

## Pubertal Development of Turkish Children\*

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### ABSTRACT

**Aim:** To investigate the pubertal development of Turkish school children, to look for possible secular trends in pubertal development.

**Methods:** 1,562 girls and 1,749 boys (aged 6-16.5 years) from urban and rural schools were studied. Weight and height were measured and body mass index was calculated. Pubertal stages were assessed according to Tanner. Testicular volume was determined using an orchidometer. Menarcheal age was recorded.

**Results:** In girls, mean ages at breast stage (B) were  $7.74 \pm 1.08$  years for B1,  $10.16 \pm 0.97$  for B2,  $11.72 \pm 1.29$  for B3,  $12.97 \pm 1.17$  for B4, and  $13.66 \pm 0.89$  for B5. Mean ages at pubic hair stage (PH) were  $8.72 \pm 1.50$  years for PH1,  $10.57 \pm 1.39$  for PH2,  $12.12 \pm 1.10$  for PH3,  $13.10 \pm 1.04$  for PH4, and  $13.87 \pm 0.83$  for PH5. Mean age at menarche was 12.41 years. Menarcheal age was earlier in overweight and obese children compared with that in normal children. In boys, mean ages at each maturity stage according to testis volume (G) were  $8.70 \pm 1.38$  years for G1,  $11.76 \pm 1.28$  for G2,  $12.81 \pm 1.0$  for G3,  $13.17 \pm 0.87$  for G4, and  $13.87 \pm 0.98$  for G5. Mean ages at PH in boys were  $9.39 \pm 1.81$  years for PH1,  $12.02 \pm 1.33$  for PH2,  $13.05 \pm 0.88$  for PH3,  $13.42 \pm 0.87$  for PH4, and  $14.02 \pm 0.92$  for PH5.

**Conclusions:** The current study provides an up-to-date reference of normal sexual maturation of Turkish children. While the mean age at onset of puberty in boys was comparable to that of other populations in the world, girls were found

to start pubertal development earlier than in other populations.

### KEY WORDS

onset of puberty, pubertal stages, menarche, secular trend, Turkey

### INTRODUCTION

Assessment of the onset and progression of sexual maturation are important in pediatrics because this information has immediate clinical application in the interpretation of endocrine and growth status<sup>1</sup>. There is a wide variation in the age of normal onset and there are many conditions which may affect this normal process. Genetic factors, nutritional status and ethnicity seem to play a role for timing and progression of puberty<sup>2</sup>. In addition, secular trends appear to influence the physiological range of pubertal onset<sup>3</sup>. There are data suggesting that stage 2 of breast and pubic hair development is being achieved approximately one year earlier in White American girls and two years earlier in African-American girls than previous studies have shown<sup>4</sup>. The Pediatric Research in Office Settings (PROS) study involved over 17,000 girls between 3 and 12 years of age. At age 7 years, 27% of African-American girls, and at age 6 years, 7% of White girls showed breast or pubic hair development. New American guidelines thus proposed that girls with either breast or pubic hair development should be evaluated if this occurs before the age of 7 years in White girls and before 6 years in African-American girls<sup>5</sup>. During the past

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century, an earlier start of puberty has been observed in most European countries, though during the past few decades this effect has slowed or even halted, as shown by recent data from The Netherlands<sup>6,7</sup>.

The age of menarche in industrialized European countries and in the United States has fallen 2-3 months per decade over the past 100-150 years<sup>8</sup>. The age of onset and completion of puberty in boys is less well defined and documented than the age of menarche in girls. Overall, there has been little change with respect to the timing of onset of puberty in boys<sup>7,9</sup>.

In clinical practice, assessment of pubertal stages in the individual child is extremely useful, but should at all times be related to updated and reliable reference data from same background population. If the age at onset of puberty is indeed decreased, the definitions of precocious and delayed puberty should be adjusted. Thus, it is important to define the normal process of sexual maturation for specific ethnic groups. In 1975, Neyzi *et al.*<sup>10,11</sup> reported age of menarche in girls and ages of pubertal onset in boys and girls living in Istanbul. There has not been any major population study of pubertal development in boys and girls in our country in recent years.

In this study, we investigated the pubertal development of Turkish children, in order to look for possible secular trends in pubertal development.

## CHILDREN AND METHODS

A cross-sectional school-based study was performed between March and May 2005. The study included school children who were in grades 1 to 8 of primary schools in Denizli province. The target population of the survey was all 116,229 children attending primary schools.

Denizli is located in the west region of Turkey and is the second principal city in the Aegean part of Turkey. The population of Denizli was 850,029 in 2000. During 1980-2000, the population employed in industry, services, construction, and agricultural sectors increased by 119%, 84.2%, 42.7%, and 32.9%, respectively. Per capita gross national product was US\$ 2807 in 2000.

A multistage stratified clustered sampling design

was employed. It has been hypothesized that the age of pubertal onset might occur 1 year earlier considering the secular trend. The age of pubertal onset was predicted as  $9 \pm 0.5$  years in girls and  $10.5 \pm 0.5$  years in boys. Using the formula below, clustered sample was calculated and it was decided to attain a target number of at least 1,218 girls and 1,648 boys:

$$n = \frac{N (t_{1-\alpha})^2 \times (x)^2}{S^2 (N - 1) + (t_{1-\alpha})^2 (x)^2}$$

All urban and rural regions of Denizli were included in the study. Primary schools were randomly selected. Subsequently, one class from every eligible grade from each school was randomly selected and all students from the selected classes were included in the sample. A total number of 3,311 children (1,562 girls and 1,749 boys) aged 6-16.5 years from both urban and rural schools participated in this study.

Before initiation of the study, a detailed explanation was given to all teachers, participants and their parents. Approval of the local authorities was obtained. Informed consent was obtained from parents. Weight and height were measured and body mass index (BMI) calculated. Body weight was measured to the nearest 0.1 kg with a balance scale (Baurer, PS 07), and height was measured to the nearest 0.1 cm with a stadiometer (Hysna Limfog, AB), with participants lightly dressed and without shoes. BMI was calculated as weight (kg) divided by height squared ( $m^2$ ). The degree of obesity was quantified using the reference data of Cole *et al.*<sup>12</sup>. Pubertal stages were assessed by clinical examination according to the methods of Marshall and Tanner<sup>13,14</sup>. Breast stages (B1-5) in girls, genital stages (G1-5) in boys, and pubic hair (PH1-5) in both sexes were assessed. To increase the reliability of visual assessment of B2, it was evaluated by both inspection and palpation. When two breasts of an individual were not in the same stage of development, the stage of the more advanced side was recorded. The stage of genital development (G) in boys was based on direct palpation measurement of testicular volume (TV), which is usually considered to be an important indicator in the assessment of pubertal develop-

ment, rather than on inspection of changes in scrotal skin and enlargement of the testes<sup>15</sup>. Not to cause cremaster reflex, testis examination was done while the boy was standing and at appropriate room temperature. TV was determined using a Prader orchidometer<sup>16</sup>. This orchidometer consists of 12 models of rotation ellipsoids with volumes of 1, 2, 3, 4, 5, 6, 8, 10, 12, 15, 20, and 25 ml. The registered volume was the volume of rotation ellipsoid palpated to the nearest volume to that of the testis examined. If the two testes were not identical, the larger was chosen to determine TV. A testis volume of 1-3 ml was assessed as G1, 4-9 ml as G2, 10-14 ml as G3, 15-20 ml as G4, and greater than 21 ml as G5<sup>16,17</sup>. Fourteen boys did not allow measurement of testis volume; thus, TV was measured in 1,735 boys. The onset of puberty was recorded as the age of breast development at Tanner stage 2 (B2, appearance of a breast bud) for females and at TV equal to 4 ml for males<sup>8,16</sup>. The age at menarche was determined by asking each girl when she had had her first menstrual period. Menarcheal age was recorded.

The measurements of height and weight and examination of puberty were performed by trained staff. Breast and pubic hair development for each girl were assessed by one female pediatrician; genital and pubic hair development for each boy was assessed by one male pediatrician. To validate the accuracy of the examination of puberty, pubertal staging in 50 students was done by two observers. One of the observers was a pediatric endocrinologist. Inter-observer differences were tested using kappa analysis. In girls, kappa statistics were 0.902 for pubic hair stage and 0.806 for breast development. In boys, kappa statistics were 1.000 for pubic hair stage and 0.953 for genital development.

### Statistical analysis

SPSS for Windows version 13.0 was used for analyses. Data were used to calculate means, standard deviations (SD), median, ranges and percentiles of ages for sexual development in girls and boys. One-way ANOVA was used to compare the relationship between the mean age for menarche and weight status.

## RESULTS

Means, SD, ranges and percentiles of ages for sexual development in girls (B and PH stages) are shown in Tables 1 and 2. Percentile values for breast development and pubic hair stages in girls reached at the different ages are shown in Figure 1 A and B. The mean age for the onset of breast development was 10.16 years and the mean age for the onset of pubic hair development was 10.57 years for girls.

Table 3 shows the percentage of girls in each stage of pubic hair development when they reached each breast stage. 77.5% of the girls who reached B2 had no pubic hair development; 21.2% were in PH2, 1.2% were in PH3, and none in PH4 or PH5. 1.9% of the girls who reached PH2 stage had no breast development.

The mean age at menarche was  $12.41 \pm 0.92$  (9-15) years. Menarcheal age was significantly lower in girls with BMI above the median compared with girls with BMI below the median (12.11 vs 12.53 years,  $p < 0.0001$ ).

Means, SD, ranges and percentiles of ages for sexual development in boys (G and PH stages) are shown in Tables 4 and 5. Percentile values for genital and pubic hair stages in boys reached at the different ages are shown in Figure 1 C and D. The mean age for the onset of puberty according to genital stage was 11.76 years and the mean age for the onset of pubic hair development was 12.02 years for boys.

Table 6 shows the percentage of boys in each stage of pubic hair development when they reached each genital stage. 66.9% of the boys who reached G2 had no pubic hair development; 25.4% were in PH2, 6.8% were in PH3, 0.9% in PH4, and none in PH5. 1.9% of the boys who reached PH2 had no genital development.

Percentile values for TV reached at different ages are shown in Figure 2.

## DISCUSSION

To obtain normal reference data for pubertal development in a given population is extremely important. In order to assess any child who may have precocious or delayed pubertal development,

**TABLE 1**  
Mean age and percentile (p) values for breast development stages in girls

	Mean age (yr)	SD	Min	Max	3p	10p	25p	50p	75p	90p	97p	Mod	n (%)
<b>B1</b>	7.74	1.08	6.05	11.48	6.36	6.63	6.93	7.54	8.38	9.33	10.25	7.76	209 (13.4%)
<b>B2</b>	10.16	0.97	5.98	14.16	6.74	7.19	7.94	9.93	10.18	11.10	11.95	10.00	659 (42.2%)
<b>B3</b>	11.72	1.29	8.07	15.30	9.32	10.04	10.89	11.80	12.71	13.33	14.06	12.44	415 (26.5%)
<b>B4</b>	12.97	1.17	9.90	16.31	10.31	11.37	12.28	12.98	13.90	14.51	15.10	12.82	96 (6.1%)
<b>B5</b>	13.66	0.89	10.86	16.51	11.75	12.39	13.15	13.82	14.28	14.68	15.35	14.32	183 (11.7%)

**TABLE 2**  
Mean age and percentile (p) values for pubic hair stages in girls

	Mean age (yr)	SD	Min	Max	3p	10p	25p	50p	75p	90p	97p	Mod	n (%)
<b>PH1</b>	8.72	1.51	5.98	13.63	6.56	6.86	7.51	8.67	9.84	11.79	11.79	7.78	794 (50.8%)
<b>PH2</b>	10.57	1.39	6.92	14.16	7.79	8.55	9.81	10.72	11.42	12.36	13.16	10.58	261 (16.7%)
<b>PH3</b>	12.12	1.11	9.88	15.07	10.06	10.52	11.39	12.09	12.86	13.56	14.17	12.44	169 (10.8%)
<b>PH4</b>	13.10	1.04	9.36	16.31	11.11	11.86	12.41	13.16	13.84	14.32	14.98	11.72	237 (15.2%)
<b>PH5</b>	13.87	0.83	11.49	16.51	12.09	12.91	13.38	14.04	14.31	14.88	15.38	14.19	101 (6.5%)

TABLE 3

Percentage of girls in each stage of breast development on reaching each stage of pubic hair development

	PH1	PH2	PH3	PH4	PH5	n
<b>B1</b>	205 (98.1%)	4 (1.9%)				209
<b>B2</b>	511 (77.5%)	140 (21.2%)	8 (1.2%)			659
<b>B3</b>	77 (18.6%)	112 (27.0%)	134 (32.3%)	87 (21.0%)	5 (1.2%)	415
<b>B4</b>	1 (1.0%)	5 (5.2%)	25 (26.0%)	59 (61.5%)	6 (6.3%)	96
<b>B5</b>			2 (1.1%)	91 (49.7%)	90 (49.2%)	183
<b>n (%)</b>	794 (50.8%)	261 (16.7%)	169 (10.8%)	237 (15.2%)	101 (6.5%)	1,562

TABLE 4

Mean age and percentile (p) values for genital development stages in boys

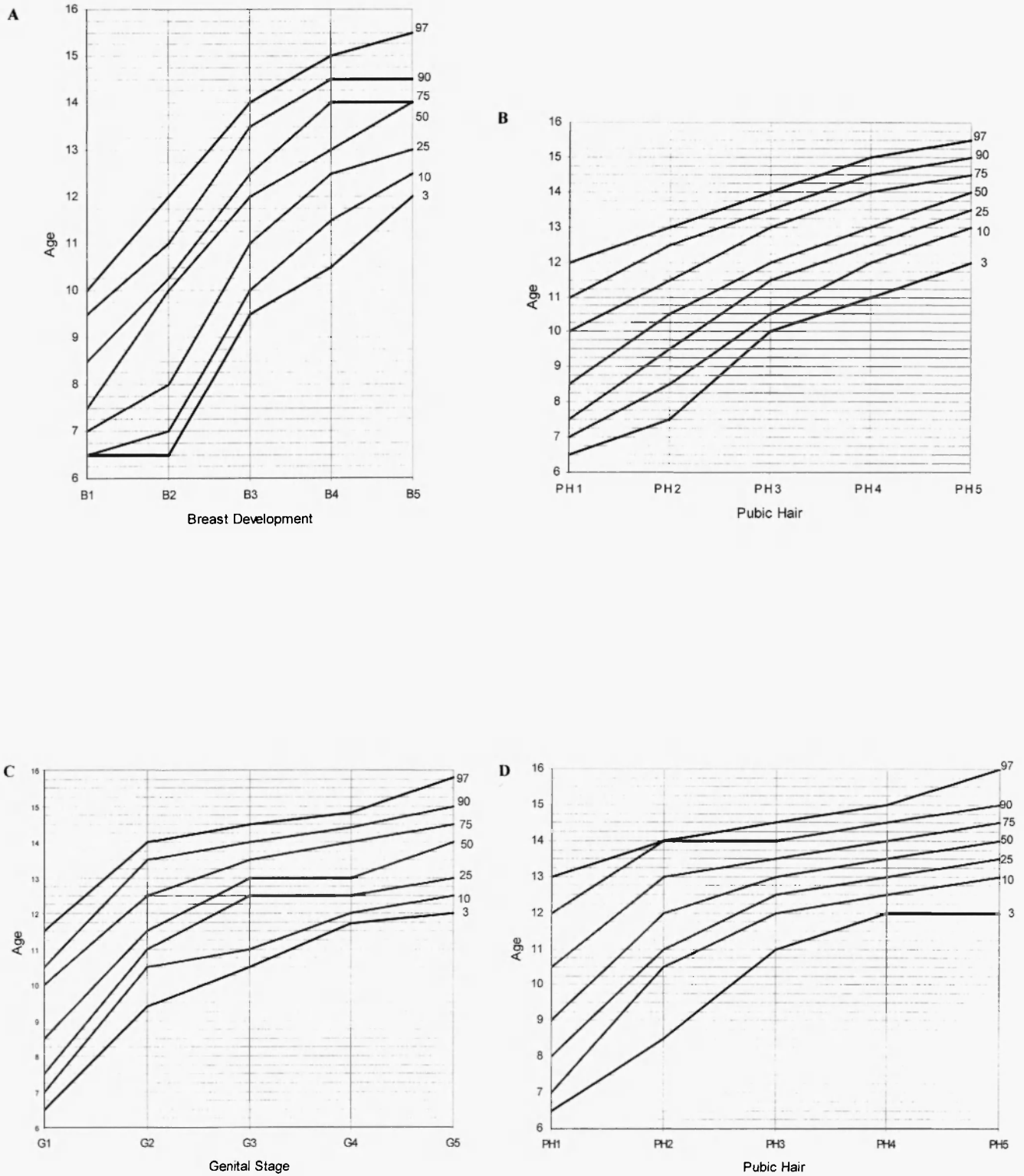
	Mean age (yr)	SD	Min	Max	3p	10p	25p	50p	75p	90p	97p	Mod	n (%)
<b>G1</b>	8.70	1.38	5.58	14.19	6.65	6.99	7.61	8.61	9.79	10.66	11.28	9.32	884 (50.5%)
<b>G2</b>	11.76	1.28	6.97	15.33	9.34	10.31	10.99	11.80	12.63	13.60	14.17	11.16	429 (24.5%)
<b>G3</b>	12.81	1.00	9.59	14.97	10.72	11.36	12.33	12.90	13.56	14.02	14.32	12.74	124 (7.1%)
<b>G4</b>	13.17	0.87	11.41	15.99	11.64	12.04	12.58	13.12	13.94	14.35	14.99	13.01	80 (4.6%)
<b>G5</b>	13.97	0.98	11.56	16.51	12.03	12.61	13.25	13.99	14.49	15.16	15.85	13.69	218 (12.5%)

**TABLE 5**  
Mean age and percentile (p) values for pubic hair stages in boys

	Mean age (yr)	SD	Min	Max	3p	10p	25p	50p	75p	90p	97p	Mod	n (%)
<b>PH1</b>	9.39	1.81	5.58	16.51	6.69	7.14	7.93	9.26	10.77	12.01	12.98	9.32	1,180 (67.5%)
<b>PH2</b>	12.02	1.33	7.34	14.56	8.77	10.47	11.24	12.11	13.05	13.85	14.24	11.63	169 (9.7%)
<b>PH3</b>	13.05	0.88	10.34	15.21	11.10	12.01	12.53	13.18	13.79	14.06	14.53	12.74	113 (6.5%)
<b>PH4</b>	13.42	0.87	11.41	15.33	11.82	12.26	12.74	13.43	14.12	14.52	15.19	13.03	125 (7.1%)
<b>PH5</b>	14.02	0.92	11.86	16.27	12.23	12.84	13.41	14.11	14.58	15.25	16.01	13.94	162 (9.3%)

**TABLE 6**  
Percentage of boys in each stage of genital development on reaching each stage of pubic hair development

	PH1	PH2	PH3	PH4	PH5	n
<b>G1</b>	867 (98.1%)	17 (1.9%)	–	–	–	884
<b>G2</b>	287 (66.9%)	109 (25.4%)	29 (6.8%)	4 (0.9%)	–	429
<b>G3</b>	12 (9.7%)	34 (27.4%)	47 (37.9%)	30 (24.2%)	1 (0.8%)	124
<b>G4</b>	2 (2.5%)	7 (8.8%)	26 (32.5%)	39 (48.8%)	6 (7.5%)	80
<b>G5</b>	1 (0.5%)	2 (0.9%)	10 (4.6%)	51 (23.4%)	154 (70.6%)	218
<b>n (%)</b>	1169 (67.4%)	168 (9.7%)	113 (6.5%)	124 (7.1%)	161 (9.3%)	1,735



**Fig. 1:** A. Percentile values for breast development stages in girls. B. Percentile values for pubic hair stages in girls. C. Percentile values for genital stages in boys. D. Percentile values for pubic hair stages in boys.

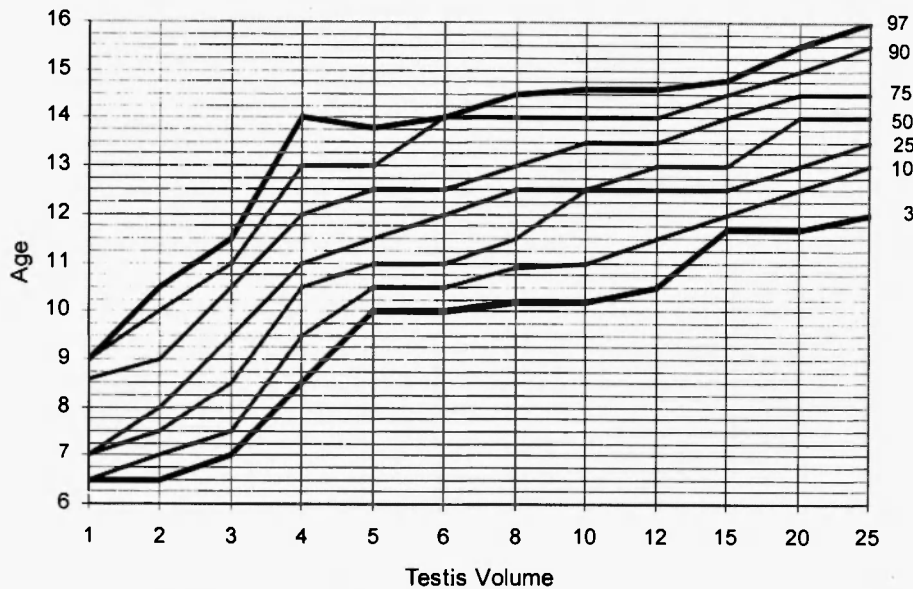


Fig. 2: Percentile values for testicular volume in boys.

accurate normal reference data are required. There has not been any major population study of pubertal development for Turkish children in recent years. We present here data on pubertal development in 1,562 girls and 1,749 boys living in Denizli in Turkey.

We found a mean age at B2 of 10.16 years. Our mean age of pubertal onset in girls was lower than that reported in studies on puberty from other European studies. Age at B2 was estimated to be 10.7 years in The Netherlands in 1997, 10.81 years in East Germany in 1985, 10.8 years in Sweden in 1980, 11.1 years in the UK in 1969, 10.9 years in Switzerland in 1954-1980, and 10.88 years in Denmark in 2006<sup>7,18-21</sup>. A recent study from central Italy found a slightly lower age at B2 (10.3 years) compared with other European countries<sup>22</sup>. Much earlier sexual maturation in American girls was evident from two recent epidemiological studies (PROS and NHANES III) showing ethnic differences<sup>4,23</sup>. In the PROS study, the occurrence of B2 was 8.87 years in African-American girls and 9.96 years in White girls<sup>4</sup>. In the NHANES III study, age at B2 was 9.48 years in African-American girls and 10.38 years in White girls<sup>23</sup>. In the present study, pubertal onset in girls was seen

earlier than that in most European girls, but in accordance with that in White American girls.

In their study performed in Istanbul in 1975, Neyzi *et al.*<sup>11</sup> found a mean B2 age of 9.8 years in a group of children who represent high socio-economic status. Akarsu *et al.*<sup>24</sup> reported mean B2 age as 11.4 years in a study they performed in 498 healthy female children living in the Eastern part of Turkey. Many studies address the age of menarche as a marker for the timing of puberty. It is well known and a worldwide phenomenon that there is a difference between urban and rural regions in menarcheal age, with the urban girls undergoing menarche earlier than rural girls<sup>6</sup>. Mean menarcheal age was reported as 13.5 years in England in 1969, 13.4 years in Switzerland in 1983, 13.3 years in German girls, 12.9 years in Turkish girls living in Germany in 1984, 12.27 years in Greece in 1999, 12.44 years in Egypt in 2005, 13.42 years in Denmark in 2005, and 12.6 years in Italy in 2004<sup>14,20-22,25-27</sup>. In the United States, the mean age of menarche in the studies reviewed varied between 12.2 and 13.3 years; the differences are most likely to be caused by racial proportions in the study populations<sup>28</sup>. Many studies have found an inverse relationship between menarcheal age and



BMI or other reflections of obesity<sup>29</sup>. What seems clear from almost all observers is that African-American girls have earlier menarche than White girls, and this gap might be widening, in particular, because of increasing differences in BMI<sup>29</sup>. We found a mean menarcheal age of 12.41 years in the present study. Similar to other most studies<sup>4,6</sup>, menarcheal age in our study was earlier in overweight and obese children.

Neyzi *et al.* reported a mean menarcheal age of 12.8 years in 1975 (12.4 years for girls with high socio-economic status, 13.2 years for girls with low socio-economic status)<sup>11</sup>. It was 12.9 years in Turkish girls living in Bremen<sup>26</sup>; 12.8 years in Turkish girls living in The Netherlands<sup>30</sup>. The mean menarcheal age was 13.0 years in girls living in the Eastern part of Turkey<sup>24</sup>. The mean menarcheal age in the present study was lower than those reported in the studies above.

In our study, the median age of onset of pubic hair development in girls was 10.57 years. In 1975, Neyzi *et al.*<sup>11</sup> found the mean age of PH2 was 10.4 years. Although onset of breast development occurs slightly earlier, the onset of clinical signs of adrenarche is similar to that reported in other studies in Europe<sup>18-21</sup>. This study indicates that Turkish girls had earlier breast development and menarche rather than the appearance of pubic hair.

In boys, we found that the ages of G2 and PH2 were similar to those reported in other studies<sup>7,13,19,21,30-32</sup>. The mean age for G2 in the present study was 11.76 years. It was 11.6 years in England, 11.6 years in Sweden, 11.2 years in Switzerland, 11.2 years in Central Italy, 11.8 years in Denmark, 11.5 years in The Netherlands and 12.2 years in Turkish boys living in The Netherlands. The mean age at G2 was 9.2, 10.0 and 10.3 years in non-Hispanic Black boys, non-Hispanic White boys and Mexican-American boys, respectively<sup>1</sup>. The finding that NHANES III data for G2 differ from those of older studies in the US raises the suggestion that different criteria were applied in the different studies. Because the median age of PH2 was similar to data obtained over the last decades, PH probably seems more reliable to determine the onset of puberty in US boys<sup>16</sup>.

In previous studies performed in Turkey, the mean age for G2 was 11.0 years in 1975<sup>10</sup>, 11.1

years in 1988<sup>33</sup>, and 11.6 years in 1995<sup>34</sup>.

The mean age for PH2 in boys in the present study was 12.02 years, while it was 13.4 years in England, 12.7 years in Sweden, 12.2 years in Switzerland, 11.5 years in Greece, 12.4 years in Spain, and 11.8 years in Denmark<sup>13,19,21,32,35,36</sup>. The median ages for attainment of PH2 were reported as approximately 11.2 years for non-Hispanic Black boys, 12 years for non-Hispanic White boys, and 12.3 years for Mexican-American boys<sup>1</sup>. In previous studies performed in Turkey, the mean age for PH2 in boys was reported as 11.8 years<sup>10</sup>, 12.9 years<sup>33</sup>, and 12.19 years<sup>34</sup>. Our results in boys were similar to those reported from Europe and Turkey<sup>10,19,21,32,34-36</sup>.

Tanner genital staging criteria are based upon appearance only and, thus, only consider TV as it affects the appearance of scrotal fullness. It has long been recognized that testicular growth begins well before any other physical evidence of pubertal onset<sup>28</sup>. A study that used TV to determine the age of onset of puberty in boys provides useful data but cannot be directly compared with other investigations<sup>17</sup>. To be more objective in our study, TV was used to evaluate genital stages. We observed that TV during the period of pubertal development showed a skewed distribution. Pubertal testicular growth in some boys has already started by age 8 years while in others it did not start prior to 15 years.

The girls or boys were not all in the same stage of breast development or genital stage when they reached a given stage of pubic hair development. Similarly, when they reached a given breast or genital stage, they were in different stages for pubic hair<sup>13,14</sup>. However, these discrepancies were not too obvious in our study. Marshall and Tanner reported that of the girls seen on reaching PH2, 16% were in B1, 49% in B2, etc.<sup>14</sup>. In the present study, 77.5% of the girls who reached B2 had no pubic hair development and 21.2% were in PH2. PH, as a first sign of puberty, was detected at a similar rate (1.9%) in both girls and boys.

In conclusion, the current study provides an up-to-date reference of normal sexual maturation of Turkish children. The wide variation of pubertal development was confirmed in this study. The mean ages of sexual maturation for boys were

comparable to other population groups in developed countries, but the mean ages of breast development and menarche for girls were earlier than those living in most European countries.

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