth curves from which comparisons to the norm can be made it was necessary to obtain data from children with optimum growth opportunities. Therefore, the sample for this study was restricted to children from upper and middle socioeconomic groups attending fee-paying schools, who could be presumed to experience optimum conditions for growth and maturation. Inclusion criteria were normal healthy children whose mothers had a normal delivery of a normal-birth-weight baby after a normal pregnancy. Exclusion criteria included major genetic or organic diseases known to cause deviation from normal growth patterns. All schools and children fitting the inclusion criteria were included. Only non-qualifying subjects or those who refused were excluded.

Data collection

Ethical consent

Approval of the concerned authorities was obtained. Explanatory meetings by the principal investigator of the project and board members were held with parents, school headmasters and physicians. Schools were approached by formal letters and personal interviews. Orientation was performed about the project and its importance, and informed consent was obtained from all participating parents as well as participating adolescents. Interviews and examinations took place at schools with the help of the school administration who offered the location and facilities.

Training and quality control

The team members included 54 highly trained personnel, 41 of whom were physicians. Each team comprised 1 supervisor, 3 practitioners, 1 social worker and 1 assistant. Each team received 20 hours of classroom instructions over a 10-day period plus practical training for 4 hours per day for 2 weeks. This training was provided by the coinvestigators from the Diabetes Endocrine Metabolic Paediatric Unit, Children's Hospital, University of Cairo and the Anthropology and Child Health Department, National Research Centre, Cairo.

Each team member was responsible for specific tasks associated with data collection. The supervisor monitored the accuracy of the measurements that were performed, reviewed the pooled sheets, excluded non-qualifying subjects and replaced them with qualifying ones of appropriate sex and age group. Two physicians assigned to each team acquired the clinical history and performed the physical examination, anthropometric measurements and pubertal assessment. A social worker completed the family and social data questionnaires. Finally, an assistant dressed and undressed the children, and helped the practitioners to perform the measurements. The accuracy of each team's measurements was evaluated during the training course and during the field study by their respective supervisors.

Protocol

For each child, the parents completed a questionnaire about the child's personal and social data as well as previous medical history. A complete clinical examination as well as anthropometric measurements and pubertal examination were performed, the latter was done for boys and girls 6 years or older by male and female physicians respectively. During the survey fieldwork, the actual assessments were done during a general physical examination, after obtaining consent from the parents.

Assessment of sexual maturity

Pubertal evaluation of the secondary sexual characteristics of both sexes was done by inspection, and classified by Tanner stages (Table 1) [*9,10*]. Maturity stages were assigned to breast development in females and pubic and axillary hair in males and females. Five Tanner stages were defined for pubic hair and breast development, examined accurately by both inspection and palpation by female physicians. Direct questioning of the girl was used to record the attainment of menarche at the time of examination. For males, in addition to assessment of pubic and axillary hair, left and right testicular volume was recorded by palpation of the testes using a Prader orchidometer. This examination was done by male physicians, well-trained in anthropometry and pubertal evaluation. A testicular volume of 4 mL of the larger testis represented the first clear sign of the onset of puberty (genital stage G2), volume 8 mL was G3, volume 12 mL G4 and volume 15–25 mL was G5; the latter was considered as the last pubertal event reached by all normal boys, as previously established [*10*].

Statistical analysis

Descriptive statistics for age by sex and Tanner stage were computed separately for male and female pubic and axillary hair, female breast development and male testicular size. One-way analysis of variance (ANOVA) was used to test for any overall significant differences among mean ages of the Tanner stages within each sex.

For menarche data, female subjects were divided into 24 age groups ranging from 6.5 to 18.5 years of age. Groups were created in

Table 1 **Tanner's sexual maturity rating for males and females, source: [6]**

Pubertal stage	Pubic hair in males and females	Axillary hair in males and females	Genitalia in males	Breast in females
P1	None	None	Pre-adolescent	Pre-adolescent
P2	Scanty, long, slightly pigmented	Scanty, slightly pigmented	Enlarged scrotum, pink texture altered	Breast and papilla elevated as small mound; areolar diameter increased
P3	Darker, starts to curl, small amount	Darker, curly, adult pattern	Scrotum enlarges, penis longer	Breast and areola enlarged, no contour separation; increased breast contour
P4	Resembles adult type, but less in quantity, coarse, curly		Scrotum larger, dark; penis larger, with glans and breadth increased in size	Areola and papilla form secondary mound
P5	Adult distribution, spread to the medial surface of the thighs		Adult size penis and scrotum	Mature; nipple projects, areola part of general breast contour

half-year intervals from 6.5 to 7.0 years up to 18.5 years of age. The midpoint of each age group was used as the reference value for that group. For instance, in the 6.5 to 7.0 year age group, 6.75 years was used as the reference value. The proportion of those females obtaining menarche was calculated within each age group. A probit analysis was then completed and the average age at menarche obtained. The empirical proportions were plotted and a function of the natural log was used to model the proportion of those who had obtained menarche.

All tests were run using *SAS*, version 6.12 [*11*], procedure PROC GLM, assuming a type-1 error rate of 0.05.

Results

Table 2 shows the ages at attainment of male and female axillary and pubic hair as well as female breast development. The mean age for attainment of pubic hair (stage PH2), was 10.46 [standard deviation (SD) 1.36] years for girls and 11.86 (SD 1.45) years for boys. For axillary hair (stage A2), the mean age was 11.65 (SD 1.62) years for girls and 13.55 (SD 1.52) years for boys. The mean age at the lowest maturity level of pubic hair was the same for both males and females (8.65 and 8.64 years respectively), but for the highest maturity level it was 15.76 years for males and 14.72 years in females respectively. The mean age upon reaching adult maturity for pubic and axillary hair was about 1 year earlier in females than in males.

The results for breast development in girls show that the mean age for the attainment of stage B2 was 10.71 (SD 1.30) years, range 8.11–14.23 years. Stage B3 occurred as early as 7.56 years.

Table 2 **Mean ages by Tanner stages of various maturity indicators for Egyptian males and females**

Tanner stage	Males					Females				
	n	Mean age (years)	SD	Min.	Max.	*n*	Mean age (years)	SD	Min.	Max.
Pubic hair										
PH1	443	8.65	1.56	6.53	15.87	479	8.64	1.51	6.52	13.38
PH2	359	11.86	1.45	8.08	15.21	164	10.46	1.36	7.56	14.00
PH3	295	13.94	1.41	8.14	17.49	191	11.82	1.49	8.16	15.77
PH4	246	14.99	1.23	8.76	18.26	258	13.32	1.62	9.65	17.75
PH5	143	15.76	1.02	12.85	18.08	436	14.72	1.51	9.93	18.23
Axillary hair										
A1	725	9.74	2.01	6.53	15.58	610	9.07	1.70	6.52	13.89
A2	413	13.55	1.52	8.14	17.49	227	11.65	1.62	8.23	18.01
A3	413	15.25	1.25	8.76	18.26	690	14.19	1.73	8.57	18.23
Breast development										
B1	–	–	–	–	–	485	8.56	1.40	6.52	12.37
B2	–	–	–	–	–	178	10.71	1.30	8.11	14.23
B3	–	–	–	–	–	300	12.86	1.73	7.56	17.21
B4	–	–	–	–	–	256	13.45	1.81	9.93	17.75
B5	–	–	–	–	–	317	14.86	1.43	10.99	18.23

Data presented are those of pubertal children and adolescents only excluding prepubertal children.
All sex-specific means were significantly different at $P < 0.05$.
n = *number of subjects examined; SD = standard deviation; Min. = minimum; Max. = maximum.*

Figure 1 shows the probit plot for age at menarche of girls. The point at which 50% of the girls reported achieving menarche, i.e. the average age at menarche, was 12.44 years.

The first sign of breast development (stage B2) occurred about 1.7 years before menarche, for pubic hair (stage PH2) about 2 years before menarche, while for axillary hair it was 0.79 years before menarche.

Table 3 shows mean ages for each of the 12 testicular sizes measured by palpation. Testicular volume by palpation showed that the mean age of testicular stage T4 (i.e genital stage G2) was 10.56 (SD 1.40) years. The duration of male puberty from the beginning of testicular enlargement to testicular stage T15 (i.e. G5) was about 4 years.

Discussion

The study presents the sexual maturity stages of 3113 Egyptian students (1550 girls and 1563 boys).

For girls, the mean age for the attainment of breast development stage B2 was 10.71 years. Of interest is the observation that the minimum age for stage B3 was 7.56 years, indicating that the onset of puberty in this sample of girls occurred as early as 7 years. Age at menarche is a more reliable event for determining sexual maturity in girls than the appearance of secondary sexual characteristics [12–14]. In our study, the average age at menarche was 12.44 years, which is lower than another study in Egypt in 1978 that reported the mean menarcheal age in Egyp-
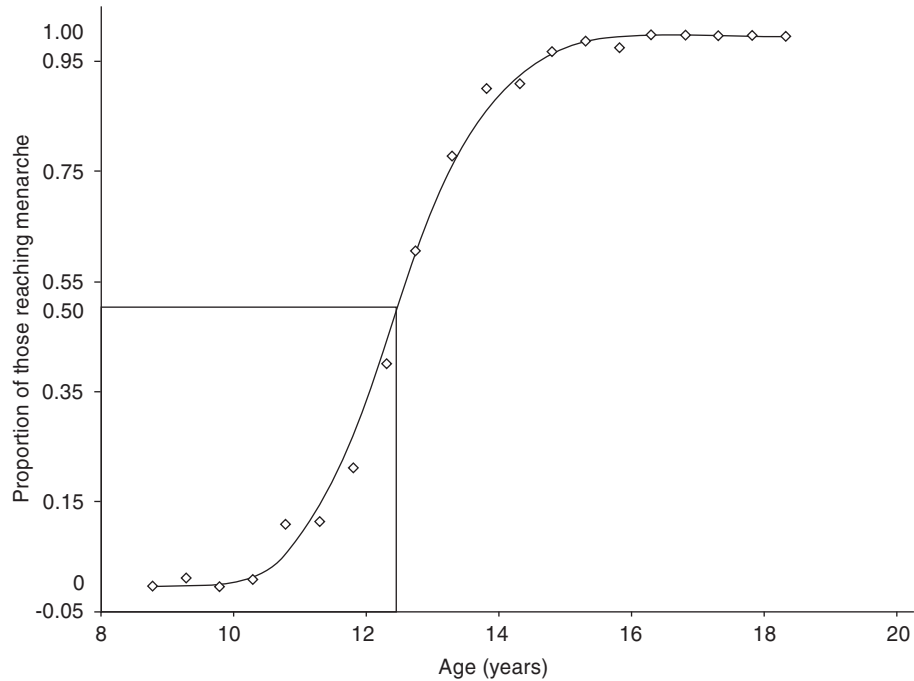
Figure 1 **Probit analysis of age of menarche for Egyptian girls**

Table 3 **Mean ages by Tanner stages for testicular size in Egyptian males**

Pubertal stage	Testicular size	n	Left testis				n	Right testis			
			Mean age (years)	SD	Min.	Max.		Mean age (years)	SD	Min.	Max.
G1	T1	39	8.88	1.60	6.58	12.02	35	9.16	1.64	6.58	12.53
	T2	210	8.64	1.58	6.53	13.32	220	8.60	1.56	6.55	13.48
	T3	243	9.13	1.57	6.55	13.71	240	9.10	1.52	6.53	13.39
G2	T4	91	10.56	1.40	6.90	13.39	84	10.86	1.29	7.86	14.12
	T5	45	11.56	1.49	7.89	14.45	50	11.27	1.58	7.89	13.94
	T6	62	12.35	1.24	8.15	15.09	54	12.41	1.27	9.99	16.26
G3	T8	61	12.67	1.11	10.52	15.18	70	12.81	1.18	10.52	15.46
	T10	60	13.19	1.25	10.64	15.87	56	12.99	1.21	10.64	15.87
G4	T12	71	13.50	1.09	10.95	15.98	81	13.65	1.00	11.46	17.49
G5	T15	151	14.27	1.27	11.04	17.49	144	14.34	1.20	11.04	17.07
	T20	223	14.91	1.18	11.49	18.26	221	14.88	1.24	11.49	18.26
	T25	213	15.42	1.14	12.82	18.08	210	15.43	1.13	12.63	17.87

n = number of subjects examined; SD = standard deviation; Min. = minimum; Max. = maximum.

tian girls was 12.59 years among girls of high social class and 13.89 years in the low social class [15]. Another cross-sectional study in 1984 ascertained the morphological, metric and developmental norms of Egyptian children [16]. The sample comprised 591 schoolgirls, drawn mainly from the middle and low social classes with ages ranging from 9 to 18 years. The mean menarcheal age was 13.24 years, which is 9 months older than in the present study. The difference in menarcheal age between these 2 studies and ours cannot be explained by the occurrence of secular trends over the past 18 years because of the difference in social class. It has been previously shown that a relatively large difference exists (1.3 years) between the mean menarcheal age of high and low social classes [15].

For boys, the mean age of start of puberty was 10.56 years and the duration of male puberty from the beginning of testicular enlargement to stage T15 was about 4 years. Comparison with other studies worldwide demonstrates the effect of genetic factors and environment in different geographical regions and intrauterine growth on start and progression of sexual maturation [17]. In the Netherlands, Fredriks et al. showed that the start of puberty T4 occurred at 11.5 years [5], later than our Egyptian boys. In the United States of America, the onset of pubic hair growth occurred at a mean age of 12.0, 11.2 and 12.3 years for white, African–American and Mexican–American boys respectively [18]. The data indicated significant differences in these 3 racial ethnic groups in the age at onset of sexual maturation. Compared with these data, Egyptian boys started pubic hair development earlier than white Americans and Mexican–Americans, but later than African–American boys. For testicular development (stage T4), it started at a mean age of 10.56 years in Egyptian boys, later

than white American and African–American, but at a similar age to Mexican–American boys. On the other hand, Egyptian boys completed their genital development earlier than American boys. However, it is worth mentioning that comparison of genital development with other studies across nations is difficult because of the different methods used for clinical assessment of pubertal development: photography [10], genital development by inspection [18], self-assessment [19], the use of biological maturation and peak height velocity (PHV) skeletal age [20].

The aim of the present study was to report on the optimal age of sexual maturation in Egyptian adolescents. For that reason, subjects were recruited from the middle and high social classes. The strengths of the study include the adequate sample size, the adequate age range from 6.5 to 18.5 years, which can detect the early stages of sexual maturation, and the accuracy of physical examination by well-trained physicians with estimation of testicular volume by palpation. The results may aid in the diagnosis of pubertal disorders in Egyptian adolescents.

Future studies should aim to discover if there is a secular trend in sexual maturation in Egyptian children, as has already been observed in many industrialized countries. This trend has been attributed to improvements in health care, decreasing incidence of infectious diseases, vaccination programmes, better socioeconomic conditions and improved nutrition [21–23].

Acknowledgements

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