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SONOGRAPHIC DETERMINATION OF NORMAL TESTICULAR VOLUME IN AN ADULT NIGERIAN POPULATION

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ABSTRACT

Aim of study: The testicular volume is an essential parameter in the workup of patients with testicular and androgenic disorders. The aim of the study is to establish baseline data for testicular volume measurements using ultrasonography in an apparently healthy adult population in Nigeria.

Material and methods: This was a prospective cross-sectional study carried out in Abuja, Nigeria. A total of 306 apparently healthy adult males with no evidence of testicular pathology and who consented to the study were recruited. The longitudinal, AP and transverse diameters of the Right and Left testes were obtained with a standard B-K ultrasound equipment with 12MHz linear transducer. Using the Lambert's formula (length x Weight x Height x 0.71), the testicular volume was calculated. The data obtained were analyzed using Graph Pad. A $p \leq 0.05$ was considered statistically significant

Results: The mean age of the participants was 42.52± 12.42years. The mean total testicular volume was 17. 74±6.64ml. The volume of the right testicle was significantly greater than the left testicle ($p=0.0177$). The mean volume of the right testicle was 18.46±6.42ml while 17.01±6.78ml was the mean for the left testicle.

Conclusion: The study has provided baseline values in adult population which can serve as reference values during the assessment of various testicular abnormalities and male infertility evaluation.

INTRODUCTION

The testes are the chief organ for fertility in males. They are mainly responsible for the production of spermatozoa and the male sex hormone, testosterone. The seminiferous tubules which make up about 80-90% of the testicular mass, are chiefly responsible for the production of spermatozoa [1,2].

The testicular volume is an essential parameter in the diagnosis and clinical management of many testicular abnormalities. In the adult male, it is a significant factor in the assessment of spermatogenic activities and also an integral aspect of male infertility evaluation [1]. Previous studies have demonstrated the relationship between infertility and testicular volume [3,4]. In pediatrics

and adolescents, it is a major factor in pubertal development evaluation as well as a clinical indicator for puberty. This is because the first visible sign of puberty is testicular enlargement [1,5]. The volume of the testes is also essential in the diagnosis and management of the effects of cryptorchidism and varicocele; and also valuable in evaluating macroorchidism from such conditions as fragile X syndrome, follicle stimulating hormone (FSH) secreting pituitary adenoma, lymphomas, chronic hypothyroidism; and also microorchiditic conditions such as Klinefelter's syndrome, and recurrent torsion. [6].

The size of the testicles can affect the testicular function and researchers have established a direct correlation between them [3,4]. This is probably so because the seminiferous tubules and germ cells make up about 90% of the testicular size, therefore, reduction of these cells either as a result of dysplasia or damage will result in the reduction of testicular size and consequently, a reduction in spermatogenesis [3,7]. This emphasizes the importance of testicular volume in the management of testicular disorders especially male infertility [3].

Accurate determination of the testicular volume is important during the assessment of patients with testicular and androgenic disorders especially as the testicular size can be affected by a number of local and systemic pathologies [2,6,8]. Traditionally, the testicular volume has been assessed using orchidometers and calipers but these tools often overestimate the volume thereby raising inter- and intra-observer objectivity concerns. Radiological methods like CT and MRI are more accurate but they are much more expensive, not easily available and associated with ionizing radiation or claustrophobic challenges. [6]. Ultrasound on the contrary, is nonionizing and well suited for the evaluation of the testicles. It is an accurate, reproducible, safe, easily available and affordable method for testicular volume evaluation and can detect small volume changes [2,6].

Many studies on normal testicular volume and its relationship with various parameters have been carried out [9,10,11,12,13], however, there has been conflicting results regarding values to serve as reference values. Moreover, the critical minimum testicular volume that assures adequate function is not clear. The aim of this study therefore is to sonographically determine the testicular volume in apparently healthy Nigerian adult males in order to generate values that could serve as reference values during the workup of male fertility and testicular abnormalities.

METHODS

This prospective and cross-sectional study was conducted in the ultrasound unit of Chivar Specialist Hospital and Urology Centre Limited, Abuja, Nigeria. Three hundred and six apparently healthy adult Nigerian males aged between 20-79 years, who met the selection criteria and consented to the study were recruited. The subject selection criteria included were patient absence of clinical suspicion of scrotal lesion, varicocele, malignancy or other pathologies and no history of scrotal surgery, and on ultrasound examination, no anomalies were seen, and whose semen analysis were also within normal limits qualified for the study. Patients with conditions which included diabetes mellitus, hypertension as well as chronic smokers and alcoholics were also excluded from the study. The study was approved by the Federal Capital Territory Health Research Ethics Committee. Also, informed consent was obtained from participating individuals and confidentiality of all information obtained from all subjects was assured.

A BK medical ultrasound scanner, model type Pro focus 2202 with a high resolution 12MHz linear probe was used to scan the subjects. The weight was measured using a Hana's analog scale while height was measured using a standard stadiometer.

Using the protocol according to Aziz and Lewis-Jones[14] and Sanders and Winter [15], the scan was carried out with the patient in the supine position, exposing the scrotum with the lower thighs and the upper abdomen covered. The patient was asked to support the penis against the abdomen, and with the thighs adducted, the scrotum and its contents are made to rest above the proximal thighs. Care was taken to ensure the testis was not compressed during measurement to avoid undersizing the anteroposterior diameter and oversizing the sagittal diameter. The testis, epididymal head, body and tail as well as the contents of the spermatic cord were examined sequentially, ensuring that there were no pathologies seen.

To measure the testicular volume in three dimensions, an image of the testicle was taken in

the longitudinal axis at the level of the mediastinum testis, in which both the longitudinal diameter (length), from lateral to medial, and anteroposterior diameter (height), from superior to inferior, were measured. Transverse imaging was performed and the transverse diameter (width) from lateral to medial was measured at the maximum transverse axis (Fig 1).

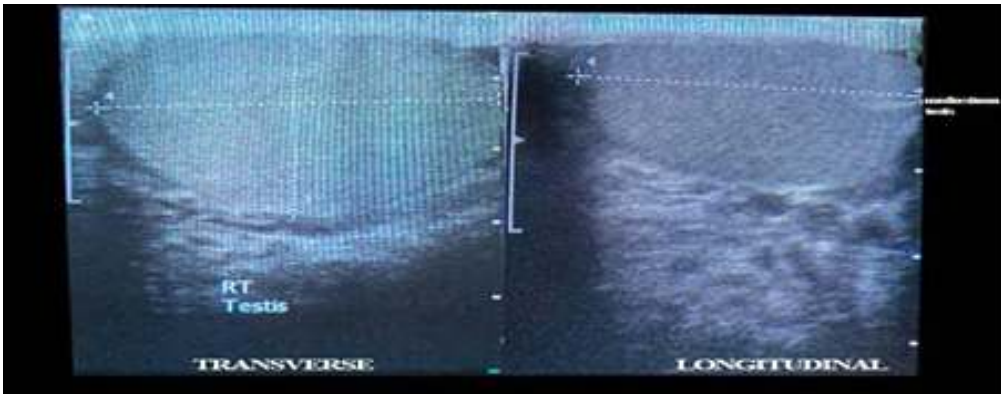

FIG 1: Sonogram Showing the Longitudinal, Antero-Posterior and Transverse Diameters of the Testis

All measurements were obtained thrice by one sonographer and the mean values were recorded. The testicular volume was calculated using the Lambert formula: L x W x H x 0.71 which has been recognized as the most accurate formula for evaluating testicular volume [16].

All statistical analyses were performed using GraphPad Prism version 7.0 (GraphPad, San Diego, CA, USA). Data obtained (weight, height, BMI and testicular volume) were expressed as Mean ± S.D (Standard deviation). Critical value or test of probability less than 0.05 ($p < 0.05$) was considered statistically significant. Prior to the test of significance, D'Agostino-Pearson omnibus normality test was used to test for normality of data. Intra and inter class correlation were used to determine intra and inter observer reliability. Independent Student T-test (two-tailed) was used to compare mean differences in testicular volumes of the two ipsilateral (Right & Left) testicles and determine if there was any statistically significant difference between the testicular volume of the two testicles. One-way Analysis of variance (ANOVA) was used to compare mean differences among groups. Pearson's product moment correlation was used to test for correlation of testicular volumes (Right, Left and Mean testicular volume) with other variables (Age, weight, height and BMI)

RESULTS

The age range of the study participants was 23-76 years and the mean age was 42.52 ± 12.422 years. The highest number of participants were in the 30 - 39 age group, (n=113; 36.9%), while the age group of 70 – 79 years had the lowest number of subjects, (n=9; 2.9%) as shown in Table 1a.

Table 1a: Characteristics of the Subjects

Age(Mean ± S.D)	**Minimum**	**Maximum**	**BMI (Mean ± S.D)**	**Minimum**	**Maximum**
42.52 ± 12.422	**23**	**76**	**28.0433 ± 4.3594**	**18.93**	**45.28**
Age groups (years)	**Number sampled**	**Percentage (%) frequency**	**BMI groups (kg/m^2)**	**Number sampled**	**Percentage (%) frequency**
20 – 29	42	13.7%	Underweight	0	0%
30 – 39	113	36.9%	Normal weight (18.5 – 24.99)	80	26.1%
40 – 49	68	22.2%	Pre-obesity (25.0 – 29.99)	125	40.8%
50 – 59	54	17.6%	Obesity class I (30.0 – 34.99)	79	25.8%

Age(Mean ± S.D)	**Minimum**	**Maximum**	**BMI (Mean ± S.D)**	**Minimum**	**Maximum**
42.52 ± 12.422	**23**	**76**	**28.0433 ± 4.3594**	**18.93**	**45.28**
Age groups (years)	**Number sampled**	**Percentage (%) frequency**	**BMI groups (kg/m^2)**	**Number sampled**	**Percentage (%) frequency**
60 – 69	20	6.5%	Obesity class II (35.0 – 39.99)	19	6.2%
70 – 79	9	2.9%	Obesity class III	3	1.0%
Total	**306**	**100%**		**306**	**100%**

The highest number of participants were in the 30 -39 age group, (n=113; 36.9%)

The mean height observed in the participants was 174.8 ± 15.53cm, and the range obtained was 145-195cm. The mean weight of study subjects was 85.78 ± 15.43kg and the minimum and maximum weight recorded was 53kg and 127kg respectively (Table 1b). The mean BMI of the study subjects was 28.0433 ± 4.3594 kg/m^2, and the range of BMI observed were 18.93 - 45.28 kg/m^2. With respect to BMI, the pre-obese group of subjects (25.0 – 29.99) constituted the highest number of subjects with frequency of 125 (40.8%) while subjects with Class III obesity (≥40) were the least subjects with frequency of 3 (1.0%) as depicted by Table 1a. The mean BSA recorded from the study was 2.02 ± 0.22 with minimum and maximum BSA of 1.00 and 2.60 respectively (Table 1b).

Table 1b: Weight, height and BSA of the study subjects

	Height (cm)	**Weight (Kg)**	**BSA (m^2)**
Minimum	145	53	1.00
Maximum	195	127	2.60
Range	145 – 195	53 – 127	1.00-2.60
Mean ± S.D	**174.8 ± 15.53**	**85.78 ± 15.43**	**2.02 ± 0.22**

The mean height, weight and BSA observed in the participants were 174.8 ± 15.53, 85.78 ± 15.43, and 2.02 ± 0.22 2.60 respectively.

The mean (±SD) of the transverse, AP and longitudinal diameters of the right testicle obtained in this study were; 30.00 ± 5.252mm, 22.01 ± 3.833mm and 38.04 ± 5.59mm respectively and the mean (±SD) transverse, AP and longitudinal diameters of the left testicle obtained from the subjects were 29.03 ± 4.759mm, 21.79 ± 4.127mm and 36.92 ± 6.357mm respectively (Table 2).

Table 2: Baseline data and comparison between right and left testicles

GROUPS	**Transverse (mm) Mean ± S.D**	**Anteroposterior (mm) Mean ± S.D**	**Longitudinal (mm) Mean ± S.D**	**Volume (cm^3) Mean ± S.D**	**Lower and Upper Limits at 95% C.I (cm^3)**	**Mean (R + L) testicular volume**
Right testicle (n=306)	30.00 ± 5.252	22.01 ± 3.833	38.04 ± 5.59	18.46 ± 6.423	7.89 - 29.03	17.74 ± 6.636
Left testicle (n=306)	29.03 ± 4.759	21.79 ± 4.127	36.92 ± 6.357	17.01± 6.787	5.85 - 28.17	
p-value	**0.0177***	**0.4955**	**0.0209***	**0.0071****		

The total mean testicular volume is 17.74 ± 6.636 cm^3 and significant differences is noted in the mean transverse and longitudinal diameters and the mean volume of both testicles.

The mean volume obtained for the right testicle was 18.46 ± 6.423cm^3 with a range of 6.9cm^3 – 31.9cm^3 and the mean testicular volume attained for the left testicle was 17.01± 6.787cm^3 with a range of 5.0cm^3 – 36.4cm^3. The cutoff points (lower and upper limits) obtained for the right mean testicular volume at 95% confidence interval (C.I) was 7.89 – 29.03cm^3 and the cutoff points obtained for the left mean testicular volume at 95% confidence interval (C.I) was 5.85 – 28.17cm^3. The mean total testicular volume for the right and left testicle obtained was 17.74 ± 6.636cm^3 (Table 2).

The right testicle was observed to be significantly larger than the left testicle. Statistically significant differences in the mean transverse diameter and longitudinal diameter of the right and left testicle were noted (p =0.0177 and 0.0209 respectively). Statistically significant difference (p=0.0071) in the mean testicular volume of the right and left testis was also observed. Table 2 further demonstrates the relationship.

The highest mean total testicular volume for both testicles was seen within the age range of 20-29 years, with its value being 19.40 ± 6.95cm^3 and the lowest was observed within the 70-79 years range (16.09 ± 2.72cm^3). Table 3 further illustrates these findings.

Table 3: Testicular volume and age

Age (years)	Right Testicular volume (cm^3) Mean ± S.D	Left Testicular volume (cm^3) Mean ± S.D	Mean Testicular volume (Right + Left) ± S.D
20 – 29	20.14 ± 6.39	18.66 ± 8.13	19.40 ± 6.95
30 – 39	18.66 ± 7.14	17.60 ± 6.11	18.33 ± 5.80
40 – 49	17.98 ± 5.86	15.81 ± 5.80	16.89 ± 5.43
50 – 59	17.32 ± 6.35	16.53 ± 7.65	16.93 ± 6.61
60 – 69	16.27 ± 6.80	17.12 ± 8.45	16.69 ± 7.47
70 – 79	18.37 ± 4.81	11.81 ± 4.75	16.09 ± 2.72
p-value	0.171	0.054	0.180
F-ratio	**1.559**	**2.206**	**1.532**

The highest mean total testicular volume for both testicles was seen within the age range of 20-29 years.

Correlation between age and mean testicular volume showed a weak negative correlation as observed in Table 4. No significant correlation was found between weight, BSA, BMI and mean testicular volume. Height however showed a very weak positive correlation with mean testicular volume. (Table 4).

Table 4: Correlation of Right and Left testicular volumes with age, weight, height, Body

Right Testicular volume	p-value (two-tailed)	Coefficient of correlation (r)	Left testicular volume	p-value	Coefficient of correlation (r)
Age	0.0309*	-0.1234	Age	0.0134*	-0.1414
Weight	0.7912	0.01519	Weight	0.2292	0.06906
Height	0.3007	0.05935	Height	0.0677	0.1048
Body Mass Index (BMI)	0.7536	-0.01801	Body Mass Index (BMI)	0.8434	0.01135
Body Surface Area (BSA)	0.6112	0.02917	Body Surface Area (BSA)	0.1086	0.09207

Age showed a significant but weak negative correlation with right and left testicular volume. Weight, BMI and BSA showed no significant statistical correlation with right and left testicular volumes.

Discussion

The testicular volume is an important clinical tool in the diagnosis and management of a variety of androgenic and testicular diseases and previous studies on infertile men have shown that it has a positive correlation with seminal fluid and hormonal assay [3,4,8]. Techniques used in the determination of the testicular size may include direct measurements using orchidometers or sonographic measurements. Ultrasound, being safe, cheap, available and reliable is fast becoming the technique of choice especially when the Lambert formula for calculating testicular volume is used. This formula has been identified as the most accurate [16] and was employed in this study.

In this study, the testicular volume of 306 apparently healthy men were measured in order to establish a reference value. The mean volume of the right testis was 18.46 ± 6.423cm^3 and it ranged from 6.9cm^3 – 31.9cm^3 while the mean volume of the left testis was 17.01± 6.787cm^3 ranging from 5.0cm^3 – 36.4cm^3. The total mean testicular volume for both right and left testes was 17.74 ± 6.636cm^3. This result is slightly different from previous studies among the Caucasians where approximately 20cm^3 was reported [17,18,19]. Findings of our study are quite similar to findings made on the Asian population which reported a total mean testicular volume of approximately 18cm3 and 10-25cm3 range [9,12,13,20,21]. The cause of racial differences in testicular volume is unclear but may be closely related to differences in the average body size, dietary customs and lifestyle, demographic and environmental factors [21,13].

Majority of the previous works done in Nigeria were mainly among neonates and children. However, Kiridi *et al* [16] obtained 16.3+5.3cm^3 and 15.0+5.9cm^3 for mean volume of the right and left testis respectively and the mean total testicular volume was 15.6+5.3cm^3 in an adult population in South-south, Nigeria. This appeared smaller than the volume we obtained in our study. Also Tijani *et al* [4] observed an average total testicular volume of 19.89cm^3 in apparently healthy South-western Nigerian population, with mean values of 19.84 cm^3 and 19.69 cm^3 on the right and the left, respectively. Reasons for such differences in Nigeria is unclear but may also be linked to geographical and ethnic differences.

It was also observed in this study that the mean right testicular volume was significantly larger than the mean left testicular volume (p= 0.0071), suggesting that the right testicle in most men are significantly larger than the left testicle. This is consistent with findings of other researchers [4,16,22]. This could be due to the fact that the pampiniform plexus of the veins are more prominent on the left, due to the sluggish drainage of the left testicular vein into left renal vein, resulting in an increased temperature in the left testis, with subsequent reduction in spermatogenesis and testicular volume on that side [16,22].

Results of this study also showed a weak negative correlation between the age of the subjects and the right testicular volume (p = 0.0309, r = -0.1234) as well as a weak negative correlation between the left testicular volume and the age of the subjects (p = 0.0134, r = -0.1414). The mean testicular volume also had a very weak negative correlation with age (p= 0.0011, r= -0.132). This suggests that, with an increase in age of the subjects, there was a decrease in testicular volume, although the differences were not statistically significant. This is in agreement with results of other authors [4,10,23,24]. From our findings, the volume was observed to be highest within the 20-30 age range and with an increase in age, there was a mild decrease in the mean total testicular volume of the study subjects, although these differences were not statistically significant. These findings like findings of other researchers, suggest that men are at their peak fertility at that period and as suggested by Ford et al, [25] that beyond age 50, the serum testosterone and spermatogenesis reduce

The cutoff values obtained from the study for the right mean testicular volume at 95% confidence interval were 7.89 – 29.03cm3 at the lower and upper limits respectively, and the cutoff values obtained for the left mean testicular volume at 95% confidence interval (C.I) was 5.85 – 28.17cm3 at the lower and upper limits respectively. These findings may imply that 95% of most adult males have a mean right testicular volume that is between 7.89 – 29.03cm3 and a mean left testicular volume that is between 5.85 –28.17cm3. This information is vital and may also serve as a basis for considering bilateral difference as a risk factor for testicular anomalies in adult males.

Conclusion

Our study provides baseline values for testicular volume in apparently healthy Nigerian men. A

mean testicular volume of 17.74 ± 6.636cm^3 was established. This can serve as reference value during the assessment of various testicular abnormalities and male infertility evaluation.

Conflict of Interest: The authors declare that there is no conflict of interest.

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