Original Article

Testicular Volume of Boys Aged 5-17 Years in Relation to Sexual Maturity Rating and Clinical Onset of Puberty in an Urban Setting in Gujarat, India

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Background : Assessment of Sexual Maturity Rating and Testicular Volume are indispensable in the routine assessment of puberty in boys. There is paucity of data in Indian population for Testicular Volume particularly in early adolescence.

Aims : The aims of the study were to collect data for testicular volume,correlate testicular volume with Sexual Maturity Rating (SMR) and the clinical onset of puberty; and to identify Testicular abnormalities in boys aged 5 to 17 years in an Urban setting in Gujarat, India.

Materials and Methods : A prospective observational study was undertaken in boys aged5 to 17years of age from Gujarat from April, 2019 to August, 2019. Mean Testicular Volume was measured with a Prader's orchidometer. Parameters like Age, Weight and Height were also measured and Body Mass Index (BMI) was calculated. Pubertal stage was categorized using Tanner staging. Data was statistically analyzed using Microsoft Excel and SPSS software.

Results : 977 boys were included in the study. Mean age at SMR stage 2 was 11.22 years. SMR stage 2 was earliest seen at 6 years and latest at 15 years of age. 15% of boys in pre-adolescence, 60% in early adolescence and 94% in middle adolescence showed changes of Puberty. Precocious puberty was detected in 33 boys (3.38%). Delayed Puberty was detected in 4 boys (0.4%) and Undescended Testes in 4 boys (0.4%). Testicular Volume showed positive correlation with Weight, Height and BMI.

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Key words **: Testicular Volume, Puberty, Sexual Maturity Rating, Congenital Anomalies.**

The assessment of Testicular Volume has been extensively studied in recent years. In adult males, Testicular Volume is measured in relation to spermatogenic activity, whereas in Paediatric population, it is mainly of importance in assessing pubertal development and to evaluate Testicular abnormalities. The Orchidometer is widely used for this purpose in clinical practice[1].

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Editor's Comment :

- It is necessary to generate a baseline data of age appropriate Testicular Volume in every population to assess puberty and Sexual Developmental Disorders.
- Due to paucity of data in Indian population for Testicular Volume particularly in early adolescence, local norms of testicular development are necessary to confirm normality and to identify any abnormality.
- Early assessment is particularly important when normal pubertal staging may be changing due to environmental or other unknown factors.

Assessment of sexual maturity rating and testicular volume are essential components of routine assessment of puberty in boys, which is unfortunately, often missed during routine office visits. Moreover, there is paucity of data for Testicular Parameters particularly in pre-school and early adolescence. Hence, local norms of Testicular development are necessary to confirm normality and to identify any abnormality.

Aims and Objects

The present study was conducted in school going boys from Gujarat to (1) collect data for Testicular Volume, (2) correlate Testicular Volume with Sexual

Maturity Rating and the clinicalonset of Puberty and (3) Identify testicular abnormalities.

Materials and Methods

This prospective observational study was conducted in schools in an urban setting in Gujarat between April, 2019 and August, 2019. The study was approved by the Institutional Review Board of the Hospital. After obtaining informed consent from parents and the concerned authorities of the schools, boys between 5 and 17 years of age were screened.The sample size was calculated from OpenEpi.com (version 3) (confidence level 99%). The boys having Congenital Anomalies, Cerebral Palsy, Epilepsy, Inguinal Hernia Surgery and those not willing to give consent for the study were excluded . Boys with Congenital Anomalies of the Genitalia (such as cryptorchidism, epispadias, and hypospadias) were noted for further follow up but the data was not included for statistical analysis.

The following preliminary parameters were recorded: *Age* (in completed years) from school records, *Weight* (in kilograms) and *Height* (in centimetres). The Weight was determined with a mechanical analogue weighing scale (*GVC analogue*)and the Height was measured with a Stadiometer (*Aussin*). *BMI* was derived from weight and Height (kg/m^2).

IAP growth charts were used to chart the height, Weight and Body Mass Index (BMI) in centiles.

The *Sexual Maturity Rating (SMR*) of all the enrolled boys was done as per Tanner's staging criteria (Annexure 1)[5].

Testicular Examination was done in the undressed child by stretching the scrotal skin over the Testis in a warm room. Examination of the Left Testis was carried out first, followed by the Right Testis with the boy in standing position. Testicular examination was done by the same doctor to minimise inter observer variation. A Prader's Orchidometer *(Genentech Inc)* was used to assess Testicular Volume (in cubic centimetre / ml), which consists of 12 ellipsoid models ranging in volume from 1 to 25 cm^3 (1 to 6, 8, 10, 12, 15, 20 and 25 cm^3).The ellipsoid, which best matched the Testicular size was taken and the Testicular Volumes were recorded.In the present study, Testicular Volume of 4 ml was taken as corresponding to SMR -2 (to assess clinical onset of Puberty)[6].

Microsoft Excel software was employed to compute the Mean Age, Weight, Height, Testicular Volumes and BMI. SPSS version 20 software was used to determine the Weight centiles and the statistical significance between various parameters.

Sexual Maturity Rating (SMR) Stages in Males

SMR STAGE	PUBIC HAIR	PENIS	TESTES
1	None	Preadolescent	Preadolescent
2	Scant, long, slightly pigmented	Minimal change/enlargement	Enlarged scrotum, pink, texture altered
3	Darker, starting to curl, small amount	Lengthens	Larger
4	Resembles adult type, but less quantity; coarse, curly	Larger; glans and breadth increase in size	Larger, scrotum dark
5	Adult distribution, spread to medial surface of thighs	Adult size	Adult size

From Tanner JM: *Growth at adolescence*, ed 2, Oxford, England, 1962, Blackwell Scientific.

Annexure 1 : Tanner Stages (Sexual Maturity Rating scales) for males

Results

A total of 1001 students was considered for inclusion in the study, out of which 12 did not give consent and 12 were excluded due to the following reasons. There were 4 boys with Undescended Testes (Incidence 0.4%), 2 boys with Congenital Anomalies (Pectus Carinatum and Left Microtia) and 6 boys with other conditions (Epilepsy, Autism Spectrum Disorder with Epilepsy, Cerebral Palsy and Inguinal Hernia Surgery). Hence 977 boys were included in the present study. All of them belonged to a lower Socio-economic status.

The age wise distribution of the sample has been given in Table 1.

All boys at 5 years were Pre-pubertal with SMR 1. Five out of 79 boys aged 6 years, 5 out of 83 boys aged 7 years and 23 out of 94 boys aged 8 years had SMR 2 or more. By definition, these 33 boys could be categorised under Pre-cocious Puberty. Similarly, there were 4 boys aged 14 years who had SMR 1 and no signs of onset of puberty, thus qualifying by definition for delayed Puberty[7]. All boys in 15, 16 and 17 year category had attained at least SMR 2. In Pre-adolescent years, 85% boys were Pre-pubertal and had SMR 1. Only 15 % showed onset of Puberty with SMR 2 and 3. In early adolescence, 40% boys were pre-pubertal while rest 60% showed SMR 2, 3 and even 4. In middle adolescence, only 6.3% boys were pre-pubertal whilst the rest 93.7% showed SMR 2, 3, 4 and 5.

In pre-adolescent boys, SMR 2 or more was seen in only 15 % cases, in early adolescence 61% and in middle adolescence 93.5 % . The right testis was larger than the left in 46.3% (n=452) of the children; 25% (n=244) had their left testis larger than the right and

Table 1 — *Distribution according to Age*

	Pre-adolescence (n= 431)					Early adolescence (n=484)				Middle adolescence (n=62)			
Age(in years)	5	6	7	8	9	10	11	12	13	14	15	16	17
N	49	79	83	94	126	125	130	143	86	38	15	8	1

both were equal among the rest (28.8%)(n=281). This had statistical significance (p<0.001). According to IAP growth charts, only 1 boy was classified as overweight and 1 boy as obese. We found a significant positive correlation between SMR and Height, Weight and BMI (Tables 2-5).

Discussion

Puberty is associated with accelerated growth velocities. Weight, Height, Testicular Volume and SMR increase proportionally with age. A consistent rise of BMI from 13.7 kg/m^2 at 5 years to 21.64 kg/m^2 at 17 years was noted indicating accelerated growth velocities and growth spurt.

For the onset of Puberty, most Clinicians use an Orchidometer cut-off of 4 mL[8,9], although some studies showed that a volume of 3 mL can already be considered a sign of puberty[10]. The MTV in present study at the age of 8 years was 3.4 cc, which was higher, compared to studies by Lall[11], Goede[12] and Boben, *et al*[13]. During prepubertal years, we found minimal growth of testicular volume till 9 years of age and rapid increase was observed from 11 years of age; these results are similar to previously reported studies by Lawal[14], Tomova[15] and Joustra *et al*[8]. The MTV at the age of 11 years was 4.68 cc, which was similar to the study by Matsuo[16] *et al* and higher compared to studies done by Lall[11], Boben[13], Goede[12] and Marshall, *et al*[17]. But at 12 years, the MTV of 6.05 cc was similar to that of Goede[12], lower than Chin[18] and Goede[12]; and higher than Lall[11] and Boben, *et al*[13].

At the age of 16, the MTV in children enrolled in our study was 13.44 cc which was lower than the results of Lall[11], Goede[12] and Boben, *et al*[13]. There was a rapid increase in Testicular Volume after the age of 11 years in our study, which was similar in studies done by Chin[18], Jaiswal[2], Beres[19], Joustra[8], Tomova[15] and Lawal, *et al*[14].

The mean age attained at SMR Stage-2 in our study was 11.22 years, which was similar to the results of studies done by Hafez[20], Singhi[21], Wong[22] and Papadimitriou, *et al*[23]. There was only one boy with SMR stage 5 in our study, so it was not possible to compare with other studies.

Pubertal changes

Table 2 — *Anthropometric parameters, MTV and SMR according to age*

Age	n	Mean Weight (kg)	Mean Height (cm)	Mean BMI (kg/m^2)	Mean TV (ml)	SMR 1	2	3	4	5
5	49	15.35 ± 1.9	105.7 ± 3.80	13.7 ± 1.39	2.88 ± 0.74	49	0	0	0	0
6	79	16.40 ± 2.19	110.13 ± 6.42	13.50 ± 1.37	3 ± 1.00	74	5	0	0	0
7	83	18.29 ± 3.32	115.08 ± 6.95	13.83 ± 2.49	3.34 ± 1.11	78	4	1	0	0
8	94	19.52 ± 3.22	119.40 ± 6.47	13.64 ± 1.58	3.4 ± 0.89	71	22	1	0	0
9	126	21.45 ± 3.30	124.24 ± 5.56	13.86 ± 1.56	3.7 ± 1.00	94	31	1	0	0
10	125	24.71 ± 4.89	131.01 ± 7.16	14.3 ± 1.96	4.28 ± 1.72	76	46	3	0	0
11	130	27.45 ± 6.98	135 ± 6.32	14.87 ± 2.80	4.68 ± 1.66	70	63	7	0	0
12	143	29.07 ± 5.88	139.42 ± 7.33	14.82 ± 2.16	6.05 ± 2.89	37	95	10	1	0
13	86	33.6 ± 7.4	144.95 ± 8.39	15.86 ± 2.5	7.46 ± 3.34	12	50	19	5	0
14	38	35.49 ± 5.65	149. 58 ± 9.07	15.89 ± 2.12	8 ± 3.29	4	19	10	4	1
15	15	38.47 ± 9.49	155.7 ± 9.08	15.72 ± 3.17	10.44 ± 2.32	0	4	10	1	0
16	8	48.87 ± 6.81	160.25 ± 7.78	18.2 ± 1.94	13.44 ± 3.64	0	3	2	3	0
17	1	50	152	21.64	7	0	0	1	0	0

Table 3 — *Stages of adolescence and SMR*

SMR Staging	Age		
	Pre-adolescence (<10 years) n=431	Early adolescence (10-13 years) n=484	Middle adolescence (14-17 years) n=62
SMR 1 (562)(57.5%)	366	193	3
SMR 2 (334)(34.2%)	62	245	27
SMR 3 (66)(6.8%)	3	40	23
SMR 4 (14)(1.4%)	0	6	8
SMR 5 (1)(0.1%)	0	0	1

Table 4 — *Growth parameters according to stages of adolescence*

	Pre-adolescence (n=431)	Early adolescence (n=484)	Middle adolescence (n=62)
SMR ≥2	65 (15 %)	299 (61%)	58 (93.5%)
Mean BMI (kg/m^2)	13.70	14.96	17.86
MTV (cc)	3.26 ± 1.01	5.61 ± 2.69	9.72 ± 3.43

Table 5 — *Anthropometric parameters and MTV according to stages of SMR*

SMR	n	Mean age (Years)	Mean weight (Kg)	Mean Height (cm)	BMI (kg/m^2)	MTV (cc)
1	562	8.53 ± 2.17	21.59 ± 6.48	122.19 ± 11.77	14.18 ± 2.20	3.5 ± 1.15
2	334	11.22 ± 1.87	27.60 ± 7.31	136.30 ± 11.64	14.59 ± 2.11	5.88 ± 2.61
3	66	12.88 ± 1.86	33.45 ± 8.96	145.32 ± 13.22	15.59 ± 2.57	8.83 ± 3.94
4	14	14 ± 1.30	41.57 ± 6.63	154.07 ± 7.98	17.59 ± 2.26	12.03 ± 2.42
5	1	14	39	163	14.68	17.5

were seen to start in some boys at 9-10 years, the mean age being 11.22 years. This is similar to studies done by Lall[11], Tomova[15], Joustra[8] and Beres[19] but earlier compared to Wacharasindhu[24] and Largo, *et al*[25]. MTV at 15 and 16 years of age in present study were lower than the studies of Lall[11] , Goede[12], Boben[13] and Beres, *et al*[19].

The Right Testes was found to be larger in studies by Boben[13] and Beres *et al*[19]. According to Beres, *et al* the Left Testis which forms an entity and moves together with the epididymis, gubernaculum, afferent vascular plexus and vas deferens, descends sooner to and settles lower in, the scrotum; whereas the right testis, owing to more abundant blood supply across a shorter plexus, grows to larger size[19]. Another explanation is that the pampiniform plexus of veins are more prominent in the left due to sluggish drainage of the Left Testicular Vein into the Left Renal Vein which may lead to increased temperature on the left and hence decreased Sertoli cell proliferation[26].

A spurt in BMI was noted in boys at 10 years of age. The mean age at onset of Puberty and SMR 2 was 11.22 years in the study. There were 33 boys less than 9 years showing SMR 2 or more who could be categorised in Pre-cocious puberty group. The reasonably large number of boys with "Precocious Puberty" as per existing definition points to an advancement of age of normal onset of Puberty in present times due to improved nutrition. But none of them was overweight or Obese. There were 4 boys with delayed Puberty, ie, SMR 1 at ≥14 years and none of them were underweight. Since there was a positive correlation of TV with Weight, Height and BMI, it indicates that nutrition might play a role in Puberty progression. But no apparent impact of nutrition on the onset of Puberty could be noted.

Limitations of the study :

The number of boys greater than 15 years of age was limited (0.02 % of study population). Axillary hair staging and confirmation of Testicular Volume by Ultrasonography could not documented.Concomitant LH/FSH/testosterone values could not be assessed for the biochemical confirmation of onset of Puberty.

Conclusion

In the present study, 977 school going boys between ages 5 and 17 years in an Urban setting were studied and data regarding Weight, Height, Testicular Volume and SMR were recorded. No role of nutritional status on clinical onset of puberty was noted. Precocious puberty was observed in 3.38% of boys (less than 9 years). Hence, possibility of an earlier onset of Puberty can be entertained. It is necessary to generate a baseline data of age appropriate Testicular Volume in every population to assess Puberty and Sexual Developmental Disorders.

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