

Anthropometrical indices and pubertal maturation of boys in Bulgaria

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Puberty is a maturational process that leads to ability for reproduction. There should be reference ranges for every population for pubertal progress and therefore we describe the pubertal development of Bulgarian males. 131 boys from two primary schools in Sofia were included in this longitudinal study. They were monitored from the first to the seventh class of the primary school. The testicular volumes, pubic hair stage, penile length, and penile circumference as well as height, weight, waist and hip circumferences were registered. The anthropometric and genital characteristics according to the chronological age were presented to serve as a basis for further comparisons. There is some evidence for earlier or more rapid pubertal development in Bulgaria now in comparison to 1970s. Probably, the taller and heavier boys enter the puberty earlier, however, larger studies are necessary to confirm or reject this hypothesis.

Key words: puberty, boys, height, testicular volume, weight.

Introduction

Puberty is a time of immense developmental change. From the early work of Marshall and Tanner is known that the process occurs in a predictable sequence of events in both girls and boys. The first sign of puberty in boys is testicular enlargement, which is followed by pubic hair development, changing of the scrotum, penile growth, linear growth spurt [9]. The differences in the age of sexual maturation between populations are largely due to the different socio-economic conditions, as well as genetic factors. Consequently, each ethnic group has to construct its own normative data [4].

Therefore, we present the results of a longitudinal study on the pubertal development of Bulgarian boys. They show the pubertal progression and the corresponding anthropometrical indices.

Material and Methods

In the study were included 131 boys from two schools in Sofia chosen at random. The children were examined every consecutive year from 1993 to 2000. The signs of pubertal development (testicular volumes, pubic hair, penile length, penile circumference) and anthropometric indices /height, weight, waist circumference, hip circumference and body mass index (BMI)/ were determined. For technical reasons, in 1996 only the anthropometric values were described. At the beginning of the study 9 of the children were 6 years old, 112 were 7 years old, 9 were 8 years old and one was 9 years old. Some of the boys were monitored for a period shorter than 7 years, because of transfer to another school, disease or refusal of examination. The pubertal development of all boys was estimated by only one experienced investigator (Philip Kumanov) in order to avoid the inter-observational error. The anthropometrical indices were measured at the same time by well-trained team from the Institute of Experimental Morphology and Anthropology by the Bulgarian Academy of Sciences, Sofia. The study was approved by the Bulgarian Ministry of Education and Science. Statistical analysis was conducted with SPSS v. 11.0 (Chicago, IL, USA). Descriptive statistics and frequency analysis were used. Differences in the anthropometric indices were established through independent sample t-test or Mann—Whitney test after a Kolmogorov—Smirnov test for the normality of distribution. The data were shown as means and standard deviations.

Results and Discussion

Our data describing the pubertal development and the corresponding changes in the anthropometrical indices are shown on the Table 1. Rapid growth of the testes occurred between 11 and 14 years of age. The increase in the penile length and circumference was more gradually. These results supported completely the conclusions of our previous cross-sectional study of 6200 Bulgarian males between 0 and 19 years of age [17].

One of the most important questions discussed in the literature is whether secular trends in male pubertal development still exist. Therefore, we tried to compare our data to those of previous studies. An investigation of 3254 boys from the region of Blagoevgrad was conducted in the 1970s [16]. The results showed more rapid progress in the testicular volumes and a greater increase in the penile length in the current study in comparison to previous study (Fig. 1). However, data from another transversal study of 6207 boys from the region of Pleven, published at the same time (1980), leads to the conclusion that pubertal events start nowadays at similar age as before [15]. According to our study, volume of the right testis exceeded 2 ml at 11.50 ± 1.03 years, while the corresponding age for the left testis was 11.63 ± 1.05 years. Pubic hair reached stage 2 soon after the testicular enlargement at the mean age of $11.76 \text{ years} \pm 1.24$. According to the study of Stanchev and Stanimirova [15], the puberty began at 11.50 ± 1.44 years with the development of the genital stage 2, while the pubic hair stage 2 occurred at 11.61 ± 1.55 years which is very close to our results.

The comparison between these three studies could not lead to definitive conclusions, because of some serious limitations. First of all, the two previous studies were cross-sectional, while we examined the boys longitudinally. The three studies were conducted in Pleven, Blagoevgrad and Sofia respectively, and thus the interregional differences as well as inter-observer errors could not be excluded. The other bias

Table 1. The anthropometrical and pubertal characteristics of the investigated boys.

	7 years	8 years	9 years	10 years
VRT	1.26±0.49	1.25±0.48	1.77±1.05	
VLT	1.26±0.47	1.22±0.46	1.67±0.98	
PH	1.01±0.10	1.02±0.20	1.11±0.44	
PL	4.89±0.65	5.12±0.67	5.19±0.67	
PC	5.66±0.50	5.87±0.49	5.87±0.51	
Height	125.90±5.35	131.55±5.68	136.60±6.14	141.75±6.51
Weight	25.82±4.25	28.41±4.98	32.62±6.15	35.41±7.34
BMI	16.22±1.90	16.36±2.03	17.39±2.45	17.51±2.70
WC	54.55±4.72	56.29±5.05	58.33±5.61	60.06±6.22
HC	57.49±5.10	59.73±5.36	62.86±6.51	64.86±7.59
	11 years	12 years	13 years	14 years
VRT	3.09±2.07	5.70±3.73	10.24±5.19	11.20±4.89
VLT	2.97±2.09	5.13±3.47	9.60±5.34	10.14±4.20
PH	1.45±0.70	2.08±1.02	3.40±1.32	3.39±1.33
PL	5.41±0.88	5.54±1.41	6.72±1.77	7.79±1.58
PC	6.29±0.85	6.80±1.30	8.32±1.50	8.60±1.35
Height	147.00±6.68	152.40±7.32	158.57±8.29	163.60±8.88
Weight	39.36±7.69	43.66±8.80	48.00±10.10	52.82±10.64
BMI	18.10±2.71	18.68±2.84	18.97±3.11	19.63±3.13
WC	62.07±6.64	63.70±6.44	66.28±6.67	67.97±6.52
HC	66.55±7.42	69.63±7.94	73.26±7.61	74.69±7.43

VRT — right testis volume; VLT — left testis volume;
 PH — pubic hair stage according to Tanner;
 PL — penile length; PC — penile circumference;
 WC — waist circumference; HC — hip circumference.

could result from the different age of the boys. We examined children mostly aged between 7 and 14 years, while in the 2 previous studies were included boys from 7 to 18-20 years and late pubertal events were also registered. Consequently, some data suggests earlier or more rapid pubertal development in Bulgaria now in comparison to the 1970s but solid ground for this definitive conclusion is lacking. Our results about the pubertal onset in Bulgaria were close to those in other Balkan countries like Greece and Turkey, where earlier pubertal maturation was not demonstrated [3, 10, 11].

Stanchev and Stanimirova [15] mentioned in their paper that almost every table that represented mean anthropometric indices was based on the chronological age. However, the mean anthropometrical characteristics varied significantly in boys at the same chronological age, but in different pubertal stages. Among 12 years old boys the authors described children from pubertal stages I to IV and the difference in their mean height was 16,63 cm. With the progression of puberty this difference

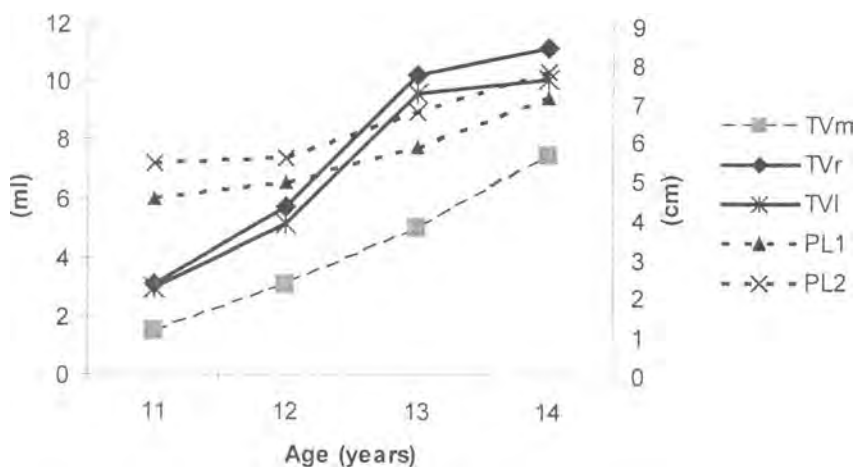


Fig. 1. Comparison between the data from our longitudinal study and from the previous study [16]. TVm — Mean testicular volume, 1970s; TVr — right testicular volume and TVl — left testicular volume in the present study; PL1 — penile length, 1970s; PL2 — penile length in the present study

decreased and in the 17 years old boys it was only 1,03 cm [15]. Similarly in our study, pubic hair stages from I to IV were observed in 12 years old boys and the difference in the mean height between them was 12.73 cm. Consequently, the pubertal progression should be considered by the evaluation of the physical development in adolescent boys.

One of the most interesting unsolved problems in the literature is if the height, weight and BMI have any influence on the pubertal development in males. The recent secular trends in pubertal maturation especially in girls seem to coincide with the increasing prevalence of overweight and obesity and have raised considerable discussion as to whether the early maturation is due to the obesity epidemic [2]. According to He and Karlberg, a higher BMI gain in childhood is related to an earlier onset of puberty in both sexes [5]. However, according to Lee et al. [8], boys in the highest BMI trajectory (mean BMI z score at age of 11.5 years, +1.84) had a greater relative risk of being prepubertal compared with boys in the lowest BMI trajectory (mean BMI z score at age 11.5 years, -0.76). The authors suggest that the relationship between body fat and timing of pubertal onset is not the same in boys as it is in girls [8]. Besides the contradictory results it should be mentioned also that some longitudinal studies used only anthropometrical data like the onset of pubertal growth spurt and the peak height velocity to establish the onset and the progress of puberty [2, 5]. Obviously, it would be better to make conclusions considering not only the height and weight of the children, but also testicular volumes or pubic hair stages.

Therefore, we decided to compare the boys that had testicular volume 3 ml or more at the age of 12 years (earlier maturing boys, group A) to those that did not enter puberty and respectively did not show any testicular enlargement at the same (12 years) age (later maturing boys, group B). As expected, the children in puberty were higher and heavier than those which did not enter puberty at the age of 12 (Table 2).

Table 2. Differences in the anthropometrical indices at the ages of 7 and 12 years in earlier maturing boys (right or left testis 3 ml or more at the age of 12) and later maturing boys (no testicular enlargement at the age of 12 years)

7 years old boys	Height*	Weight*	BMI
Earlier maturing	126.39±5.07 cm	26.04±3.73 kg	16.25±1.70 (kg/m ²)
Later maturing	123.02±6.32 cm	23.72±3.08 kg	15.63±1.18 (kg/m ²)
12 years old boys	Height**	Weight**	BMI*
Earlier maturing	154.27±6.74 cm	45.51±8.42 kg	19.05±2.86 (kg/m ²)
Later maturing	146.58±7.33 cm	37.39±7.06 kg	17.32±2.25 (kg/m ²)

* — $p < 0.05$; ** — $p < 0.001$.

However, it was more important to find if the earlier maturing boys were more obese in their childhood in comparison to the others. Therefore, we compared the height, weight and BMI of the earlier maturing boys (group A) at the age of 7 years to the same indices in the later maturing children (group B) (Table 2). The results showed that in their childhood the earlier maturing boys were at the same time taller and heavier than the later maturing boys. Probably, because of the unidirectional distinctions in the height and weight of the children, the difference in the BMI did not reach statistical significance. Thus, we could speculate that the taller and heavier but not more obese boys enter the puberty earlier. However, we think that the number of investigated children is small for making definitive conclusions.

Laron [7] investigated also the relationships between the obesity and the sexual maturation in males. He found that at all ages, the obese boys were taller and their bone age was more advanced than the controls up to age 14. However, there was no difference between the two male groups in the time of appearance and development of axillary or pubic hair, moustache, beard, acne or breaking of the voice, testicular volume, and penile size. The mean overall pubertal score and age of first ejaculation were also similar [7]. On the other hand, a study in Spain established a significant positive correlation between the age of the pubertal onset and BMI in boys, indicating a tendency towards higher BMI at pubertal onset when onset is later [12]. Wang analyzed data for 1520 American boys and established that comparing to their counterparts, early maturing boys were thinner [13]. On the contrary, a recently published study of 21 612 Danish boys born between 1940 and 1969 suggested that during the study period the heaviest category of prepubertal children entered puberty significantly earlier than the lightest category of children. However, the secular change was found in all BMI categories suggesting that the obesity is not solely responsible for the earlier maturation [2]. It should be mentioned, that conclusions from data collected between 1940s and 1970s should not be automatically transferred to 1990s, because of dramatically changed life conditions. For instance, Juul et al. found that the Danish boys in 1991-1993 were significantly taller compared with data from 1964, but timing of pubertal maturation seemed unaltered [6].

Clear associations between childhood adiposity, as reflected in BMI, and early pubertal development in girls have been established [1]. Increased adiposity in prepubertal children could lead to higher conversion rate of androgens to estrogens, thereby overexposing tissues to estrogens during prepubertal years. Insulin

resistance in obese subjects is associated with compensatory hyperinsulinaemia and lower levels of sex-hormone-binding globulin (SHBG), resulting in increased sex steroid bioavailability. Thus, there are several mechanisms whereby the increased prevalence of overweight and obesity could trigger early pubertal development by increased exposure to sex steroids in girls.

However, as we have shown, the influence of the fat tissue on the sexual maturation in boys remained unexplained. Thus, the information about the anthropometrical and pubertal indices in investigated by us children could serve for further comparison and conclusions for the pubertal development and acceleration in Bulgarian boys.

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