Ultrasound measured testicular volume in Nigerian adults: Relationship of the three formulae with height, body weight, body-surface area, and body-mass index

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ABSTRACT

Background: Measurement of testicular volume is one of the ways of assessing testicular function. Ultrasonography is an important and accurate radiological method for measurement of testicular volume. Objective: This study was aimed at evaluating the relationship of ultrasound measured testicular volume using the three formulae with the subjects' height, body weight, body surface area (BSA), and body mass index (BMI) in adults. Methodology: One hundred twenty-five adult male subjects comprising staff and students of a University Teaching Hospital were recruited into the study. Height and body weight were measured while the BMI and BSA were calculated. Ultrasound measurement of the height, length, and width of both testes were done and used to calculate the volumes using the three formulae. Results: The subjects' age ranged from 19 to 29 years with a mean of 23.48 ± 2.26 yrs. The mean ultrasound measured volumes for the right and left testes were 15.38 ± 3.29 ml and 15.29 ± 3.89 ml using the prolate ellipsoid formula; 22.86 ± 5.43 ml and 23.54 ± 6.88 ml by the prolate spheroid formula; 21.20 ± 5.28 ml and 20.87 ± 5.35 ml by the Lambert formula, respectively. The calculated mean for height, body weight, BMI, and BSA were 174.64 ± 6.36 cm, 68.68 ± 8.25 kg, 22.48 ± 2.17 kg/m², and 1.82 ± 0.13 m², respectively. The right testes showed a negative correlation, while the left and combined testicular volumes showed a positive correlation with the subjects' height, body weight, BMI, and BSA for all the three formulae. Conclusion: The right testicular volume showed negative correlation, while the left and combined testicular volumes showed a positive correlation with the height, body weight, BSA, and BMI in Nigerian adults.

Key words: Anthropometric measurements, Nigerian adults, testicular volume, ultrasound

INTRODUCTION

The testes are paired oval-shaped male gonads housed in the scrotum. The average testis measures about 4 cm × 3 cm × 2.5 cm.[¹] The physiologic functions of the testes are the production of spermatozoa and the male...
sex hormone, testosterone. The seminiferous tubules constitute about 70%–90% of the testicular mass, and as such, spermatogenesis can be assessed by measuring the testicular volume. Testicular function, in other words, can be assessed by accurate measurement of the testicular volume. In infertile men, semen profiles have been found to correlate with the testicular volume. Measurement of the testicular volume is very useful in monitoring pubertal status and in assessing the clinical significance of varicocele in puberty and adolescence.

Several measurement methods or tools have been used for the clinical assessment of testicular volume. These are divided into radiological and nonradiological methods. The nonradiological techniques include the use of graphic method, dimensional measurement, orchidometers, rulers, and calipers. These methods, however, have been found to largely overestimate the testicular volume. Ultrasonography (US) and magnetic resonance imaging (MRI) are the common radiological methods used in the measurement of testicular volume. Ultrasound is considered to be the standard radiological method for measuring the volume of the testes as shown by some studies. Some studies have shown that ultrasound as a method of measuring testicular volume is more accurate than the clinical (orchidometer) methods as determined by comparing with the actual volume measurement using water displacement method which is still the gold standard.

Ultrasound measured testicular volumes are determined by measuring the anteroposterior diameter on comparable transverse images of the right and left sides or by calculating testicular volumes using the three formulae: (a) for a prolate ellipsoid: volume = length × width × height × 0.52 (LWH0.52); (b) the formula for a prolate spheroid: length × width^2 × 0.52 (LW^20.52); and (c) the empiric formula of Lambert: length × width × height × 0.71 (LWH0.71).

Ultrasonography has been shown to be the most readily available and accurate method of measuring testicular volume as determined by comparison with the actual volume. However, several studies have shown that ultrasound measured testicular volume varies widely depending on the formula used.

A wide range of anthropometric parameters has been proposed in human subjects. They have been widely used as an index for measurement of nutritional status and have been used as a predictor of well-being and risk of some disease conditions. A number of studies have been done on various radiological and nonradiological methods of measurement of the testicular volume and its correlation with body weight, height, and body mass index (BMI) both in Nigeria and other countries. None to the best of the knowledge of the author has been done on correlation of ultrasound measured testicular volume with height, body weight, body surface area (BSA), and BMI in the region of study in Nigeria. The aim of this study was to evaluate the relationship of ultrasound measured testicular volume using the three formulae with height, body weight, BSA, and BMI in Nigerian adults.

**METHODOLOGY**

We conducted a cross-sectional study of male subjects selected from the staff and students of a University Teaching Hospital. It was a 1-year prospective study from June 1, 2012, to May 31, 2013. Approval was sought and obtained from the Ethical Committee of the Nnamdi Azikiwe University Teaching Hospital before the commencement of the study.

Adult male subjects without any inguinal or scrotal lesion/surgery, malignancy, recent weight loss were included in the study. Those who refused consent were excluded from the study. The procedure was duly explained to the subjects, after which their informed written consent was obtained. The body weight was evaluated clinically (history and physical examination).

The subjects’ weight was measured by asking subjects to remove their outer clothing and shoes. The participants were asked to stand in the center of the weighing balance, weight distributed evenly to both feet. The weights were moved along the beam until it balances (the arrows are aligned). The body weight was recorded to the nearest 0.1 kg.

The height was measured using a stadiometer; the height rule was held vertically to the hard flat surface with the base touching the floor level. Participants were asked to take off their shoes, heavy outer clothing, and head coverings. The participants stood with their back to the height rule. The subjects were placed with the posterior part of their head, back, buttocks, calves, and heels touching the upright and feet together. The top of the ear canal was level with the inferior border of the cheek bone. The participants were requested to look straight. The head piece of the height meter was lowered to make firm contact with the hair (if present). The subjects’ height was recorded to the nearest centimeter. The subjects’ height and body weight were used to calculate the BSA and BMI.

The scrotal ultrasound scan was done using a curvilinear 7.5 MHz probe (EDAN, DUS3, China). The ultrasound probe was placed in contact with the stretched scrotal skin over the testes to get the longitudinal plane and moved until the mediastinum testis was seen in the same...
The length of each of the testes was measured with the electronic caliper in the topmost and most inferior points of the testes. The image was frozen and the height of the testes was measured with the calipers on the widest anterior–posterior point of the testes. The width of the testes was then measured by moving the probe until it was perpendicular to the longitudinal plane. The calipers were placed at the widest transverse diameter.

Ultrasound measurement of the length, width, and height of both testes were used to calculate the volumes using the three formulae: (a) for a prolate ellipsoid: volume = length × width × height × 0.52 (LWH0.52); (b) the formula for a prolate spheroid: length × width² × 0.52 (LW0.52); and (c) the empirical formula of Lambert: length × width × height × 0.71 (LWH0.71). All the values were recorded in the proforma used for the study and results were analyzed using Statistical Package for Social Sciences version 17.0. P < 0.05 was considered statistically significant.

RESULTS

A total of 125 subjects were recruited into the study. The age of the subjects ranged from 19 to 29 years with a mean of 23.48 ± 2.26 yrs.

Testicular volumes were estimated using the three different formulae [Table 1]. The mean ultrasound testicular volumes for the right and left testes were: 15.38 ± 3.29 ml and 15.29 ± 3.89 ml using the prolate ellipsoid formula (formula 1); 22.86 ± 5.43 ml and 23.54 ± 6.88 ml for prolate spheroid formula (formula 2); 21.20 ± 5.28 ml and 20.87 ± 5.35 ml for the Lambert formula (formula 3), respectively. The ranges as well as the mean testicular volumes for the right, left, and combined testes are shown in Table 1.

Measurement of some anthropometric parameters is shown in Table 2. The calculated mean for height, weight, BMI, and BSA were 174.64 ± 6.36 cm, 68.68 ± 8.25 kg, 22.48 ± 2.17 kg/m², and 1.82 ± 0.13 m², respectively. The ranges and mean measurements of the subjects’ height, weight, BMI, and BSA are shown in Table 2.

Correlation of testicular volumes with body weight is shown in Table 3. The right testicular volume showed a negative correlation with the body weight, while the left testis as well as the combined testicular volumes showed positive correlation using the three formulae. However, only the left testicular volume calculated using the second formula (prolate spheroid) was statistically significant (r = +0.287, P = 0.001). [Table 3].

Correlation of testicular volumes with height of subjects is shown in Table 4. The left testicular volume showed a positive correlation with the height in all the three formulae, and all were significant. The right testis and combined volumes showed no significant correlation [Table 4].

Correlation of testicular volumes with BMI is shown in Table 5. The left testicular volume using the second

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**Table 1: Testicular volumes using different formulae**

| Side of testis | Formula I (ml) | Formula II (ml) | Formula III (ml) |
|---------------|----------------|----------------|------------------|
| Right testis  | Range 12.01-35.77 | Mean 15.38±3.29 | 11.56-37.92 |
| Left testis   | Range 13.57-42.60 | Mean 15.29±3.89 | 13.65-35.20 |

**Table 2: Subjects’ anthropometric measurements**

| Height (cm) | Weight (kg) | Body mass index | Body surface area |
|-------------|-------------|-----------------|-------------------|
| Range 163-191 | 55-88 | 17.96-28.09 | 1.62-2.14 |
| Mean 174.64±6.36 | 68.68±8.25 | 22.48±2.17 | 1.82±0.13 |

**Table 3: Correlation of testicular volumes with body weight**

| Side of testis and formula used | Correlation coefficient | P value |
|-------------------------------|------------------------|--------|
| Left testicular volume formula 1 | +0.160 | 0.074 |
| Left testicular volume formula 2 | +0.287 | 0.001* |
| Left testicular volume formula 3 | +0.160 | 0.075 |
| Right testicular volume formula 1 | −0.112 | 0.212 |
| Right testicular volume formula 2 | −0.054 | 0.553 |
| Right testicular volume formula 3 | −0.112 | 0.213 |
| Combined testicular volume formula 1 | +0.063 | 0.488 |
| Combined testicular volume formula 2 | +0.160 | 0.074 |
| Combined testicular volume formula 3 | +0.027 | 0.765 |

*Pearson correlation coefficient significant at the ≤0.05 level (two-tailed)

**Table 4: Correlation of testicular volumes with height**

| Side of testis and formula used | Correlation coefficient | P value |
|-------------------------------|------------------------|--------|
| Left testicular volume formula 1 | +0.279 | 0.002* |
| Left testicular volume formula 2 | +0.202 | 0.024* |
| Left testicular volume formula 3 | +0.278 | 0.002* |
| Right testicular volume formula 1 | −0.142 | 0.115 |
| Right testicular volume formula 2 | −0.019 | 0.838 |
| Right testicular volume formula 3 | −0.159 | 0.077 |
| Combined testicular volume formula 1 | +0.111 | 0.218 |
| Combined testicular volume formula 2 | +0.119 | 0.185 |
| Combined testicular volume formula 3 | +0.071 | 0.434 |

*Pearson correlation coefficient significant at the ≤0.05 level (two-tailed)

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formula showed a positive correlation with BMI and was significant. The other volumes showed no significant correlation [Table 5].

Correlation of testicular volumes with BSA is shown in Table 6. The left testicular volume showed a positive correlation with the BSA in all the three formulae, and all were significant. The other volumes showed no significant correlation [Table 6].

**DISCUSSION**

The age range of the subjects in this study extended from 19 to 29 years with a mean of 23.48 ± 2.26 yrs. This is comparable to the age in a similar study by Bahk et al. on 1139 normal young men in military service with a range of 19–27 years and mean of 23.52 ± 2.74 yrs. It also compares to the mean age of 23.02 ± 2.53 yrs in the study by Lim et al. of 1002 adult Korean men to investigate the relationship and correlation of testicular volume with height, body weight, and BMI. This however differs from the age of the subjects in the study by Kiridi et al. to determine in healthy Nigerian adults, the normal testicular volume where the age range was 18–64 years with a mean of 31.6 ± 9.9 years. It has been shown that the testis attains its maximal size by 18 years and remains at the same size until 80 years when it starts regressing in size.\[38-40\]

In the current study, the testicular volumes showed significant variations using the three formulae. However, using the Lambert’s formula which has been established the most accurate,\[17,27,28,33\] the right testicular volume ranged from 11.56 to 37.92 ml with a mean of 21.20 ± 5.28 ml; the left testicular volume ranged from 13.65 to 35.20 ml with a mean of 20.87 ± 5.35 ml; combined (right and left) testicular volume ranged from 25.21 to 64.80 ml with a mean of 42.06 ± 9.41 ml. The above values are significantly higher than the values obtained by Kiridi et al.\[38\] in their study where the mean of the testicular volume was 16.3 ± 5.4 ml on the right and 15.0 ± 5.9 ml on the left side. This finding may be because the age range in the current study was relatively younger as indicated above. This may also be because the subjects in this study were drawn from the staff and students of a tertiary health institution whose nutritional state is expected to be above average. Bahk et al.\[36\] reported a mean testicular volume of 18.13 ± 3.85 ml on the right and 18.37 ± 3.62 ml on the left side, while Lim et al.\[37\] reported mean testicular volume as 18.26 ± 3.21 ml on the right and 18.09 ± 3.79 ml on the left side. The values in the above two studies done on Korean men were also lower than the values obtained in the current study. This also negates the assertion by Kiridi et al.\[38\] that the lower mean testicular volume in their study on Nigerian men was probably due to higher environmental temperature and malnutrition in Nigeria. The mean right testicular volume showed no significant difference from the left. This correlates with the finding by Bahk et al.\[36\] and Lim et al.\[37\].

The right testicular volume showed negative correlation with the body weight while the left testis as well as the combined testicular volumes showed positive correlation using the three formulae. Only the left testicular volume calculated using the second formula (prolate spheroid) significantly correlated. The left testicular volume showed a positive correlation with the height in all the three formulae and all were significant. The right testis and combined volumes showed no significant correlation. The left testicular volume using the second formula showed a significant positive correlation with BMI. The other volumes showed no significant correlation. The left testicular volume showed a significant positive correlation with the BSA using all the three formulae. The right and combined volumes showed no significant correlation. In the study by Kiridi et al., they found a weak positive correlation between subjects’ body weight, height, and BMI with the right and the mean testicular volumes. Similarly, in the studies by Bahk et al. and Lim et al., they found significant weak correlations...
between the testicular volumes and the subjects’ body weight, height, and BMI.

In general, in this study, it was found that the right testicular volume negatively correlates with the weight, height, BMI, and BSA, but none was statistically significant. The left testicular volume was found to show statistically significant positive correlation with the body weight, height, BMI, and BSA. However, no immediate biological explanation could be inferred to the differential association of the right and left testes with the measured anthropometric parameters. Further studies in this subject area are needed to establish the above findings.

**CONCLUSION**

In this study, the right testicular volume showed negative correlation while the left and combined testicular volumes showed a positive correlation with the body weight, height, BSA, BMI in Nigerian adults. Further studies are needed to support or negate these findings.

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**Conflicts of interest**

There are no conflicts of interest.

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