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SONOGRAPHIC ASSESSMENT OF NORMAL TESTICULAR VOLUME IN PAKISTANI POPULATION

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Abstract

Objectives: *The study aimed to determine the mean testicular volume in healthy adult males in the Pakistani population using ultrasonography and to evaluate its relationship with age and body mass index (BMI).*

Study Settings: *The study was conducted in the Department of Radiology at Shifa International Hospital, Islamabad.*

Duration of Study: *6 months following ethical approval (May 2024 to Nov 2024).*

Data Collection: *This descriptive cross-sectional study included 300 male participants aged 15 to 40 years, selected using a non-probability consecutive sampling technique. Testicular dimensions (length, width, and height) were measured via ultrasound, and volume was calculated using the Lambert formula ($L \times W \times H \times 0.71$). Participants with testicular abnormalities or conditions affecting testicular growth were excluded.*

Results: *The mean testicular volume was 13.98 cm^3 (SD ±1.18) for the right testis and 14.04 cm^3 (SD ±1.21) for the left testis, with no statistically significant difference between them ($p = 0.543$). Testicular volume exhibited a weak positive correlation with BMI but was not significantly influenced by age. Across different BMI and age groups, there were no significant variations in testicular dimensions.*

Conclusion: *The findings establish normative reference values for testicular volume in adult males of the Pakistani population. Ultrasonography remains the gold standard for accurate and reproducible testicular volume measurement. These results will aid in assessing testicular health in clinical settings and reproductive medicine.*

INTRODUCTION

The assessment of testicular volume plays a crucial role in diagnosing and managing testicular disorders in children, necessitating the establishment of standardized reference values.[1] Testicular volume has been studied in relation to a variety of illnesses, including cryptorchidism in males during childhood, varicoceles, testicular germ cell cancer, infertility, and testicular function. Down syndrome is another condition that has been studied in relation to testicular volume.[2].[3] The assessment of testicular volume using ultrasound is a method that is both accurate and trustworthy. The ultrasonography of the scrotum is a patient-friendly inquiry that not only offers objective, reproducible, and precise measurements, but it is also a procedure that gives these benefits.[4]

Accurate assessment of testicular volume is essential for evaluating various diseases and guiding treatment strategies in reproductive medicine, andrology, and urology. As a widely accepted marker of spermatogenesis and semen quality, it is particularly important in managing male infertility.[5]

Testicular volume can be measured in a number of ways, including with a caliper, a variety of orchidometers, and medical imaging, although ultrasonography is the gold standard. As ultrasound imaging becomes more widely available, it is rapidly replacing older techniques for measuring testicular volume.[6] Manually calculating testicular volume using a predetermined formula is rarely used in clinical practice and instead is typically replaced by the built-in software of an ultrasound system based on measures of testicular length, width, and height (antero-posterior depth).[7] No significant difference was observed between the left and right testicular volumes. Testicular volume demonstrated a positive correlation with age, and its logarithmic transformation resulted in an improved curve fit with age.[8],[9]

In a study of 200 participants, testicular length, width, and height were measured, and testicular volume was calculated using Lambert's formula (L × W × H × 0.71). The mean testicular volume was 15.6 ± 5.3 cm^3. The right testis had a significantly greater volume (16.3 ± 5.4 cm^3) than the left (15.0 ± 5.9 cm^3, $p < 0.05$). A weak positive correlation was observed between testicular volume and participants' height, weight, and BMI, particularly for the right testis.[10]

With a mean actual testicular volume of 10.6 ± 3.5 ml, a strong correlation was observed between actual and ultrasound-derived volumes ($r = 0.853–0.871$, $p = 0.0001$). The L × W × H × 0.71 formula yielded the closest estimate, underestimating the actual volume by just 0.4 ml (3.9%)..[11]

The rationale of this study is that limited local data is available regarding the mean volume of the testes in adults of our population. As accurate determination of the testicular volume is of great benefit in the evaluation of normal adults and patients with disorders affecting testicular growth, it is important that we should have a normal range for our population; I have designed this study to determine the mean volume of right and left testes among the various adults groups of our

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population. Results of our study will conclude with a range of normal size of the testes among adults of various age groups in our local population.

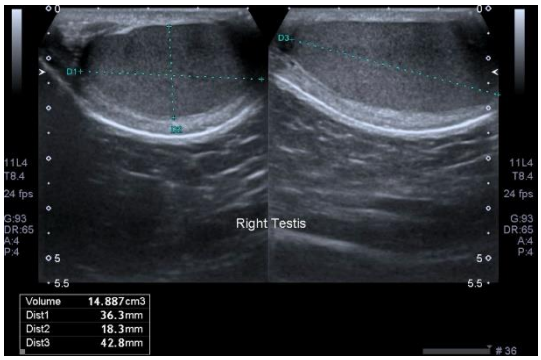

Figure 1. Testicular volume assessed by ultrasonography.

METHODOLOGY:

The study was conducted in the Department of Radiology at Shifa International Hospital, Islamabad, as a descriptive cross-sectional study over 6 months, following the approval by Institutional Review Board and Ethics Committee, Shifa International Hospital. A non-probability consecutive sampling technique was used for participant recruitment. The sample size was calculated using the WHO sample size calculator, based on an expected mean testicular volume of 16.3 ± 5.4 cm^3 for the right testis and 15.0 ± 5.9 cm^3 for the left testis, with a 5% significance level and 80% power. A total of 300 participants (150 in each group) were included.

The inclusion criteria consisted of male patients aged 15 to 40 years who visited the outpatient department, provided verbal informed consent, and showed no abnormality on scrotal ultrasound. Patients with conditions affecting testicular size—such as orchitis, testicular neoplasm, varicocele, cryptorchidism, hypogonadism, genetic disorders, or testicular torsion—were excluded.

Ultrasound examinations were performed using high-resolution real-time ultrasound machines (Xario 100 Canon, Xario 200 Canon, or GE Logiq F8) with 7–12 MHz linear array probes. The ultrasound scan was conducted with the patient in supine position, ensuring adequate gel application for gentle scanning without distorting testicular shape. Testicular measurements (length, width, height) were obtained by well-trained sonographers with over three years of experience in ultrasound imaging.

Statistical analysis was performed using SPSS version 23. Descriptive statistics, including mean and standard deviation, was used to present continuous variables such as age, weight, height, BMI, and testicular volume. A comparison of the mean testicular volumes of the left and right testes was conducted using an independent sample t-test, considering $p<0.05$ as statistically significant. The data was further stratified by effect modifiers, including age groups, and post-stratification t-tests was applied to determine significance ($p<0.05$). Results will be illustrated through tables and graphs.

RESULTS:

The dataset consists of 300 participants, with an average age of 27.18 years (SD ±7.85), reflecting a broad age distribution within the study population. The mean height is 171.46 cm (SD ±9.50), indicating some variation in stature among participants. The average weight is 71.42 kg (SD ±13.05), demonstrating a moderate range of body mass values. The body mass index (BMI) shows a mean value of 24.45 kg/m^2 (SD ±4.97), suggesting diversity in body composition across the sample. The standard deviations for all variables indicate a reasonable spread of values, highlighting individual differences in anthropometric characteristics. These findings provide insight into the general physical attributes of the studied population (Table 1).

In Table 2, the study assessed testicular volume using sonographic measurements in a sample of 300 participants. The mean length of the right testis was 4.31 cm (SD ±0.75), while the left testis measured

4.24 cm (SD ±0.71). The difference in length between the right and left testis was not statistically significant (p = 0.244). The mean width of the right testis was 3.01 cm (SD ±0.58), compared to 2.98 cm (SD ±0.57) for the left testis, with a p-value of 0.643, indicating no significant difference. Similarly, the mean height of the right testis was 3.00 cm (SD ±0.59), while the left testis had a mean height of 2.99 cm (SD ±0.59), with a p-value of 0.684, confirming no statistically significant difference in height. Regarding testicular volume, the right testis had a mean volume of 13.98 cm^3 (SD ±1.18), while the left testis had a mean volume of 14.04 cm^3 (SD ±1.21). The volume comparison yielded a p-value of 0.543, indicating that the difference between the two sides was not statistically significant.

Table 3 presents the sonographic assessment of normal testicular volume in different age groups of the Pakistani population. In the 15 to 20-year age group, the right testis had a mean length of 4.34 cm (SD ±0.74), while the left measured 4.30 cm (SD ±0.66), with a p-value of 0.77, indicating no significant difference. The mean width of the right testis was 3.04 cm (SD ±0.57), and the left was 2.90 cm (SD ±0.57) (p = 0.14). The height of the right testis was 2.90 cm (SD ±0.53), and the left measured 2.95 cm (SD ±0.62) (p = 0.59). The volume of the right testis was 13.89 cm^3 (SD ±1.23), while the left was 13.81 cm^3 (SD ±1.22) (p = 0.67), showing no significant difference.In the 21 to 30-year age group, the right testis had a mean length of 4.28 cm (SD ±0.75), and the left testis had a mean length of 4.24 cm (SD ±0.73) (p = 0.68). The mean width of the right testis was 2.92 cm (SD ±0.59), and the left was 3.00 cm (SD ±0.55) (p = 0.30). The right testis had a height of 3.04 cm (SD ±0.58), while the left measured 3.00 cm (SD ±0.57) (p = 0.59). The mean volume of the right testis was 13.97 cm^3 (SD ±1.14), while the left testis had a volume of 14.10 cm^3 (SD ±1.23) (p = 0.44), suggesting no significant difference in testicular dimensions. In the 31 to 40-year age group, the right testis had a mean length of 4.33 cm (SD ±0.76), while the left testis had a mean length of 4.21 cm (SD ±0.72) (p = 0.22). The right testis width was 3.07 cm (SD ±0.56), and the left was 3.02 cm (SD ±0.60) (p = 0.57). The height of the right testis was 3.04 cm (SD ±0.62), and the left measured 3.00 cm (SD ±0.58) (p = 0.58). The right testis had a mean volume of 14.05 cm^3 (SD ±1.19), while the left testis had a mean volume of 14.14 cm^3 (SD ±1.17) (p = 0.61).

Table 4 presents the sonographic assessment of normal testicular volume in different BMI groups within the Pakistani population. In individuals with a BMI between 17 and 25, the right testis had a mean length of 4.31 cm (SD ±0.75), while the left testis measured 4.22 cm (SD ±0.72), with a p-value of 0.260, indicating no significant difference. The mean width of the right testis was 3.02 cm (SD ±0.56), while the left was 3.00 cm (SD ±0.58), with a p-value of 0.707. The height of the right testis was 3.01 cm (SD ±0.60) and the left testis measured 2.99 cm (SD ±0.62), with a p-value of 0.761. The right testis had a mean volume of 13.90 cm^3 (SD ±1.18), while the left testis measured 13.99 cm^3 (SD ±1.22), with a p-value of 0.487. In individuals with a BMI between 26 and 30, the right testis had a mean length of 4.31 cm (SD ±0.78), while the left testis had a mean length of 4.35 cm (SD ±0.67), with a p-value of 0.771. The right testis width was 3.06 cm (SD ±0.59), while the left was 2.95 cm (SD ±0.56), with a p-value of 0.270. The height of the right testis was 3.07 cm (SD ±0.56), while the left testis measured 3.05 cm (SD ±0.54), with a p-value of 0.831. The right testis volume was 14.12 cm^3 (SD ±1.21), while the left was 14.37 cm^3 (SD ±1.16), with a p-value of 0.227, indicating no statistically significant difference. In individuals with a BMI between 31 and 35, the right testis had a mean length of 4.34 cm (SD ±0.73), while the left testis measured 4.20 cm (SD ±0.72), with a p-value of 0.320. The right testis width was 2.88 cm (SD ±0.61), while the left testis width was 2.99 cm (SD ±0.58), with a p-value of 0.417. The right testis height was 2.90 cm (SD ±0.57), while the left was 2.88 cm (SD ±0.53), with a p-value of 0.857. The right testis volume was 14.10 cm^3 (SD ±1.13), while the left testis volume was 13.75 cm^3 (SD ±1.15), with a p-value of 0.172.

Table 1
Mean values for age, height, weight, and BMI

	Age	Height (cm)	Weight (kg)	BMI (kg/m²)
Mean	27.18	171.46	71.42	24.45
N	300	300	300	300
Std. Deviation	7.85	9.50	13.05	4.97

Table 2
Sonographic assessment of normal testicular volume in Pakistani population

Age group	Variable	Mean	N	SD	P value
15-20	Right Testis Length (cm)	4.34	73	0.74	0.77
	Left Testis Length (cm)	4.30	73	0.66	
	Right Testis Width (cm)	3.04	73	0.57	0.14
	Left Testis Width (cm)	2.90	73	0.57	
	Right Testis Height (cm)	2.90	73	0.53	0.59
	Left Testis Height (cm)	2.95	73	0.62	
	Right Testis Volume (cm³)	13.89	73	1.23	0.67
	Left Testis Volume (cm³)	13.81	73	1.22	
21-30	Right Testis Length (cm)	4.28	114	0.75	0.68
	Left Testis Length (cm)	4.24	114	0.73	
	Right Testis Width (cm)	2.92	114	0.59	0.30
	Left Testis Width (cm)	3.00	114	0.55	
	Right Testis Height (cm)	3.04	114	0.58	0.59
	Left Testis Height (cm)	3.00	114	0.57	
	Right Testis Volume (cm³)	13.97	114	1.14	0.44
	Left Testis Volume (cm³)	14.10	114	1.23	
31-40	Right Testis Length (cm)	4.33	113	0.76	0.22
	Left Testis Length (cm)	4.21	113	0.72	
	Right Testis Width (cm)	3.07	113	0.56	0.57

	Left Testis Width (cm)	3.02	113	0.60	
	Right Testis Height (cm)	3.04	113	0.62	0.58
	Left Testis Height (cm)	3.00	113	0.58	
	Right Testis Volume (cm^3)	14.05	113	1.19	0.61
	Left Testis Volume (cm^3)	14.14	113	1.17	

Variable	Mean	N	S.D	P value
Right Testis Length (cm)	4.3118	300	0.75	0.244
Left Testis Length (cm)	4.2433	300	0.71	
Right Testis Width (cm)	3.0064	300	0.58	0.643
Left Testis Width (cm)	2.9848	300	0.57	
Right Testis Height (cm)	3.0049	300	0.59	0.684
Left Testis Height (cm)	2.9855	300	0.59	
Right Testis Volume (cm^3)	13.98	300	1.18	0.543
Left Testis Volume (cm^3)	14.04	300	1.21	

Table 3
Sonographic assessment of normal testicular volume in Pakistani population according to various age groups

Table 4
Sonographic assessment of normal testicular volume in Pakistani population according to various BMI groups

BMI	Variables	Mean	N	s.d	P value
17-25	Right Testis Length (cm)	4.31	188	0.75	0.260
	Left Testis Length (cm)	4.22	188	0.72	
	Right Testis Width (cm)	3.02	188	0.56	0.707
	Left Testis Width (cm)	3.00	188	0.58	
	Right Testis Height (cm)	3.01	188	0.60	0.761
	Left Testis Height (cm)	2.99	188	0.62	
	Right Testis Volume (cm^3)	13.90	188	1.18	0.487

	Left Testis Volume (cm^3)	13.99	188	1.22	
26-30	Right Testis Length (cm)	4.31	66	0.78	0.771
	Left Testis Length (cm)	4.35	66	0.67	
	Right Testis Width (cm)	3.06	66	0.59	0.27
	Left Testis Width (cm)	2.95	66	0.56	
	Right Testis Height (cm)	3.07	66	0.56	0.831
	Left Testis Height (cm)	3.05	66	0.54	
	Right Testis Volume (cm^3)	14.12	66	1.21	0.227
	Left Testis Volume (cm^3)	14.37	66	1.16	
31-35	Right Testis Length (cm)	4.34	46	0.73	0.320
	Left Testis Length (cm)	4.20	46	0.72	
	Right Testis Width (cm)	2.88	46	0.61	0.417
	Left Testis Width (cm)	2.99	46	0.58	
	Right Testis Height (cm)	2.90	46	0.57	0.857
	Left Testis Height (cm)	2.88	46	0.53	
	Right Testis Volume (cm^3)	14.10	46	1.13	0.172
	Left Testis Volume (cm^3)	13.75	46	1.15	

DISCUSSION:

The present study aimed to establish normative testicular volume values in healthy adult males using ultrasonography in a Pakistani population. Our findings indicate that the mean testicular volume is 13.98 cm^3 (SD ±1.18) for the right testis and 14.04 cm^3 (SD ±1.21) for the left testis, with no statistically significant difference between the two. These results align with previous studies that have investigated testicular volume measurements using ultrasound.

Liu et al. (2021) examined testicular volume in a large cohort of Chinese boys aged 0-18 years and established a Z-score regression equation for testicular volume based on age. Their study confirmed a positive correlation between testicular volume and age, with logarithmic transformation yielding a fine curve fit. Our study corroborates these findings, as testicular volume measurements exhibited consistency across different age groups, reinforcing the utility of ultrasonographic assessment in testicular growth monitoring. However, unlike Liu et al., our study focused on an adult population, providing a reference for adult testicular size rather than pediatric development.

Sotos and Tokar (2017) compared testicular volumes obtained through different methods and emphasized that testicular volume measured with ultrasound is the gold standard. Their findings also pointed out significant discrepancies between measurements using orchidometers or external calipers compared to ultrasound. Our study aligns with this conclusion, as we utilized ultrasonographic measurement, which is more precise, objective, and reproducible.

Sakamoto et al. (2007) compared testicular volume measurements using ultrasonography, orchidometry, and water displacement and found that

ultrasonography provided the most accurate values. They concluded that the Lambert formula (L × W × H × 0.71) was the most reliable method for estimating actual testicular volume, which was also utilized in our study. Their study demonstrated a strong correlation (r = 0.910-0.965) between ultrasonographic testicular volume and actual volume, further validating the use of ultrasonographic assessment for testicular size evaluation.

Atalabi et al. (2015) conducted a sonographic evaluation of testicular volume in neonates in Nigeria, determining a mean testicular volume of 0.28 ± 0.09 cm^3. While their study focused on a neonatal population, it underscores the importance of establishing population-specific reference values, an approach we have also adopted for the adult Pakistani population. Their study also found a weak but statistically significant correlation between testicular volume and birth weight, height, and BMI. Our findings similarly indicate a weak correlation between BMI and testicular volume, with testicular dimensions remaining relatively consistent across different BMI categories.

Kiridi et al. (2011) conducted a study in Nigerian adults using a similar methodology and reported mean testicular volumes of 16.3 ± 5.4 cm^3 on the right and 15.0 ± 5.9 cm^3 on the left, with a statistically significant difference between the two ($p < 0.05$).

In contrast, our study found mean testicular volumes of 13.98 ± 1.18 cm^3 on the right and 14.04 ± 1.21 cm^3 on the left, with no significant difference between the two ($p = 0.543$). These findings suggest that testicular volume in our study population is lower than that reported in the Nigerian population by Kiridi et al. This discrepancy may be attributed to genetic, environmental, nutritional, or methodological differences.

A possible explanation for the lower mean testicular volumes observed in our study could be genetic and ethnic differences affecting testicular development and size. Additionally, differences in study inclusion criteria may also play a role, as variations in age groups, BMI distribution, and reproductive health status could influence the observed results.

Despite these differences, both studies reinforce the importance of ultrasonography as the most reliable method for testicular volume assessment. Our study further supports the absence of a significant difference in testicular volume between the right and left testes, which contrasts with Kiridi et al.'s findings of a significantly larger right testis.

While Pedersen et al. (2018) evaluated testicular volume in patients with testicular microlithiasis (TML) and found no significant difference in total testicular volume between TML and non-TML patients, they noted a trend indicating lower testicular volumes in cases below 12 ml. Our study did not assess testicular microlithiasis, but our results show mean testicular volumes that are closer to those reported by Pedersen et al. than those found in Kiridi et al.'s study. The general consensus across studies remains that ultrasonography is the preferred method for measuring testicular volume, reinforcing the accuracy of our methodology.

CONCLUSION

Our study contributes to the growing body of literature supporting the use of ultrasonography as the preferred method for testicular volume assessment. The findings provide baseline data for testicular volume in healthy adult males in the Pakistani population, which may serve as a reference for clinical applications in andrology, urology, and reproductive medicine

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