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Original Article

Evaluation of testicular volume in children aged 8-17 years in south India

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ABSTRACT

Background: The standard five-stage clinical systems of Tanner and Marshall for assessing pubertal development are limited by observer variations. The measurement of testicular volume, in addition, will make assessments objective. It is important to determine the mean testicular volumes (MTVs) for a given population as reference standards. **Aim:** To determine the MTVs in children between 8 and 17 years and to compare the MTV with Tanners staging. **Methods:** A cross-sectional study was conducted on 750 healthy school boys from 2 schools in Chennai between 8 and 17 years of age by a single observer to reduce the observer variation. Tanner's staging and testicular volume measurement were done using a Prader's orchidometer. **Results:** Of the 750 boys studied, the MTV of both the right and left testes was found to increase from 2.47±0.70 cc at 8 years of age, to 3.84±1.91 cc at 12 years, to 15.93±6.65 cc at 17 years of age (p=0.0001). The mean age was found to be increased from 12.69 years at sexual maturity rating (SMR) Stage-2, to 15.66 years at SMR Stage-5. We found a significant positive correlation between SMR and height (p=0.0001), weight (p=0.0001) and body mass index (p=0.0001). The average size of both the right and left testes was found to be increased from 2.86±1.12 cc at SMR Stage-1 to 12.51±4.67 cc at SMR Stage-3 to 18.90±4.64 cc at SMR Stage-5. In our study, 0.5% (n=4) had an MTV of 4 cc at the age of 8, 0.4% (n=3) had an MTV of <4 cc by the age of 14. **Conclusion:** The measurement of MTV along with Tanner's SMR staging makes the assessment of male genital development more objective and acts as a measure of testicular growth and spermatogenesis. Generating a baseline data on age appropriate testicular volume in a population or ethnic group is essential to assess sexual developmental disorders among males.

Key words: *Adolescence, Puberty, Tanner staging, Testicular volume*

Puberty is a process leading to physical and sexual maturation that involves the development of secondary sexual characters as well as changes in body composition, and psychosocial maturation [1]. The standard clinical system for describing normal pubertal development and its variation is the conventional five-stage system developed by Tanner and Marshall [2]. An accurate measurement of testicular volume is beneficial to the evaluation of children with a variety of disorders affecting testicular growth and development and reflects spermatogenesis [3].

Prader's orchidometer is a medical instrument, comprising beads of various sizes and known volumes, used to objectively measure and compare the volume of the testis [4,5]. Limited data is available on the normal reference range of testicular volume among Indian adolescents. Several reference values are available among the western population, but these values cannot be extrapolated amongst Indian children. We sought to define the age appropriate mean testicular volume (MTV) in Indian children aged 8-17 years.

METHODS

This cross-sectional study was conducted in two schools in Chennai after obtaining approval from the Institutional Ethics Committee. After taking permission from the authorities of the respective schools, all the children between 8 and 17 years of age with normal growth and development were screened. Prior informed consent for physical examination was obtained. Children having history of (or suspected on clinical examination) genital injury, congenital anomalies of the genitalia (such as ectopic testis, epispadias, and hypospadias), mumps and endocrine disorders (such as hypopituitarism, hypogonadism, hypothyroidism, and cushing's disease), painful or asymmetric enlargement of the testes (hydrocoele, varicocele, and tumors) or with chromosomal anomalies (like Down's syndrome) and those not willing for the study were excluded from the study.

The following preliminary parameters were recorded: Age (in completed years) from school records and birth certificates; weight (in kilograms), height (in centimeters). A physical examination of all the recruited children was done, to stage the sexual maturity rating (SMR) as per Tanner's staging criteria. A Prader's orchidometer, which is a series of graded ovoid beads on a string, which consists of 12 ellipsoids, which vary in volume from 1 to 25 cm^3, was used to assess MTV in (cc), after stretching the scrotal skin tightly, in the room temperature. The ellipsoid, which best represents the testicular size was taken, and

the testicular volume were recorded by a single observer once per student.

Centers for Disease Control and Prevention (CDC) classifications charts were used to chart the height, weight and body mass index (BMI) in centiles as given in Table 1. Tanner's staging was used to classify the sexual maturity rate.

Statistical Analysis

Descriptive statistics was employed to compute the mean age, SMR, and BMI. Pearson's Chi-squared test was used to determine statistical significance between various parameters. The values were considered statistically significant if the alpha error was >5%. All statistical analysis was performed using IBM® SPSS Statistics, version 17.7.0.0.

RESULTS

A total of 869 students were screened for inclusion in the study, out of which 119 were excluded due to various reasons as given in Table 2. Hence, total 750 healthy boys were included in the study. Of the 750 boys studied, the MTV of both the right and left testes were found to increase from 2.47±0.70 cc at 8 years of age, to 3.84±1.91 cc at 12 years, to 15.93±6.65 at 17 years of age (p=0.0001). The MTV for both the right and left testis, height wise, is shown in Table 3 and age wise is shown in Fig. 1.

The mean age was found to be increased from 12.69 years at SMR Stage-2, to 15.66 at SMR Stage-5, as shown in Table 4. The average size of both the testes was found to be increased from 2.86±1.12 cc at SMR Stage-1, to 12.51±4.67 cc at SMR Stage-3, to 18.90±4.64 at SMR Stage-5. The right testis was larger than the left in 33.8% of the children while 5.8% had their left testis larger than the right and both were equal among the rests (60.4%). In our study, 0.5% (n=4) had an MTV of 4 cc at the age of 8, suggestive of precocious puberty and 0.4% (n=3) had an MTV of <4 cc by the age of 14 suggestive of delayed puberty. We found a significant positive correlation between SMR and height (p=0.0001), weight (p=0.0001), and BMI (p=0.0001) as given in Table 5.

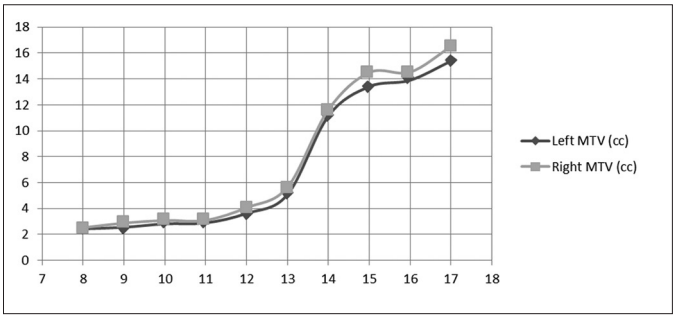

Figure 1: Comparison of age and testicular volume (cc). X axis - Age in years, Y axis - Mean testicular volume

DISCUSSION

The accurate measurement of testicular size is important in many clinical situations. In growing boys, it is important to assess the adequate and age appropriate testicular growth, and to exclude significant and persistent asymmetry in testicular size [6]. Determination of testicular volume is important in assessing pubertal development and the effects of illness on the treatment of reproductive function. Testicular enlargement is the earliest sign of the pubertal gonadotropin elevation in boys, and a testicular volume of ≥4 ml is used as a clinical marker for the onset of puberty in boys [7].

Clinically, testicular volume can be measured by a simple instrument called Prader's orchidometer. It consists of a string of 12 numbered wooden and plastic ellipsoid beads of increasing sizes from about 1 to 25 mm. The beads are compared with the testicles of the patient and the volume is read off the bead which matches most closely in size. The second method of assessment of testicular is by ultrasonography. Ultrasonography is a more accurate method of assessing testicular volume, but the cost and expertise required in this method makes it not fesible to be employed in every clinical setup. Hence, use of Prader's orchidometer is the only method that can be employed in every clinical setup but availability of this instrument in a day-to-day clinical setup is difficult. Second, observer variation is the major limitation in this method. Therefore, in our study, by having a single observer we have tried to eliminate the observer variation.

Most children enrolled in our study were in the age group of 10-15 years (75.4%). The MTV in our study at the age of 8 years

Table 1: Comparison of age, anthropometry, and testicular volume

Age (years)	Mean weight (kg)	Centile	Mean height (m)	Centile	Mean BMI	Centile	MTV (cc)	SD
8	23.87	25-50	1.24	10-25	15.35	25-50	2.47	0.70
9	26.61	25-50	1.31	25-50	15.43	25-50	2.71	0.40
10	28.28	10-25	1.33	10-25	15.80	25-50	2.94	0.83
11	27.58	5-10	1.35	10-25	14.93	5-10	2.98	1.45
12	29.77	<5	1.38	5-10	15.42	5-10	3.84	1.91
13	33.07	<5	1.45	5-10	15.59	5-10	5.36	3.64
14	40.48	5-10	1.53	5-10	17.00	10-25	11.38	5.70
15	45.72	10-25	1.59	5-10	17.99	10-25	13.95	5.06
16	46.16	<5	1.60	5-10	17.90	10-25	14.21	4.43
17	54.38	10-25	1.67	10-25	19.48	10-25	15.93	6.65

p value weight versus MTV=0.000, p value height versus MTV=0.000, p value BMI versus MTV=0.000. MTV: Mean testicular volume, BMI: Body mass index, SD: Standard deviation

was 2.47 cc, which was higher, compared to a study by Lall et al. [8]. The MTV at the age of 11 and 12 years were 2.98 and 3.84 cc, which was similar to a study done by Lall et al. [8] and Barnes [9] but was lower than in the study by Chin et al. [10]. At the age of 16, the MTV in children enrolled in our study was 14.21 cc which was lower than the results of Lall et al. [8]. Testicular growth was found to be minimal before 12 years of age, which is delayed as compared to a study done by Chin et al. in Taiwan, where testicular growth was minimal before 9-10 years of age [10]. There was a rapid increase in testicular volume at the age of 13-14 years in our study as shown in Fig. 1. Mean height, weight and BMI were correlated with the MTV and details are given in Table 1. The mean weight dropped from 25th centile to 50th centile of CDC growth chart at 8 years of age, to less than 5th centile between 12 and 13 years, and gradually increased to 10-25th centile at 17 years of age. The mean height, BMI centiles followed a similar trend as weight centiles. But in none of the age groups mean height and mean BMI was less than 5th centile. Testicular volume increased with increasing height. There was a positive correlation seen between weight, height, BMI and testicular volume.

Table 2: Study details

Details	Number
Total number of students in the school	869
Number of students not willing to participate	76
Excluded due to hypothyroidism	21
Excluded due to congenital anomalies	6
Excluded due to chromosomal abnormalities	2
Excluded due to prolonged hospitalization	14
Number of students satisfying the criteria	750

Table 3: Comparison of testicular volume and height

Testicular volume (cc)	N	Mean height (m)	SD
2-2.9	183	1.32	0.06
3-3.9	169	1.36	0.06
4-4.9	48	1.38	0.06
5-5.9	25	1.45	0.09
6-7.9	58	1.50	0.08
8-9.9	76	1.53	0.08
10-11.9	24	1.55	0.06
12-14.9	34	1.57	0.05
15-19.9	78	1.59	0,05
20-24.9	41	1.63	0.06
25	14	1.63	0.05

p=0.000. SD: Standard deviation

Table 4: Distribution of children according to age and MTV

Age (years)	N	Left MTV (cc)	Right MTV (cc)	Average MTV (cc)
8	46	2.43±0.65	2.52±0.78	2.47±0.70
9	56	2.55±0.50	2.88±0.50	2.71±0.40
10	93	2.82±0.75	3.08±0.98	2.94±1.45
11	97	2.89±1.39	3.09±1.54	2.98±1.45
12	84	3.62±1.79	4.07±2.08	3.84±1.91
13	85	5.08±3.66	5.65±3.67	5.36±3.64
14	109	11.14±5.88	11.63±5.76	11.38±5.70
15	98	13.41±4.90	14.50±5.50	13.95±5.06
16	58	13.90±4.34	14.53±5.20	14.21±4.43
17	24	15.38±6.67	16.50±7.51	15.93±6.65
				p=0.0001*

***Correlation between the mean testicular volume and the age was significant. MTV: Mean testicular volume**

The mean age attained at SMR Stage-2 in our study was 12.69 years, which was higher than the results of similar studies done by Hafez et al. [11] in Egypt (11.1 years), Juul et al. in Denmark (11.83 years), Wong et al. [12] in southern China, and Campbell et al. [13] in Zambia. However, the mean age at SMR Stage-5 in our study (15.6 years) was lower than that found in a study by Hafez et al. [11] in Egypt (16.2 years).

The mean MTV increased with increase in SMR, as expected. The left and right MTV in SMR Stage-2 in our study was 5.52 and 6.03 cc (p=0.0001) compared to the study by Daniel et al. [14] where the volume was 6.4 and 7.1 cc, respectively; while the MTV in SMR Stage-5 was 18.66 and 19.13 cc (p=0.001) which was lower compared to the study by Daniel et al. [14] where the volume was 28.3 and 30.2 cc, respectively.

The right testis was larger than the left in 33.8% children while 5.8% had their left testes larger than the right and both were equal among the rests. In a study by Wikramanayake [15] in Sri Lanka, both the testes were of equal size in 75%, and the right testis was larger in 20% of the children.

In our study, 0.5% (n=4) had an MTV of 4 cc at the age of 8, suggestive of precocious puberty. This is in comparison to the study by Prader [4], where pre-pubertal MTV is up to 3 cc, pubertal MTV was 4 cc and adult MTV was 25 cc. We found that 0.4% (n=3) had a MTV of <4 cc by the age of 14, suggestive of delayed puberty. Christie and Viner [16] iterated that, delayed

Table 5: Distribution of children according to SMR, in relation to age, MTV, mean weight, mean height and mean BMI

SMR	N	Mean age (years)	Left MTV (cc)	Right MTV (cc)	Mean weight (kg)	Mean height (m)	Mean BMI
1	266	10.9±1.48	2.72±1.02	2.99±1.26	26.97±4.34	1.33±0.07	15.16±1.74
2	288	12.6±1.61	5.52±3.48	6.03±3.72	33.57±8.50	1.43±0.09	16.04±2.89
3	84	14.5±0.98	11.86±4.54	13.14±5.23	43.63±7.83	1.57±0.05	17.51±2.88
4	59	15.10±0.94	15.92±3.86	16.32±4.58	48.68±10.86	1.61±0.04	18.66±4.00
5	53	15.66±1.05	18.66±4.51	19.13±4.64	50.94±8.64	1.63±0.06	19.00±2.56

SMR and MTV - p=0.001, SMR and mean weight - p=0.000, SMR and mean height - p=0.000, SMR and mean BMI - p=0.000. MTV: Mean testicular volume, BMI: Body mass index, SMR: Sexual maturity rating

puberty among boys can be quite distressing, but is almost always a normal variant. One of the study limitations was that we include only the population of children which was available in those schools; therefore, boys with different levels of growth and development were accepted for our study.

CONCLUSION

The measurement of MTV along with Tanner's SMR staging makes the assessment of male genital development more objective and acts as a measure of testicular growth and spermatogenesis. The Prader's orchidometer is an inexpensive and reliable tool for rapid assessment of MTV. Generating a baseline data on age appropriate testicular volume in a population or ethnic group is essential to assess sexual developmental disorders among males.

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