Assessment of mean testicular volume in adolescent school boys of Udaipur district (10–18 years) at different stages of pubertal development

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ABSTRACT

Background: The most important changes during puberty are secondary sexual characters. **Objective:** The objective of this study was to find out the mean testicular volume (MTV) by Prader orchidometer at different stages of pubertal development. **Materials and Methods:** Children between 10 and 18 years of age (sample size 525) from schools of Udaipur city were included in the study. Children, who underwent major surgery or having any systemic disorders, were excluded from the study. TV assessment was done by Prader's orchidometer with Tanner staging and correlation was statistically analyzed. **Results:** The maximum boys belonged to 15–16 years of age group (14.7%), and 9.3% of boys were in 10–11 years of age group. The secondary sexual characters were observed to increase with the increase in MTV. The MTV for P1 was 4.46 ml, for P5 was 22.68 ml, and for G1 and G5, it was 4.69 ml and 23.27 ml, respectively ($p<0.05$). **Conclusion:** TV adds more objectivity in the detection of sexual maturation and helps to differentiate early genital maturation than pubic hair. The study population had an early rise of TV before pubic hairs were clinically visible which showed that it was the first to increase with the onset of puberty.

Key words: *Body mass index, Genital stage, Pubic hair stage, Tanner staging, Testicular volume*

Puberty is defined as a period when endocrine and gametogenic functions of gonads have first developed to the point where reproduction is possible [1]. Testicular volume (TV) is the earliest indicator of puberty in adolescent boys [2]. According to Kaplan, boys' pubertal status can be accurately determined by TV at a much earlier stage [2]. Early assessment may be particularly important in a situation where normal pubertal staging may be changing due to environmental or other unknown factors. The variability in behavior problems in adolescence, particularly in boys, has profound psychological and social consequences, for example, boys developing early will be stronger and more athletic than other boys. However, late developers may be frustrated by their lack of physical and sexual development [3].

Puberty is initiated by hormone signals from the brain to gonads. In response, gonads produce a variety of hormones that stimulate growth and development of the brain, bones, muscle, skin, breast, and reproductive organs, which contribute to the development of secondary sexual characters. Nutrition is the strongest environmental factor affecting puberty. Other factors are the time of onset, ethnic/race, physical activity, stress, genetic, and social factors. Critical body weight must be attained for puberty to occur [2,4-7]. This energy balance regulates the activity of the hypothalamic gonadotropin-releasing hormone pulse generator acting through hormonal signals. Childhood obesity results in early puberty.

A high level of exercise reduces calories available for reproduction and slows puberty. The impact of stress and social factors is well known but not well understood. Intense psychological stress delays puberty. Improved nutrition and body mass seem to be important contributors to early sexual maturity. Frisch and Revelle observed that a critical amount of fat mass is needed for the onset of puberty [8].

Physical development of puberty in boys was best described by Marshall and Tanner as sexual maturation rating (SMR) and was named Tanner SMR [9]. SMR staging is the best and was supported with other physical findings such as axillary hair, facial hair, and acne. It is easy to perform. A classic determination of the onset of puberty is testicular length >2.5 cm or volume greater than 4 ml. The objective of this study was to check the effect of nutritional status (body mass index [BMI]) on TV and to find out mean TV (MTV) by Prader orchidometer at different stages of pubertal development.

MATERIALS AND METHODS

The present cross-sectional study was carried out in the schools of Udaipur district in Rajasthan. The study was conducted for 1 year from May 2018 to 2019, after obtaining permission from the Institutional Ethical Committee. The children between 10 and 18 years of age were selected for the study from various schools

of Udaipur city until the sample size of 525 children was reached. The schools of Udaipur were divided sector wise, and in each sector, schools were visited and took permission from school principal after explaining the importance of this study. At a time, 6–7 children were examined completely with TV measurement.

The sample size was calculated by the formula: $n=(S_{o/2}+Z_{1-\beta})$ $p(1-p)/E^2=525$. Written consent was obtained from the parents of each patient. Children with systemic disorders such as mumps, hypothyroidism, diabetes mellitus, trauma, and vasculitis, intake of drugs such as glucocorticoids and ketoconazole, testicular atrophy or with major surgery like hernia which could have an effect on the growth were excluded from the study. A total of 62 children were excluded as the parents did not give informed consent for complete physical examination of their children.

All the cases were subjected to a complete history and physical examination. The age of the patients was inquired and reconfirmed from the school records. Weight was recorded on a digital weight machine without shoes. Height was obtained with a stadiometer. A detailed dietary history was taken and the nutritional status was classified as normal underweight, overweight, and obese according to BMI. The term overweight was used when BMI exceeded the 85th percentile for age and sex, and the subjects were classified as obese when BMI exceeded the 95th percentile. TV assessment was done with a Prader orchidometer. The MTV was correlated with BMI, facial hair, pubic hair, axillary hair, and genital stage.

Statistical analysis was performed using the Statistical Package for the Social Sciences for MS Windows. The obtained data were entered into MS Excel. The data were analyzed using descriptive statistics and Chi-square test was used.

RESULTS

Of 525 boys, the maximum boys belonged to 15–16 years of age group (14.7%) and the minimum belonged to 10–11 years of age group (9.3%). MTV was minimum for 10–11 years of age group (4.67 ml) and maximum for 17–18 years of age group (23.71 ml) with $p<0.05$ (Table 1).

The pubic hair (P) staging was classified as 1–5 where MTV was observed to be minimum for pubic hair Stage 1 (P1 – 4.46 ml) and maximum for P5 (22.68 ml) with $p<0.05$ (Table 2).

The genital staging (G) was done clinically correlating with Tanner staging. MTV was minimum for G1 (4.69 ml) and was maximum for G5 (23.27 ml) with $p<0.05$ (Table 3).

The mean weight and height of the study group according to the genital stage were G1 (37.4 kg; 143.3 cm), G2 (42.8 kg; 149.19 cm), G3 (44.95 kg; 154.03 cm), G4 (45.9 kg; 154.71 cm), and G5 (52 kg; 162.59 cm). A total of 145 boys (27.6%) were underweight, 371 boys (70.7%) had normal weight, 8 boys (1.5%) were overweight, and 1 (0.2%) patient was obese. The correlation between MTV and BMI is shown in Table 4.

Axillary hair was present in 286 (54%) boys and the MTV was higher for cases with axillary hairs (17.43 ml) than for cases without axillary hairs (9.97 ml) with $p<0.05$. Acne was present in 331 (63%) boys and MTV was higher for cases with acne (16.29 ml) with $p<0.05$.

Table 1: Distribution of children according to mean testicular volume

Age group (years)	Number of children	MTV (ml)	SD	p-value
10–11	49	4.67	1.04	≤0.05
11–12	60	7.82	3.41	
12–13	59	8.54	3.12	
13–14	73	12.40	3.02	
14–15	66	13.85	3.69	
15–16	77	15.84	4.05	
16–17	65	20.38	3.45	
17–18	70	23.71	2.20	

MTV: Mean testicular volume, SD: Standard deviation

Table 2: Correlation between mean testicular volume and pubic hair stage

Pubic hair stage	Number of children	MTV (ml)	SD	p-value
1	13	4.46	0.776	≤0.05
2	139	6.60	2.013	
3	128	11.83	2.235	
4	134	17.60	4.062	
5	111	22.68	2.851	
Total	525	14.03	6.736	

MTV: Mean testicular volume, SD: Standard deviation

Table 3: Correlation between mean testicular volume and genital stage

Genital stage	Number of children	MTV (ml)	SD	p-value
1	45	4.69	0.973	≤0.05
2	130	7.64	2.306	
3	138	12.75	2.414	
4	111	18.50	3.411	
5	101	23.27	2.592	
Total	525	14.03	6.736	

MTV: Mean testicular volume, SD: Standard deviation

Table 4: Correlation between MTV and BMI

BMI	Number of children	MTV (ml)	SD	p-value
Underweight	145	11.13	5.292	≤0.05
Normal	371	15.12	6.934	
Overweight	8	15.25	5.874	
Obese	1	20.00		
Total	525	14.03	6.736	

MTV: Mean testicular volume, BMI: Body mass index, SD: Standard deviation

DISCUSSION

In the present study, MTV at each genital and pubic stage was studied and it was correlated that genitals began to develop at the age of 11.5–12 years which was 1–2 years earlier than the

development. These results were in accordance with the study done by Marshall and Tanner [9]. They observed that the development of genitals began at the age of 13.5 years in 95% of boys and reached maturity at the age of 15–17 years [9]. However, they did not determine the exact appearance of pubic hair and did not measure MTV for determining secondary sexual characters.

In the present study, the MTV was 4.5 ml at G1 and P1 which led to the conclusion that TV enlargement was the first sign of pubertal onset after which changes appeared in pubic hair and scrotum. On the contrary, Marshall and Tanner observed that pubic hair appeared in P2 and genital changes begin from G2 [9]. The pubertal onset occurred at 10.2±1.5 years according to MTV and at 11.1±1.6 years according to G1 ($p<0.01$). Before the age of 9, 15.2% of children had an MTV ≥4 ml, 3% had genital changes in G1, and only 3% had both changes, simultaneously. The study by Gaete *et al*. showed that testicular enlargement occurred 1 year before the changes in genitalia [10].

In the present study, the mean weight (kg) was 42.8, 44.95, 45.9, and 52 from G2 to G5. However, Agarwal *et al*. observed the mean weight of 38, 42.5, 46.8, and 52.9 kg for G2 to G5 [5]. Similarly, in the present study, the mean height (cm) from G2 to G5 was 149.19, 154, 154.71, and 162.59 cm, which is in accordance with the results obtained by Agarwal *et al*. [5]. They studied both genders and their sample size was larger compared to the present study.

In this study, the mean BMI according to the genital stage was maximum for G5 and minimum for G3. These findings were in accordance with the study by Lee [11]. Boys in the highest BMI trajectory had a greater relative risk of being prepubertal compared with boys in the lowest BMI trajectory. The relationship between body fat and timing of pubertal onset was not the same in both genders. Similar results were observed by Surana *et al*. [12] and Busch *et al*. [13].

In the present study, 68% of the school boys showed the presence of facial hair with MTV of 16.09 ml. This was well correlated with G3, P3, and P4. This is in accordance with the study by Agarwal *et al*. [5]. In the present study, MTV of 17.43 ml was suggestive of onset of axillary hairs and the maximum axillary hairs were present in G4 and P4. Agarwal *et al*. observed that the maximum axillary hairs were present in G5 [5].

Acne during pubertal onset presented mainly during G4 which had correlation with MTV of 16.29 ml. Agarwal *et al*. also showed that the incidence of acne was only 7% in G2 to 58% in G4 and G5 stages [5]. Uchendu *et al.* concluded that the increase in TV was a good predictor of onset and progression of sexual maturity [14]. The study had a few limitations. The MTV could not be correlated to levels of hormones such as FSH and testosterone due to financial issues.

CONCLUSION

There was an early rise of TV before pubic hairs were clinically visible which showed that TV was the first to increase with the onset of puberty. The study concluded that the assessment of TV by Prader orchidometer is an easy, reliable, and accurate method in community. TV adds more objectivity in SMR detection and helps to differentiate early genital maturation than pubic hair.

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