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DETERMINATION OF VARIOUS PARAMETERS OF SEXUAL MATURITY IN ADOLESCENT BOYS IN ANKARA*

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Adolescence is the period of transition from childhood to adulthood. Rapid physical growth, development of secondary sexual characteristics and psychosocial maturation characterize this period. Secondary sexual development in the male involves genital development and pubic hair growth. The rating of sexual maturity is based on secondary sexual characteristics. The developmental status of the genitalia, and change in the structure and distributional pattern of pubic hair determine the rating in boys.

Genital and pubic hair changes progress in an orderly fashion, but are not necessarily coincident with one another. Therefore, in staging sexual development it is important to stage each parameter separately[1-3]. The established and most useful criteria for staging secondary sexual development are those described by Tanner[1].

In addition to stages of sexual development, testicular dimensions or volume are used as objective criteria for staging and evaluating the progress of sexual maturity in boys[2-8]. Testicular volume can be calculated by several methods. By measuring testicular dimensions by use of calipers or a ruler, various formulas can be used to determine the testicular volume[8-11]. In addition, the orchidometer permits subjective determination of testicular volume by comparative palpation of the testis and testicular models of known volume[7]. Correlations have been published between testicular dimensions or volume and the biological age or pubic hair stages of the individual in many countries[2-7]. Since biological maturation may proceed, be concurrent with or lag behind chronologic age, the onset or progress of genital development and pubic hair stages may show striking variability within the same chronologic age group[1]. Therefore, in the evaluation

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and staging of sexual maturity, the skeletal age must be considered. In this paper we present the relationship of the testicular length and volume, pubic hair stages and chronologic and skeletal ages in adolescent boys. To the best of our knowledge, this is the first investigation in our country concerning these relationships with emphasis on skeletal age.

Material and Methods

The study group consisted of 879 healthy boys aged between 11-19 years who attended a high school in an Ankara suburb. The subjects were provided continual health care and education services by the Department of Public Health of the Hacettepe University Faculty of Medicine. X-rays of the hands and wrists were taken and the skeletal ages were rated by means of the atlas of Greulich and Pyle[12]. Genital examinations were performed on all the students by the same physician. The long diameters of the testes were measured by a Lange skinfold caliper and the mean value of the right and left testes was estimated. The mean volume of the testes was obtained using the empirical formula of Hansen and With[9] as modified by Prader and Rosenfield[13], i.e. x Volume (ml) = 0.52x long diameter x (short diameter)^2, since short diameter = 0.64 x long diameter, volume = 0.52 x long diameter x (0.64 x long diameter)^2. Since testicular development is the first sign of sexual maturation in boys and precedes pubic hair growth, a mean length of the long diameters of the testes = 24 mm is accepted as the beginning sign of sexual maturation[7,8,14].

Results

The distribution of the number of boys according to chronologic age and pubic hair stages is illustrated in Table I.

Table II shows the relationship between skeletal age and pubic hair stages. The mean value of the chronologic and skeletal ages ± SD in which various pubic hair stages are seen are noted in Table III.

The mean value of the length and volume of the testes with respect to the chronologic and skeletal ages are indicated in Figs. 1-4. Figures 5 and 6 describe the mean value of the length and volume of the testes with respect to pubic hair stages.

TABLE I: Chronologic Ages vs. Pubic Hair Stages

Chronologic age (yrs)	PH 1 No.		PH 2 No.		PH 3 No.		PH 4 No.		PH 5 No.	
11	67	(42.6%)	62	(39.5%)	19	(12.1%)	9	(5.8%)	–	
12	51	(25.6%)	86	(43.4%)	43	(21.7%)	18	(9.3%)	–	
13	15	(8.3%)	42	(23.3%)	56	(31.1%)	57	(31.7%)	10	(5.6%)
14	–		15	(10.1%)	37	(25.0%)	65	(43.9%)	31	(21.0%)
15	–		–		14	(16.3%)	22	(25.6%)	50	(58.1%)
16	–		–		–		15	(35.7%)	27	(64.3%)
17	–		–		–		9	(34.6%)	17	(65.4%)
18	–		–		–		–		16	(100.0%)
19	–		–		–		–		26	(100.0%)
Total	133		205		169		195		177	

PH: pubic hair stage.

TABLE II: Skeletal Ages vs. Pubic Hair Stages

Skeletal age (yrs)	PH 1 No.		PH 2 No.		PH 3 No.		PH 4 No.		PH 5 No.	
8	16	(100.0%)	–		–		–		–	
9	29	(69.0%)	13	(31.0%)	–		–		–	
10	36	(39.1%)	51	(55.4%)	5	(5.5%)	–		–	
11	38	(29.9%)	54	(42.5%)	35	(27.6%)	–		–	
12	10	(11.3%)	47	(52.8%)	24	(27.0%)	8	(8.9%)	–	
13	4	(2.1%)	40	(21.3%)	84	(44.7%)	60	(31.9%)	–	
14	–		–		21	(14.8%)	88	(70.0%)	33	(15.2%)
15	–		–		–		32	(49.2%)	33	(50.8%)
16	–		–		–		7	(33.3%)	14	(66.7%)
17	–		–		–		–		35	(100.0%)
18	–		–		–		–		48	(100.0%)
19	–		–		–		–		14	(100.0%)
Total	133		205		169		195		177	

PH: pubic hair stage.

TABLE III: Mean Ages with Respect to Different Pubic Hair Stages

Pubic Hair Stages	Chronologic ages ± SD	Skeletal ages ± SD
PH 2	12.04 ± 1.74	11.28 ± 1.74
PH 3	12.90 ± 2.25	12.47 ± 2.05
PH 4	13.78 ± 2.65	13.84 ± 2.24
PH 5	15.97 ± 3.15	16.41 ± 3.00

PH: pubic hair stage.

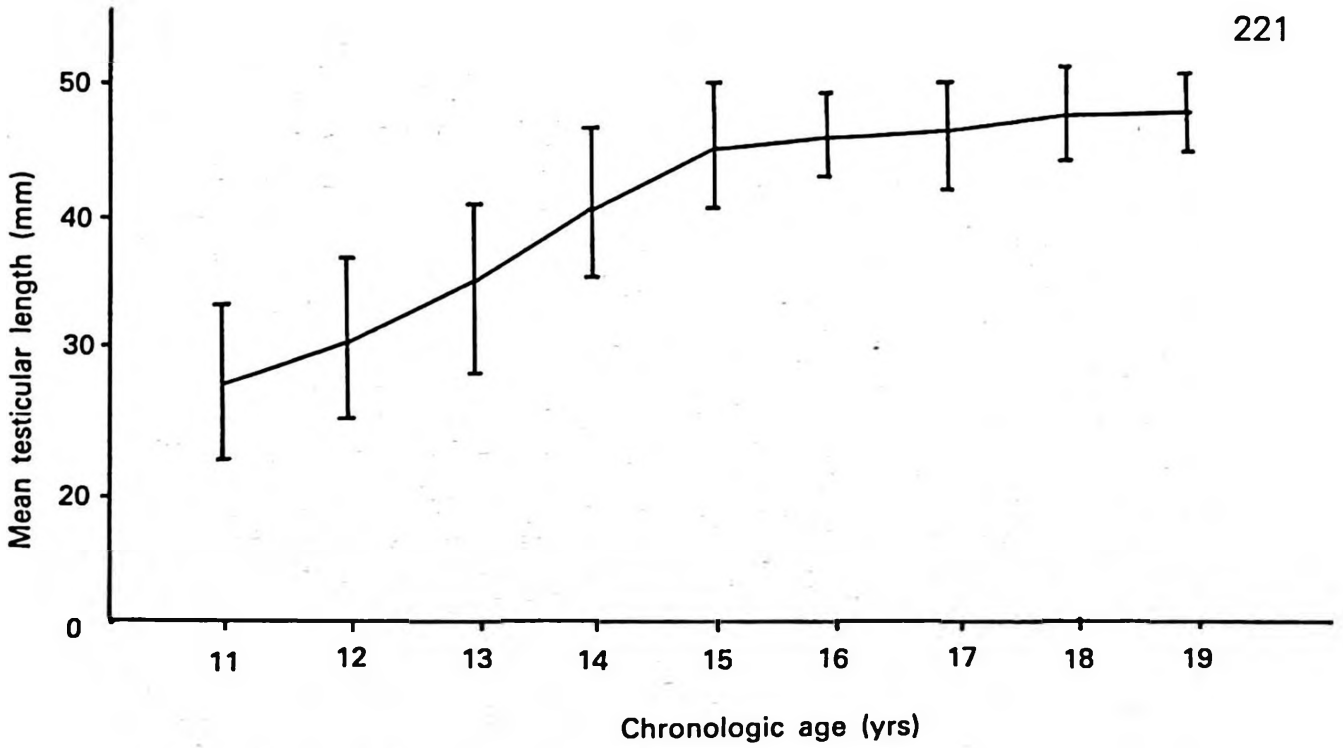
TABLE IV: Chronologic Ages vs. Pubic Hair Stages

Pubic Hair stage	Hacettepe Study mean age	SD	Waaler et al's Study (1974) mean age	Difference in years between the two studies	Marshall and Tanner's Study (1970) mean age	SD	Difference in years between the Hacettepe and Marshall and Tanner studies
PH 2	12.04	1.74	12.7	0.7	13.44	1.09	1.4
PH 3	12.90	2.25	13.4	0.5	13.90	1.04	1.0
PH 4	13.78	2.65	14.1	0.3	14.36	1.08	0.6
PH 5	15.97	3.15	15.6	0.4	15.18	1.07	0.8

PH: pubic hair stage.

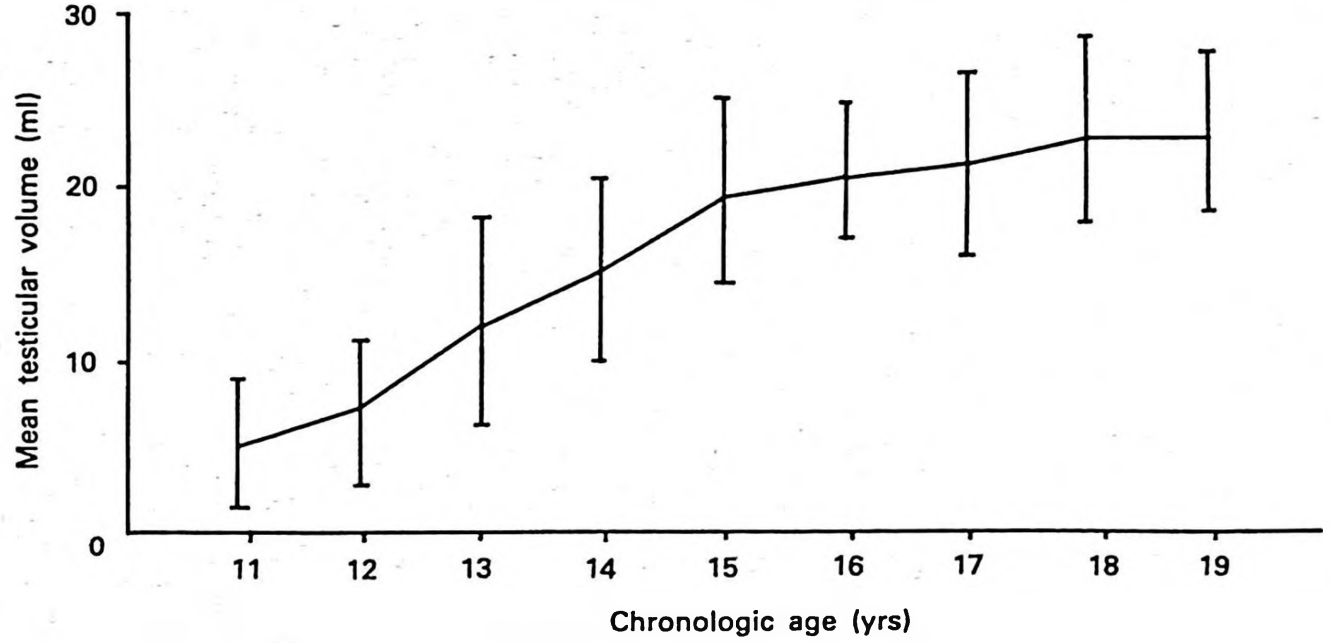
TABLE V: Skeletal Ages vs. Pubic Hair Stages

Pubic Hair Stage	Hacettepe Study mean age	SD	Waaler et al's Study (1974) mean age	Difference in years between the two studies
PH 2	11.28	1.74	11.9	0.6
PH 3	12.47	2.05	13.1	0.6
PH 4	13.84	2.24	13.6	0.2
PH 5	16.41	3.00	15.5	0.9



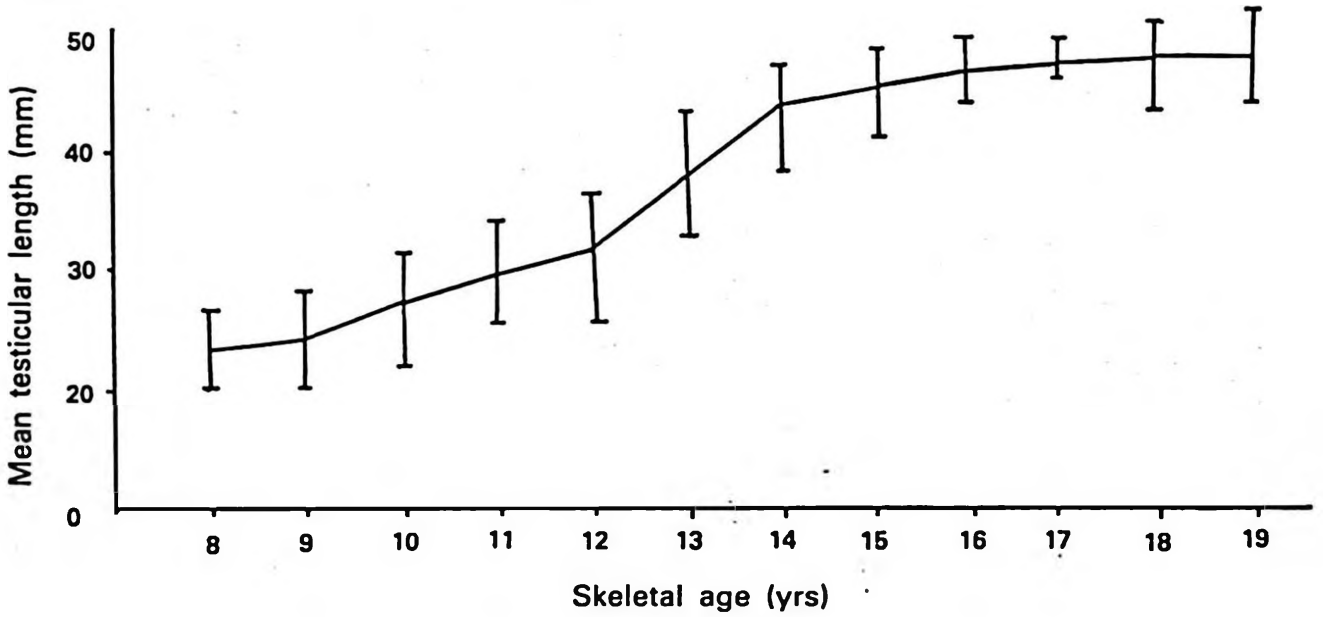
n =	157	198	180	148	86	42	26	16	26
$\bar{x}$ =	28.0	31.1	37.6	41.2	44.9	46.1	46.4	47.5	47.5
SD =	5.8	6.6	6.6	5.5	4.5	2.9	4.1	3.4	2.7

Fig. 1: Chronological age vs. Mean testicular length.



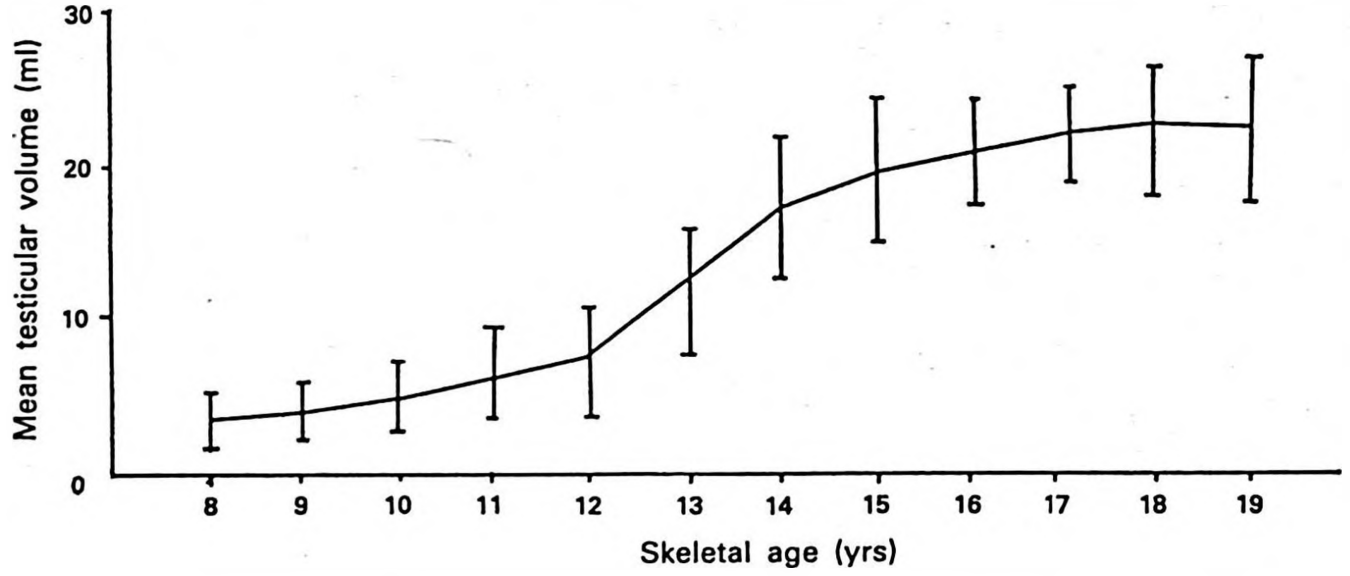
n =	157	198	180	148	86	42	26	16	26
$\bar{x}$ =	5.32	7.36	12.43	15.77	19.86	21.22	21.60	23.08	23.08
SD =	3.62	4.61	5.95	5.69	5.75	4.15	5.50	5.34	4.28

Fig. 2: Chronologic age vs. Mean testicular volume.



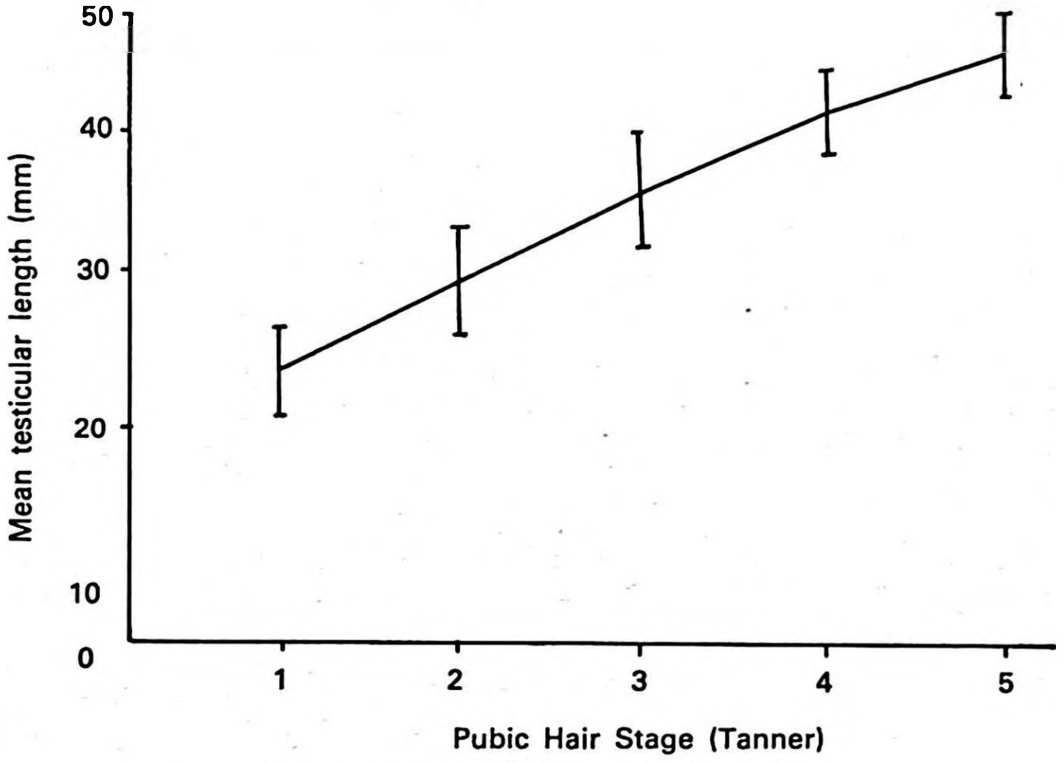
n =	16	42	92	127	89	188	142	65	21	35	48	14
$\bar{x}$ =	23.6	24.4	27.7	30.3	31.3	38.0	43.5	45.3	46.5	47.4	47.5	47.4
SD =	3.8	4.0	4.6	5.2	5.6	5.2	3.6	3.6	2.5	1.9	2.8	3.8

Fig. 3: Skeletal age vs. Mean testicular length.



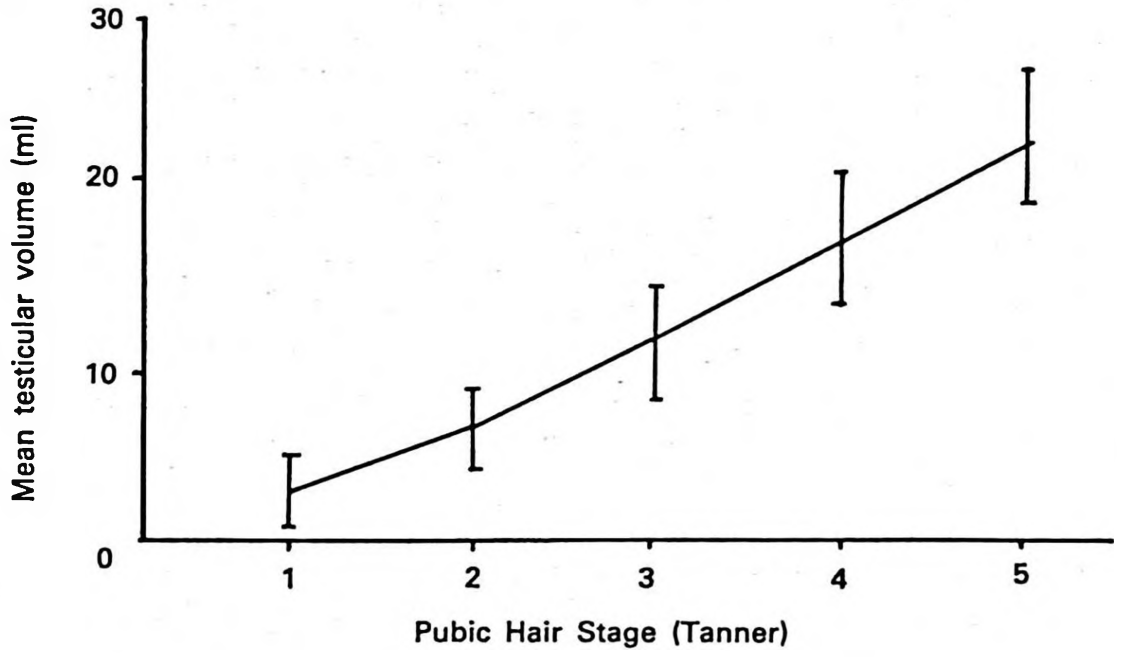
n =	16	42	92	127	89	188	142	65	21	35	48	14
$\bar{x}$ =	3.06	3.39	4.91	6.50	7.16	12.37	17.91	20.22	21.73	22.85	23.08	22.85
SD =	1.65	1.87	2.44	3.14	3.69	4.71	4.57	4.86	3.53	2.88	4.43	5.28

Fig. 4: Skeletal age vs. Mean testicular volume.



n =	133	205	169	195	177
$\bar{x}$ =	23.8	30.6	37.0	43.0	46.9
SD =	3.5	3.8	3.9	3.2	3.1

Fig. 5: Pubic Hair Stage vs. Mean testicular Length.



n =	133	205	169	195	177
$\bar{x}$ =	3.11	6.39	11.21	17.29	22.27
SD =	1.70	2.30	3.42	3.96	4.55

Fig. 6: Pubic Hair Stage vs. Mean testicular volume.

Discussion

While determining sexual maturation in adolescence, skeletal age should be mainly taken into account. Whatever the chronologic age, certain biological maturation is needed for sexual maturation to begin. Therefore, studies depending only on chronologic age seem to be insufficient in determining the stages of sexual maturation. In this study, we used both skeletal and chronologic ages with respect to genital stages. As illustrated in Tables I and II, the chronologic ages of the school boys ranged between 11-19 years while the skeletal ages ranged between 8-19 years.

Since no studies have been reported in the Turkish literature regarding the relationship of chronologic and skeletal ages, testes dimensions or volumes and pubic hair stages, we compared our results with the foreign literature. Table IV shows the comparision of our results with the results of the studies performed by others[2,6]. As illustrated in Table IV, in our study group the onset of adolescence was recorded as (PH 2), 0.7 and 1.4 years earlier than Waaler et al's[6] and Marshall and Tanner's[2] study groups, respectively. The difference between our group and Marshall and Tanner's[2] group was statistically significant (t: 9.33, $p < 0.001$). Our results could not be compared statistically with Waaler et al's[6] because the number of adolescents in Waaler's group was very small and no SD values could be obtained. As far as PH 3 is concerned, it is seen that the chronologic ages of our group were 0.5 and 1.0 years less with respect to the other two studies and the difference is statistically significant between our group and Marshall and Tanner's[2] group (t: 5.08, $p < 0.001$). The adolescents in our study group reached PH 4, 0.3 and 0.6 years earlier than the adolescents in the other two groups. No statistical difference could be established in the PH 4 phase. The mean age of the adolescents in PH 5 in our study group was 0.8 years greater than the adolescents in Marshall and Tanner's[2] group which was found to be statistically significant (t: 3.03, $p < 0.01$). The time interval between PH 2 to PH 3 and PH 3 to PH 4 is approximately 0.9 years in our study, more than 0.2-0.4 years with respect to the other two studies, and the time interval between PH 4 to PH 5 is approximately 2.2 years in our study, and more than 0.7-1.4 years with respect to the other two studies. These results may be explained by racial differences and genetic and environmental factors between the subjects of the three study groups.

The skeletal ages and the relationship between the pubic hair stages of the studies of the Hacettepe group and that of Waaler et al[6] are shown in Table V. With respect to skeletal age, pubic hair growth began in our study group 0.6 years before Waaler et al's[6] group. The time interval between PH 4 and PH 5 in our study group was 0.7 years more than Waaler et al's[6] group. Since the number of adolescents in Waaler et al's[6] group was small and no SD values could be

obtained, no statistical analysis could be made between the two groups. The differences between the two groups may again be explained as being a function of racial differences, and genetic and environmental factors of the two different countries. Since no data from Turkey could be obtained, we did not have the opportunity to compare our results with other Turkish studies.

Testicular enlargement is the first sign of pubertal development in boys. Several methods of measuring testicular volume have been described[3-5,7]. High concordance of testicular volume is obtained with an orchidometer and with measurements by caliper, calculating volume according to the formula: 0.52xlong diameter x (0.64xlong diameter)^2. The testicular length and volume of preadolescent boys are relatively constant until pubescence and known to be less than 3 cm and 4 ml respectively[7,8,14-16]. In genital Stage 1, the mean testicular volume in our study group was found to be 3.11 ± 1.70 ml while Zachman et al[7] found it to be 6.0 ± 2.6 ml and Daniel et al[3] 4.98 ± 3.31 ml in their studies. These differences may be explained by measurements of the testes in these studies at the end of Stage 1 while entering Stage 2 in the absence of pubic hair. In the same study by Zachman et al[7], the mean testicular volume in Stage 1 was found to be 2.5 ± 1.7 ml, while the mean testicular volume in Stage 2 was 3.4 ± 2.3 ml in the 30 boys that were longitudinally followed up. In our study, since the mean length of the long diameters of the testes ≥ 24 mm in the absence of pubic hair is accepted as Stage 2 the difference between our study and the others seems to be explained. The largest volume increase was observed between pubic hair Stages 2 and 3 in Zachman et al's[7] group, while in our study it was observed between pubic hair Stages 3 and 4. According to our data, in pubic hair Stage 5, the mean testicular volume recorded was 22.27 ± 4.55 ml while in Zachman et al's[7] study it was 16.3 ± 4.6 ml. Testicular volumes with respect to pubic hair stages, and testicular volumes with respect to chronologic and skeletal ages were also greater in our study group than the estimates of Zachman et al[7]. These differences could be explained by different conditions effecting the sexual maturity of adolescents in Turkish and Swiss boys.

We investigated some parameters used in determining the sexual maturity of boys. We believe that more cross-sectional and longitudinal studies should be performed in order to obtain standards in determining the sexual maturity of Turkish adolescent boys.

Summary

879 male adolescents between 11-19 years of age were investigated with respect to testicular length, testicular volume, pubic hair stages, and chronologic and skeletal ages. In pubic hair Stage 1, the mean testicular volume was found to be 3.11 ± 1.70 ml and the largest testicular volume increase was observed between

pubic hair Stages 3 and 4. In pubic hair Stage 5, the mean testicular volume was 22.27 ± 4.55 ml. Pubic hair became visible at a mean chronologic age of 12.04 ± 1.74 and a mean skeletal age of 11.28 ± 1.74. The subjects reached PH 5 at a mean chronologic age of 15.97 ± 3.15 and a mean skeletal age of 16.41 ± 3.00. Our results were compared with those in the literature.

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