Original Article

Stretched Penile Length and Testicular Size from Birth to 18 Years in Boys from Western Maharashtra

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Abstract

Background: Genital stage and testicular volume examination and assessment are essential for assessment of growth puberty in boys. There is paucity of Indian data for penile and testicular parameters particularly in pubertal years. **Aim:** The aim of this study is to present normative data for penile length, testicular volume, and testicular length from birth to 18 years in boys from western Maharashtra and to correlate these parameters with sexual maturity staging (SMR) (Tanner staging). **Materials and Methods:** A cross-sectional observational study was undertaken in apparently healthy boys from 0 to 18 years of age from western Maharashtra from October 2016 to October 2017. Age, anthropometric parameters, stretched penile length (SPL), testicular volume, and testicular length were measured. Pubertal stage was categorized using Tanner staging. Data were entered in Microsoft excel 2013 and using SPSS version 16. LMS method was used to construct age-specific *Z*-scores for SPL, testicular volume, and testicular length. **Results:** A total of 843 boys were enrolled in the study. Mean SPL was 4.1 ± 0.4, 5.4 ± 0.8, and 10.2 ± 1.7 cm at 1, 10, and 18 years of age, respectively, and showed a gradual rise from birth to 18 years. Mean testicular volume was 1.8 ± 0.5, 3.3 ± 1.2, and 24.1 ± 3.5 ml, whereas testicular length was 1.3 ± 0.4, 2.1 ± 0.5, and 4.4 ± 0.7 cm respectively, at 1, 10, and 18 years, respectively. The magnitude of increase for SPL and testicular volume was greater around 9–10 years. The increase in SPL and testicular size was hand in hand with SMR for genital development as well as for axillary and pubic hair stages. **Conclusion:** Normative data on SPL, testicular volume, and testicular length from western Maharashtra are presented. These data may be useful in disorders of puberty and genitalia in boys.

Keywords: Stretched penile length, testicular length, testicular volume

Introduction

Assessment of growth is an essential part of pediatric practice, and pubertal assessment is integral to growth monitoring. Assessment of genital stage and testicular volume is a part of routine assessment of puberty in boys.[1] Local norms of penile length and testicular development are necessary to confirm normality and identify deviations from normality. These data are useful for pediatricians, neonatologists, endocrinologists, pediatric surgeons, and urologists. Although some data are available in neonates and school age children up to 10 years of age, there is paucity of Indian data for penile and testicular parameters particularly in pubertal years.[2,3] Further, studies that have been conducted previously have suggested that there are variations in penile size in different populations.[4,5] Thus, the objectives of our study were to present normative data for penile length, testicular volume, and testicular length from birth to 18 years in boys from western Maharashtra and to correlate these parameters with sexual maturity staging (SMR) (with Tanner staging). We also compared data from the present study with available data from Indian and Western studies.

Materials and Methods

A cross-sectional study was performed on boys from birth to 18 years and data collection was performed from October 2016 to October 2017. Children were recruited from maternity wards (healthy, full-term baby boys) and pediatric outpatient clinics (healthy children coming for immunization) of a tertiary care medical college hospital from Western Maharashtra;

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further, three private schools were also approached for the study. Of all the parents and children who agreed to the study, healthy boys were selected randomly from each age group. Thus, apparently healthy children under 18 years were included in the study. Children with chronic disorders (which could result in delay in puberty), abnormalities of the penis, epispadias, hypospadias, penile curvature, buried penis, history of delayed puberty as well as children whose anthropometric parameters (height, weight, and body mass index) were outside the reference range were excluded from the study (n = 165). The study was approved by our institutional ethics committee. Written informed consent was obtained from parents and assent from boys over 7 years before the subjects were measured.

Anthropometric assessments were performed; recumbent length was measured in children younger than 2 years using an infantometer (seca 416) and height was measured in children older than 2 years on a Harpenden stadiometer (SKU: PE087) to the accuracy of 1 mm. Weight was measured in babies using an electronic digital scale (Diligent Scale, Deluxe) and in children and adolescents using a Salter weighing scale to the accuracy of 100 g. BMI was computed (weight/height in meter square). Height, weight, and BMI were then converted to *Z*-scores (WHO till 5 years and IAP 2015). As per the standard deviation of seven[4] previously published studies, for the power of study to be 0.8, total sample size required was 770 with $n >= 43$ in each age group.

Measurement of SPL, testicular volume and length, and sexual maturity staging

The stretched penile lengths (SPL) were measured by a single observer in a standing position. The penis was stretched as much as comfortably possible and length was measured up to the accuracy of 1 mm from pubic symphysis to the tip of the glans using a transparent, rigid ruler placed along the dorsal side of the penis. The prepubic fat pad was pushed to the bone so as to get an accurate reading.[6] The average of three consecutive measurements was taken as final reading.

For testicular volume and length, right and left testis were measured separately. Testicular volume was measured using a Prader Orchidometer.[7] The testes were examined by palpation to assess the size and the testicular volumes were then measured after stretching the scrotal skin over the testis in a warm room by two pediatric endocrinologists using a Prader orchidometer. The Prader orchidometer has 12 solid ellipsoid models of the testis ranging in volume from 1 to 25 cm^3 (1–6, 8, 10, 12, 15, 20, and 25 cm^3). Testicular length (vertical) was measured by the same transparent ruler after fixing the testes with one hand and measurement was made in centimeters (up to one decimal) from the upper pole to lower pole.[8] The average of three consecutive measurements was taken as the final reading.

The stages of genitalia (and pubic hair development) were graded as per Tanner SMR from stage 1 to 5 by a trained pediatric endocrinologist. Stage 1 was classified as prepubertal for genital stage and pubic and axillary hair. Genital development was classified as stage 2 when enlargement of scrotum and testes and reddening of scrotal skin and changes in texture were observed (pubic hair stage 2 – sparse growth of long, slightly pigmented hair, straight or curled, at base of penis. Axillary hair stage 2: scanty growth of slightly pigmented hair). Genital stage 3 was defined when there was enlargement of penis (length at first) and further growth of testes (pubic hair stage 3 – darker, coarser, and more curled hair, spreading sparsely over junction of pubes. Axillary hair stage 3 – axillary hair adult in quality and quantity). Stage 4 genital stage was defined when there was an increase in the size of penis with growth in breadth and development of glans, larger testes, and scrotum and the scrotal skin was darker (pubic hair stage 4 – adult type hair but covering smaller area than in adult). Stage 5 was noted when the genitalia were adult male in type with adult pattern and quantity of hair.[9]

Statistical analysis was performed using SPSS version 16 and LMS chart maker 2005 software was used for computing age-specific *Z*-scores for SPL, testicular volume, and testicular length (LMS chartmaker Pro version 2.4, 2008). The LMS method constructs reference percentiles adjusted for skewness and variable of interest is summarized by three smooth curves plotted against age, representing the median (M), coefficient of variation (S), and skewness (L) of the measurement distribution[10] and models are checked using the detrended Q–Q plot, Q tests, and worm plots.[11] Median values corresponding to *Z*-scores of −2, −1, 0, +1, and +2 are presented in (percentile curves have been given in Appendix 1 and Appendix 2, LMS values may be obtained from authors on request). Regression analysis was performed for the relationship between testicular volume and testicular length.

Further, mean SPL and testicular volume at various sexual maturity stages were computed. A comparison of mean values of SPL and testicular volume with available Indian and international data was performed; similar comparison could not be performed for testicular length as data were scarce.

Results

Eight hundred and forty three boys were enrolled; age-wise distribution of children and their mean height, weight, and BMI *Z*-scores are illustrated in Table 1. Smoothed SPL, testicular volume, and testicular length *Z*-scores (−2, −1, 0, +1, and +2) from birth to 18 years are presented in Table 2. There was a progressive increment in SPL with age, the magnitude increased after 9 years of age, and increase continued till 17–18 years. Mean SPL was 4.1, 4.6, 5.4, 8.2, and 10.2 cm at birth, 5, 10, 15, and 18 years, respectively. Mean testicular volumes at birth, 1, 5, 10, 15, and 18 years were 1.8, 1.8, 3.3, 15.3, and 24.1 ml, respectively. Similar to the SPL, greater increase was seen at 9 years and growth continued till 18 years. Testicular length was 1.3, 1.5, 2.1, 3.4, and 4.3 cm at birth, 1, 5, 10, 15, and 18 years, respectively. Greater increase was observed around 10 years. Regression analysis for relationship between testicular volume and testicular length yielded the

following equation: testicular volume = −7.5 + 6.3 × testicular length.

Appearance of axillary hair was noted at a mean age of 14.6 years (1.7) and adult pattern was reached at a mean age of 16.4 (1.3) years. Pubic hair appearance was noted at mean age of 12.7 (1.7) and pubic hair stages 3, 4, and 5 were reached at 14.7 (1.6), 15.7 (1.6), and 16.5 (1.2) years, respectively. Similarly, genital stage 2 was reached at 11.5 (1.4) and genital stages 3, 4, and 5 were reached at mean ages of 14.3 (1.6), 15.1 (1.5), and 16.4 (1.5) years, respectively. Mean (SD) Tanner stages and corresponding values of testicular volume and SPL are illustrated in Table 3. There was an increase in SPL and testicular volume with increasing SMR for genital development as well as for the axillary and pubic hair stages.

Figure 1 shows comparison of SPL with available national and international studies; most studies show a steeper increase around 10–12 years of age, whereas in our study, we found that the increment was more gradual and continued till 18 years. Figure 2 shows testicular volume in comparison with available studies; data from our as well as other studies show a steep rise in testicular volume around 10–12 years.

Table 1: Height, weight, and BMI *Z* score of subjects

Age	*n*	Height (SD)	Weight (SD)	BMI (SD)
0-1	55	0.1 (0.9)	−0.7 (0.8)	−1 (1.1)
1-2	60	−0.8 (0.8)	−0.6 (0.7)	−0.1 (1.2)
2-3	54	−0.2 (0.8)	0.2 (0.8)	0.2 (1)
3-4	50	−0.2 (0.9)	−0.2 (0.8)	0 (0.8)
4-5	44	−0.2 (0.8)	−0.1 (0.9)	0 (1)
5-6	49	−0.3 (0.9)	−0.4 (0.8)	−0.3 (0.7)
6-7	45	−0.3 (0.9)	−0.3 (0.9)	−0.2 (1)
7-8	37	−0.1 (0.7)	−0.2 (0.8)	−0.3 (1)
8-9	45	−0.4 (0.8)	−0.5 (0.8)	−0.3 (0.9)
9-10	47	−0.2 (0.8)	0 (0.9)	0.1 (1)
10-11	57	−0.4 (0.9)	−0.2 (1)	−0.1 (1.1)
11-12	40	−0.5 (0.9)	−0.2 (1)	0.1 (1.1)
12-13	45	−0.5 (1)	−0.2 (1)	0 (1)
13-14	44	−0.7 (0.9)	−0.1 (0.9)	0.2 (0.9)
14-15	44	−0.8 (1)	−0.3 (1)	0.1 (1)
15-16	40	−0.7 (0.8)	−0.5 (0.8)	−0.3 (0.8)
16-17	45	−1 (0.7)	−0.5 (0.8)	−0.1 (0.7)
17-18	42	−0.9 (0.7)	−0.5 (0.5)	−0.1 (0.6)
Total	843	−0.4 (0.9)	−0.3 (0.9)	−0.1 (1)

Discussion

We describe here genital growth parameters, namely, SPL, testicular volume, and length in boys from birth to 18 years from western Maharashtra. A progressive increase in all parameters, namely, SPL, testicular volume, and length, was noted with increasing age; magnitude of increase was greater around the age of 9–10 years, and increment was also seen in 17–18-year-old boys. Regression equation for testicular volume (−7.5 + 6.3 × testicular length) is also described which is mainly applicable after 1st year of life.

The increase in SPL and testicular size was hand in hand with SMR for genital development as well as for axillary and pubic hair stages.

SPL gradually increased from infancy till 9 years of age in our study; similar findings and values have been previously reported by other studies.[5,12] However, some studies[4,13-16] have reported slightly higher values. There has been a notable increment in SPL in studies by Park *et al.* (*n* = 909)[16] at 13–14 years, Tomova *et al.* (*n* = 6200)[12] at 12 years, and by

Table 2: Smoothed *Z*-scores (−2, −1, 0, +1, +2) of penile length, testicular volume, and testicular length

	SPL *Z*-scores					TV *Z*-scores					Testicular length *Z*-scores				
Age	−2	−1	0	1	2	−2	−1	0	1	2	−2	−1	0.0	1	2
0	3.6	3.8	4.1	4.5	4.9	0.9	1.3	1.8	2.3	2.7	0.8	1.0	1.3	1.7	2.1
1	3.7	3.9	4.2	4.6	5.1	1.0	1.3	1.8	2.3	2.7	0.8	1.0	1.3	1.7	2.1
2	3.7	4.0	4.3	4.7	5.2	1.0	1.3	1.8	2.3	2.8	0.8	1.0	1.3	1.7	2.2
3	3.8	4.0	4.4	4.8	5.3	1.0	1.3	1.8	2.3	2.8	0.8	1.0	1.4	1.8	2.2
4	3.8	4.1	4.5	5.0	5.5	1.0	1.3	1.8	2.3	2.8	0.9	1.1	1.4	1.8	2.3
5	3.9	4.2	4.6	5.1	5.7	1.0	1.3	1.8	2.4	2.8	0.9	1.1	1.5	1.9	2.3
6	4.0	4.3	4.7	5.3	5.9	1.0	1.3	1.8	2.4	2.8	0.9	1.2	1.5	2.0	2.4
7	4.0	4.3	4.8	5.4	6.1	1.0	1.4	1.9	2.5	3.0	1.0	1.2	1.6	2.0	2.5
8	4.1	4.4	4.9	5.6	6.3	1.1	1.5	2.1	2.7	3.3	1.0	1.3	1.7	2.2	2.6
9	4.2	4.6	5.1	5.9	6.7	1.2	1.7	2.4	3.2	3.9	1.1	1.4	1.9	2.4	2.8
10	4.3	4.7	5.4	6.2	7.1	1.4	2.2	3.3	4.5	5.5	1.3	1.6	2.1	2.6	3.1
11	4.5	5.0	5.7	6.7	7.8	1.9	3.1	4.9	6.9	8.7	1.4	1.8	2.3	2.9	3.4
12	4.8	5.4	6.2	7.4	8.6	2.6	4.4	7.1	10.4	13.4	1.6	2.0	2.6	3.2	3.8
13	5.2	5.9	6.8	8.2	9.5	3.6	6.0	9.7	14.4	19.0	1.8	2.3	2.9	3.5	4.1
14	5.7	6.4	7.6	9.0	10.5	4.9	7.8	12.5	18.5	24.3	2.1	2.5	3.1	3.9	4.5
15	6.1	7.0	8.2	9.7	11.2	6.9	10.1	15.3	21.9	28.4	2.3	2.8	3.4	4.2	4.8
16	6.6	7.5	8.8	10.4	11.9	9.7	13.0	18.1	24.4	30.7	2.6	3.1	3.7	4.5	5.1
17	7.1	8.1	9.5	11.1	12.6	13.7	16.7	21.0	26.3	31.4	2.8	3.4	4.1	4.8	5.4
18	7.7	8.7	10.2	11.9	13.4	18.7	21.0	24.1	27.6	30.7	3.1	3.7	4.4	5.1	5.8

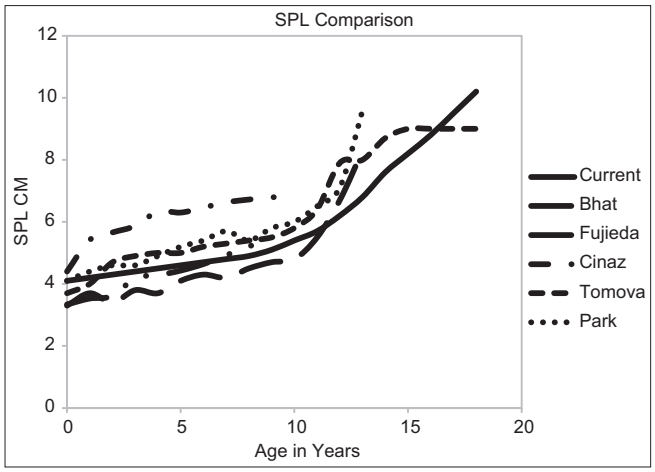

Figure 1: Comparison of SPL described by various studies with current study

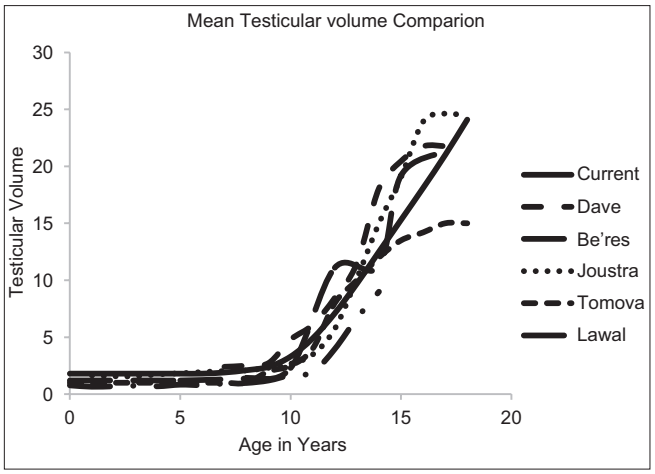

Figure 2: Comparison of testicular volumes described by various studies with current study

Table 3: Testicular volume and SPL at different Tanner stage

Parameter	Mean age	Testicular volume	SPL
	Mean age (SD)	Mean (SD)	Mean (SD)
Axillary hair			
2	14.6 (1.7)	14.8 (5.5)	8.1 (1.4)
3	16.4 (1.3)	23.2 (2.7)	9.8 (1.5)
Pubic hair			
2	12.7 (1.7)	8.1 (3.6)	6.7 (1.2)
3	14.7 (1.6)	14.3 (4.4)	8.3 (1.3)
4	15.7 (1.5)	19.3 (4.2)	8.9 (1.3)
5	16.5 (1.2)	24.1 (1.8)	9.9 (1.5)
Genital stage			
2	11.5 (1.4)	5.8 (2.4)	6.1 (0.9)
3	14.3 (1.6)	11.8 (3.7)	7.6 (1.1)
4	15.1 (1.5)	17.2 (3.6)	8.7 (1.2)
5	16.4 (1.3)	23.5 (2.8)	9.8 (1.5)

Fujieda *et al.* ($n = 420$)[13] at 11–12 years. We found a gradual and progressive increment in SPL till the age of 18 years. Gabrich *et al*.[17] reported RSL max (real length of flaccid penis fully stretched) of 5.1 ± 0.8, 7.4 ± 1.1, and 14.5 ± 1.6 cm at 1, 10, and 18 years, respectively, which is much higher than current and most other studies. This variation may be attributed to methodology, geography, and ethnic differences.

Testicular volume in infancy has been reported to be higher by Lawal *et al.* ($n = 450$)[18] (1.7 ml), similar to the present study (1 ml) by Tomova *et al*.[12] During prepubertal years, we found minimal growth of testicular volume till 9 years of age and rapid increase was observed from 11 till 18 years of age; these results are in line with previously reported studies by Lawal, Tomova, Joustra ($n = 769$), and Dave *et al.* ($n = 1000$).[3,12,18] The critical volume of 4 ml (which suggests the onset of puberty) was attained by boys in our study at 11 years which is similar to the study by Dave[3] and Joustra *et al.*[19] and was attained a bit later in studies by Lal ($n = 1000$)[2], Beres ($n = 1985$)[20], Tomova (12 years),[12] and Largo *et al.* ($n = 142$) (14 years).[21] Testicular volume of 12 ml (where a boy gets a growth spurt of puberty)[22] was reached at 14 years of age in our study which was similar to that in the study by Tomova *et al*.[12] Mean testicular volume at 18 years was smaller in the current study than in studies by Lawal,[18] Dave,[3] Largo,[21] Beres,[20] and Tomova *et al*.[12] and was similar to the study by Joustra *et al*.[12] with almost similar range (19–32 ml). Though testicular volume and length continued to grow even at 18 years of age, a substantial change in testicular size has been reported by Tomova,[12] Joustra,[19] Beres,[20] and Dave *et al*.[3] between 12 and 16 years which was not been observed by us. Boys in our study showed consistent increment in testicular volume with increasing age till 18 years. The higher testicular volume in current study is possibly due to minipuberty and maternal hormones; these have been documented to influence the testicular volume.[23,24]

Studies on testicular length are limited in literature. In many clinical situations, an orchidometer to measure testicular volume accurately is not available; in these circumstances, a ruler may be used to measure testicular length. Hence, in this study along with testicular volume, we have also described corresponding testicular length. The testicular volume of 4, 10, 12, 15, 20, and 25 in our study subjects corresponded to testicular length of 2.4, 2.8, 3, 3.2, 3.9, and 4.5 cm, respectively. In a study by Lawal *et al*.[18], testicular lengths were smaller than our study in pre-pubertal period and were comparable at 13 years of age. Keefer *et al*.[25] reported testicular length, which reduced after infancy and then showed a slow rise till puberty. This observation has however not been substantiated by other studies. Testicular lengths reported by Keefer *et al*.[25] at 2, 8–10, and 16–18 years (1.4, 2, and 5 cm, respectively) are similar to those noted in the present study (1.3, 1.9, and 4.4 cm).

The strength of our study is that we have accurately measured SPL and testicular volume and length; measurements were made by the same observers and data are presented from the neonatal period through pubertal years till 18 years of age.

Our limitations include the fact that ours was a cross-sectional study carried out at a single center. Measuring subjects above 18 years would have given an assessment of the average age till which these parameters continue to grow. Nevertheless, our study provides data on genital parameters in boys till 18 years which may be useful in assessment of these parameters in clinical situations to confirm normality and identify deviations such as in genital disorders.

In conclusion, we present here normative data for penile length, testicular volume, and testicular length from birth to 18 years in boys from western Maharashtra and their relationship with SMR. These data may be useful in assessment of these parameters in clinical situations with disorders of genitals.

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Conflicts of Interest

There are no conflicts of interest.

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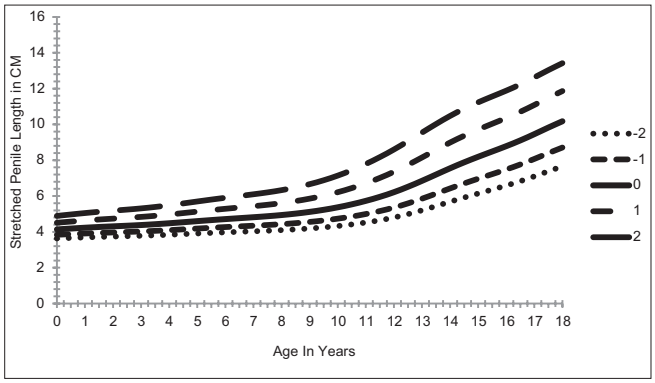
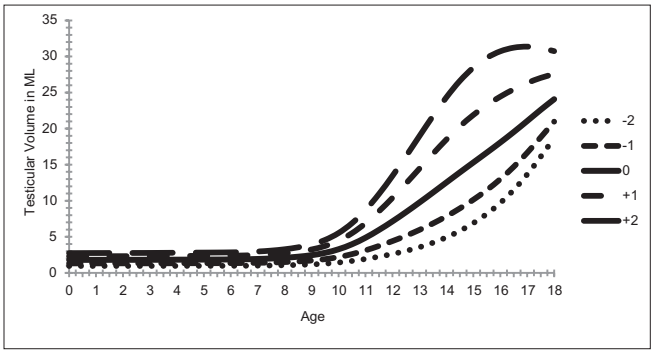
Appendix



Appendix 1: Percentile curves of Stretched Penile Length in boys 0-18 years



Appendix 2: Percentile curves of Testicular volume in boys 0-18 years