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Original Research Article

Assessment of Variations in Testicular Volumes among Healthy Adults Using Ultrasonography

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Abstract: *Introduction:* Assessment of testicular size is an essential and initial method for the evaluation of testicular function. For accurate measurement of testicular volume, ultrasonography is considered as most crucial radiological technique. Our study aims to determine variations in testicular volumes among healthy adults with the help of ultrasonography. ***Materials and Method:*** Our study was a prospective observational category study. It was carried out at the Department of Radiology, Chettinad Hospital and Research Institute, Kelambakkam, Chennai. This study was carried between August 2019 and August 2021. A total of 100 adult males aged 18 to 70 years were assessed to measure the testicular size, and Lambert's formula was used to calculate testicular volumes on both sides. The relationship between testicular volumes, anthropometric measurements and other characteristics of participants were also evaluated. ***Results:*** Lambert's formula was used, and the testicular volumes were determined. A total number of 100 adult males aged 18 to 70 years (median age 38 years) participated in this study. The mean testicular volume was recorded as 21.97 ± 5.89 cm^3 and 23.58 ± 5.62 cm^3 on the right and left sides of the testis, respectively. The differences on both sides of the volumes were statistically significant. There was also a statistically significant correlation between age, testicular volumes, right length, left length and left testicular width. ***Conclusions:*** The result from the present study shows that ultrasonography was the most accurate method for measuring the testicular volume and evaluating gonadal functions.

Key words: Ultrasonography, Testicular volume, Anthropometric measurements, Gonadal functions.

INTRODUCTION

The measurement of testicular volume in children, adolescents and adults are essential in the preliminary examinations for gonadal function since it correlates well with various testicular function indices. The testes are responsible for the production of spermatozoa and the secretion of testosterone in the man. Approximately 80–90% of the testicular volume is secreted by seminiferous tubules and germ cells [1, 2]. Thus, a reduction in the number of these cells is manifested in a reduction in testicular volume.

The assessment of testicular volume has been extensively studied in recent years. The testicular volume has traditionally been obtained using instruments such as the Prader or punched-out orchidometer. Currently, many measurement methods employed include callipers, orchidometry, and ultrasonography [3].

In the ultrasonography method, testicular volumes are measured by determining the anteroposterior diameter on transverse images of the left and right sides of the testis or by calculating testicular volumes using the three formulae:

1. The formula for a prolate ellipsoid: volume = Length × Width × Height × 0.52 (LWH0.52)
2. The formula for a prolate spheroid: Length × Width2 × 0.52 (LW2 0.52)
3. The Lambert formula: Length × Width × Height × 0.71 (LWH0.71)

Ultrasonography is the most readily available and accurate method of measuring testicular volume as determined by comparison with the actual volume. However, earlier many studies have shown that testicular volume measured by using ultrasonography varies widely depending on the formula used [1-5].

Reliable and accurate testicular volume is greatly beneficial in evaluating patients with disorders affecting testicular growth, development, and function. Studies in infertile men have shown that the testicular volume directly correlates to seminal fluid and sex hormone assay, just like the simple measurement of testicular length, width and depth [4–6]. A total testicular volume (i.e., summation of right and left) of 20 ml and more, as determined by ultrasound, indicates normal testicular function.

In adult males, testicular volume is measured, which is directly related to the spermatogenic activity. Testicular volume is related to various reproductive endocrine parameters. Measurement of testicular size and volume is connected with the assessment of male fertility. The seminiferous tubules comprise 70% to 80% of the testicular mass. The testicular volume is believed to be an index of spermatogenesis [7].

In contrast, testicular volume measurement in adolescent boys is vital in assessing the onset of puberty or pubertal development. It is also used to evaluate boys with various disorders affecting testicular growth and development, such as varicocele, cryptorchidism and after testicular torsion [7, 8].

A wide range of anthropometric parameters has been proposed in human subjects. They have been widely used as an index for measuring nutritional status, gonadal growth, development and functions and have been used to predict well-being and risk of some gonadal dysfunctions [9].

Therefore, the present study attempts to critically assess the accuracy of ultrasonography in measuring the testicular volume and verify the accuracy of the Lamberts formula for calculating the ultrasound-determined testicular volume in healthy adults.

MATERIALS AND METHODS

Our study was a prospective observational category study. The institutional scientific and ethical committee approved this study.

Recruitment of Subjects: This study was conducted during August 2019 and August 2021. It was carried out at the Department of Radiology, Chettinad Hospital and Research Institute, Kelambakkam, Chennai. A total of 100 healthy adult males aged 18 to 70 years were assessed to measure the testicular size, and Lambert’s formula was used to calculate testicular volumes on both sides. The relationship between testicular measurements and other participants’ characteristics was also evaluated.

A total of 100 healthy adult males aged 18 to 70 years (median age 38 years) were recruited for this study. Those who have willingly signed the informed consent form and self-declaration related that he does not suffer from any other metabolic disorders were considered for this study.

Subjects with a previous history of scrotal surgery, genital or scrotal abnormality and those being investigated for infertility were not considered for this study.

Patient position: Supine position for the ultrasonography of each subject was used.

Imaging examination: All the 100 subjects were evaluated with the help of the aid of the Linear 3-8mHz transducer from a GE voluson 730 expert ultrasound machine.

The sagittal length, width and transverse height were measured, all in centimetre (cm). The sagittal diameter, characterised by the mediastinum, was identified as an echogenic line running from the superior to the inferior pole of the testis. In sagittal diameter, the epididymis was projected separately from the testis. The epididymis was not included in the volume measurement. Lambert’s formula, W x H x L x 0.71, was then used to calculate the volume for both the right and left testes. The measurements were recorded on the questionnaire (datasheet) for each patient on each examination day.

Statistical analysis: The consolidated and compiled data were analysed with SPSS statistics software.

RESULTS

In this study, the subjects' mean (±SD) age was 38 years, most 23 of whom belonged to the 30–39 years age group. Out of 100 subjects, 57 subjects were married, 31 were single, and 12 were widowed/divorced. A total of 47 subjects were educated up to graduation level, and only nine subjects were from the uneducated category. Twelve participants reported a positive family history of gonadal dysfunction/infertility (Table 1).

Table 1: General Demographic features of adult healthy subjects enrolled in this study

Parameters		**Subjects (n=100)**
Age (Years)	**18-29**	22
	30-39	23
	40-49	20
	50-59	19
	60-70	16
Gender	**Male**	100
Marital Status	**Married**	57
	Unmarried	31
	Widowed/Divorced	12
Education Level	**Illiterate**	9
	Up to 10th std.	21
	Graduate	47
	Postgraduate	23
Socioeconomic status	**Lower**	16
	Middle	73
	Upper	11
Occupation	**Student**	18
	Service	48
	Self-employed	22
	Retired	12
Residence area	**Rural**	58
	Urban	42
Family history of Gonadal dysfunction / Infertility	**Yes**	12
	No	88

The variations in the testicular volume of both the right and left testis in subjects were normally distributed, as highlighted in Table 2. Mean right and left testicular volumes were 21.97 ± 5.89 cm^3 and 23.58 ± 5.62 cm^3, respectively. The left testis's mean length, width, and height were 3.55 ± 0.28 cm, 2.49 ± 0.33 cm, and 2.61 ± 0.30 cm, and The right testis's mean length, width, and height were 3.53 ± 0.30 cm, 2.46 ± 0.34 cm, and 2.57 ± 0.30 cm, respectively. Although the left testis's length, width, and volume were larger than the right, these differences were statistically significant ($p > 0.05$).

Table 2: Average of measurement of general parameters of testes among all study subjects

Variables	**Left Side**	**Right Side**
Height (cm)	2.61 ± 0.30	2.57 ± 0.30
Width (cm)	2.49 ± 0.33	2.46 ± 0.34
Length (cm)	3.55 ± 0.28	3.53 ± 0.30
Volume (cm^3)	23.58 ± 5.62	21.97 ± 5.89

Data represents Mean ± SD values.

A comparison of testicular volumes by age, groups on both sides, is shown in Table 2. Across the age groups, the right testicular volumes were predominantly larger than the left side. However, in all the age groups, the results of a paired-samples t-test, as highlighted in the table, showed no significant differences on both right and left sides ($p > 0.05$).

Table 3: Relationship between subjects age, height, weight and body mass index (BMI)

Age (Years)	**N**	**Height (m)**	**Weight (Kg)**	**BMI (Kg/m^2)**
18-29	22	1.49 ± 0.32	63.4 ± 8.2	22.0 ± 1.7
30-39	23	1.56 ± 0.49	64.2 ± 5.7	24.9 ± 1.8
40-49	20	1.53 ± 0.51	69.4 ± 6.8	25.3 ± 2.2
50-59	19	1.64 ± 0.74	73.8 ± 8.4	25.5 ± 1.8
60-70	16	1.49 ± 0.39	59.4 ± 7.2	24.9 ± 2.6

Data represents Mean ± SD values.

The results analysis of variance to detect any significant differences or trends in testicular volume compared with BMI and age groups of subjects are presented in Table 3. The age group of 18-29 years had a maximum number of underweight subjects, and the age group of 40-49 years and 50-59 years had the maximum number of obese subjects.

Table 4: Assessment of correlation between subjects' body mass index (BMI) categories and testicular volumes

BMI category	N	Left testicular volume (cm^3)	Right testicular volume (cm^3)
Underweight	5	21.47 ± 4.12	21.07 ± 3.21
Normal	57	22.54 ± 5.27	22.48 ± 4.79
Overweight	26	23.12 ± 3.23	22.97 ± 5.29
Obese	12	23.95 ± 2.98	23.16 ± 3.34

Data represents Mean ± SD values.

The results of correlation analysis to evaluate; further, the relationship between BMI and testicular volume measurements are presented in Table 4. Although there appears to be a gradual increase in left testicular volume from 21.47 ± 4.12 cm^3 in the underweight category to 23.95 ± 2.98 cm^3 in the obese, this trend was not statistically significant ($p > 0.05$). Similarly, the right testicular volume increased from 21.07 ± 3.21 cm^3 to 23.16 ± 3.34 cm^3, it was also not statistically significant ($p > 0.05$). There is generally a positive but weak correlation between BMI and testicular length, width, height, and volume on both sides. These showed that as the BMI increased, testicular dimensions increased.

DISCUSSION

The measurement of testicular volume in adults is an essential parameter in evaluating the health status of the testes in various clinical conditions such as undescended testis, torsion, malignancies, orchitis and varicocele. In addition, the estimation of testicular volume is an integral aspect of male infertility evaluation [1-3]. Compared to Prader orchidometry or the punched-out orchidometer, ultrasound has generally been recognized to be the most accurate10, 12, 39 and testicular volume measurements using the ultrasonographic formula L x W x D x 0.71, which was employed in this study, has been reported to be the closest to actual testicular volumes in humans [1-5]. Moreover, the non-invasiveness of ultrasound and the absence of concerns about radiation allow for repeated evaluations.

The sample selection criteria used in this study are similar to those used in earlier studies [6-9]. In these studies and the current one, participants with a history of testicular and scrotal surgery or disease were excluded from the study. The mean right and left testicular volumes obtained in this study were 21.97 ± 5.89 cm^3 and 23.58 ± 5.62 cm^3, respectively.

This study also revealed an increasing trend in volumes as age advances to a peak in the late 30s, followed by a decrease in the volumes. This observed peak testicular volume at this period of life is consistent with 57 reports that have suggested that men are at their peak fertility at this period and that beyond 50 years of age, serum testosterone and spermatogenesis reduce with time [10].

More detailed analysis showed no statistically significant differences in these trends for both right and left testes. Age was also positively but weakly correlated to the right length, left length and left testicular width. A negative and weak correlation was obtained between age and left testicular volume. This is different from the results obtained in other studies [7-10], where age showed no correlation with the volume of the left and the right side of the testis.

Few earlier studies had established that the testes achieved their maximal size by 18 years and remained so until 80 years when they started decreasing in size [8-12]. Further, the correlation analysis revealed a positive but weak correlation between BMI and testicular length, width, height and volume [13-15], establishing a weak and positive correlation between testicular volume and body mass index. However, few studies [9-13] showed a consistent lack of correlation between BMI and left testicular volume.

Furthermore, as argued by Sotos and Tokar [7], the measurement of the testicular volume is not an exact science. Even with the reliability of the ultrasound, variability related to the transducer used, the possibility of compression of the testis, and intra- and inter-observer variation in the measurements (width, height, length, and volumes), among other factors, exists. In addition, other reasons such as environmental, nutritional and genetic factors may be responsible for these differences [14-16].

In general, in this study, it was found that the testicular volume had a positive but weak correlation with weight, height, BMI, but none was statistically significant. Although the left testis's length, width, and volume were larger than the right, these differences were statistically significant. However, no immediate scientific explanation could be inferred to the differential association of the right and left testes with the measured anthropometric parameters. This variation warrants further studies in this subject area to establish a clinical and scientific basis of the variations in right and left side testicular volumes.

CONCLUSION

In this study, the right testicular volume showed less volume compared to the left testicular volume. Both side measurements have shown a positive but weak correlation with weight, height, BMI, but none was statistically significant in healthy adults. Further studies are needed to support or negate these findings.

This anthropological study addressed an oft-repeated question about the accuracy of the different non-invasive methods of testicular measurements. A rough estimate of testicular size may suffice in cases that do not need any active intervention.

This study complies with the published data so far and revealed ultrasonography to be the most accurate and objective in vitro method of assessing testicular volume.

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