CORRELATION OF ULTRASOUND MEASURED TESTICULAR VOLUME WITH WAIST CIRCUMFERENCE, HIP CIRCUMFERENCE, WAIST-HIP RATIO AND CONICITY INDEX IN NIGERIAN ADULTS.

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ABSTRACT

Background: Accurate testicular volume measurement is one way to assess testicular function. Some obese males exhibit altered levels of circulating sex steroids; decreased levels of total testosterone (T) and sex hormone binding globulin (SHBG) and increased estrogens levels. Some anthropometric measurements are markers for obesity.

Objective: This study aims to evaluate the correlation of testicular volume measured by ultrasound with some anthropometric measurements: Waist circumference, Hip circumference, Waist-Hip Ratio (WHR), and Conicity Index in adult males.

Methodology: One hundred and twenty-five adult male subjects comprising staff and students of a University Teaching Hospital, were recruited. The subjects' height, weight, waist circumference and hip circumference were measured and used to calculate the WHR and Conicity Index. Ultrasound measurement of the length, width and height of both testes were done and used to calculate the volumes.

Results: The age of the subjects ranged from 19 to 29 years with a mean of 23.48±2.26. The mean ultrasound testicular volumes for the right and left testes were: 15.38±3.29ml and 15.29±3.89ml using the first formula; 22.86±5.43ml and 23.54±6.88ml for second formula; 21.20±5.28ml and 20.87±5.35ml for the third formula respectively. The calculated mean for height, weight, Waist circumference, Hip circumference, WHR and Conicity Index were: 174.64±6.36cm, 68.68±8.25kg, 77.51±5.44cm, 88.76±4.46cm, 0.87±0.40 and 1.14±0.05 respectively. The left, right and combined testicular volumes showed weak negative correlation with the Waist circumference, Hip circumference, WHR and Conicity Index.

Conclusion: Ultrasound measured testicular volume showed weak negative correlation with the Waist circumference, Hip circumference, WHR and Conicity Index in Nigerian adults.

Key words: Ultrasound, testicular volumes, waist-hip ratio, conicity index, Nigerian adult.

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INTRODUCTION

The testes are primarily responsible for the production of spermatozoa and the male sex hormone, testosterone.[1-3] As the seminiferous tubules comprise approximately 70-90% of the testicular mass, testicular volume is largely a reflection of spermatogenesis.[4-6] Therefore, accurate testicular volume measurement is one way to assess testicular function. Several measurement techniques or tools are used for the clinical assessment of testicular volume. These are divided into radiological and non-radiological methods. The non-radiological techniques include the use of graphic method, dimensional measurement, orchidometers, rulers and calipers.[7-12] These methods are however known to grossly overestimate the volume of the testes.[7-18] Radiologically, ultrasonography and magnetic resonance imaging (MRI) can be employed in the measurement of testicular volume. Ultrasound is considered to be the standard radiological method of measuring testicular volume. Some literatures have shown ultrasound to be more accurate in the measurement of testicular volume than the clinical (orchidometry) methods described, as determined by comparison with the actual volume using water displacement method which is the gold standard.[8,13-16,18-21]

Ultrasound measured testicular volumes can be calculated using the three formulas: (a) for a prolate ellipsoid: $V = L \times W \times H \times 0.52$, where V = volume, L = length, W = width,

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and ***H*** = height;[6,18,22-24] (b) the formula for a prolate spheroid: L × W^2 × 0.52 ($LW^2$0.52);[7,8,16,18,20] and (c) the empiric formula of Lambert: L × W × H × 0.71 (LWH0.71).[10,11,18,25,26] Some studies have shown that the empirical formula of Lambert (LxWxHx0.71) provided better accuracy than the other two formulas evaluated.[18,20,27] However, no consensus has been reached as to the best formula in humans.[28]

Anthropometric measurements have been widely used as an index for measurement of nutritional status and as a predictor of well being and risk of a number of disease conditions.[29-30] Some of the common anthropometric measurements include: Height, Weight, Waist circumference, Hip circumference, Body-Mass Index (BMI), Body-Surface Area (BSA), Waist-Hip Ratio (WHR), Conicity Index etc. Abdominal or central obesity defined as WHRabove 0.90 for males and above 0.85 for females has been used as an indicator or measure of the health of a person, and the risk of developing serious health conditions.[31,32] Conicity Index, which evaluates waist circumference in relation to height and weight, appears to have a prognostic value similar to that of WHR in adults to assess truncal adiposity.[33] Waist circumference, Waist-Hip Ratio (WHR), Body-Mass Index (BMI) and Conicity Index have been shown by a number of studies to be accurate tool for accessing truncal or central obesity.[34-38] Obesity in men has been shown to produce altered levels of sex steroid hormones in the body.[29,32,39,40]

A number of studies have been done on various radiological and non-radiological methods of measurement of testicular volume and its correlation with height, weight and body mass index both in Nigeria and other countries.[41-43] None to the best of the knowledge of the author has been done on correlation of testicular volume with waist circumference, hip circumference, waist-hip ratio and conicity index. The aim of this study is to evaluate the correlation of testicular volume measured by ultrasound with some anthropometric measurements: Waist circumference, Hip circumference, Waist-Hip Ratio (WHR), and Conicity Index in adult males.

METHODOLOGY

This is a cross-sectional study of male subjects selected from staff and students of a University Teaching Hospital. Approval was sought and obtained from the Ethical committee of the University Teaching Hospital before the commencement of the study.

All the male subjects without any inguinal or scrotal lesion/surgery, malignancy, recent weight loss were included in the study. Those who refused to give their consent were excluded from the study. The procedure was duly explained to the subjects, after which their informed written consent was obtained. The subjects were evaluated clinically (history and physical examination). The subjects' height, weight, waist circumference and hip circumference were measured and used to calculate the Waist-Hip Ratio (WHR), and Conicity Index. Waist circumference was measured at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest, using a stretch-resistant tape that provides a constant 100 g tension. Hip circumference was measured around the widest portion of the buttocks, with the tape parallel to the floor. Conicity Index = waist circumference/(0.109 × square root of weight/height), where waist circumference and height are measured in meters and weight measured in kg.

Ultrasound measurement of the length, width and height of both testes were done and used to calculate the volumes using the three formulae: (a) for a prolate ellipsoid: ***V*** = ***L*** × ***W*** × ***H*** × 0.52, where ***V*** = volume, ***L*** = length, ***W*** = width, and ***H*** = height; (b) the formula for a prolate spheroid: L × W^2× 0.52

(LW^{2}0.52); and (c) the empiric formula of Lambert: L × W × H × 0.71 (LWH0.71). The scrotal ultrasound scan was done using a 7.5 MHz probe of Curve linear ultrasound machine, EDAN, DUS3, China.

All the values were recorded in the proforma used for the study and results analysed using SPSS version 17.0. P value less than 0.05 is accepted as significant(Pearson's correlation coefficient).

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.

Table 1: Testicular volumes using different formulae.

Formulae / Testicular volume	Formula I (ml)	Formula II (ml)	Formula III (ml)
Right testis	Range: 8.44-22.80	Range: 12.01-35.77	Range: 11.56-37.92
	Mean: 15.38±3.29	Mean: 22.86±5.43	Mean: 21.20±5.28
Left testis	Range: 10.01-25.68	Range: 13.57-42.60	Range: 13.65-35.20
	Mean: 15.29±3.89	Mean: 23.54±6.88	Mean: 20.87±5.35
Combined volume	Range: 18.45-47.30	Range: 26.50-70.65	Range: 25.21-64.80
	Mean: 30.58±6.43	Mean: 46.25±10.95	Mean: 42.06±9.41

Table 2: Subject's Anthropometric measurements.

	Height (cm)	Weight (cm)	Waist circumference (cm)	Hip circumference (cm)	Waist-Hip ratio (WHR)	Conicity index
Range	163-191	55-88	63-87	80-99	0.78-0.97	1.00-1.26
Mean	174.64±6.36	68.68±8.25	77.51±5.44	88.76±4.46	0.87±0.40	1.14±0.05

Table 3: Correlation of testicular volumes with Waist circumference.

Waist circumference / Testicular volume	Correlation	Level of significance	
Left testicular vol. formula 1	-0.042	0.640	
Left testicular vol. formula 2	+0.076	0.399	
Left testicular vol. formula 3	-0.041	0.648	
Right testicular vol. formula 1	-0.131	0.145	
Right testicular vol. formula 2	-0.324	0.000	*
Right testicular vol. formula 3	-0.150	0.095	
Comb. testicular vol. formula 1	-0.053	0.554	
Comb. testicular vol. formula 2	-0.106	0.239	
Comb. testicular vol. formula 3	-0.111	0.220	

1. Correlation of testicular volumes with Waist circumference is as shown in table 3. The right testicular volume using the second formula showed negative correlation with waist circumference and is significant. The other volumes showed no significant correlation (table 3).

Table 4: Correlation of testicular volumes with Hip circumference.

Hip circumference / Testicular volume	Correlation	Level of significance	
Left testicular vol. formula 1	+0.079	0.382	
Left testicular vol. formula 2	+0.138	0.126	
Left testicular vol. formula 3	+0.078	0.390	
Right testicular vol. formula 1	-0.163	0.069	
Right testicular vol. formula 2	-0.154	0.087	
Right testicular vol. formula 3	-0.195	0.029	*
Comb. testicular vol. formula 1	-0.010	0.912	
Comb. testicular vol. formula 2	+0.003	0.973	
Comb. testicular vol. formula 3	-0.066	0.462	

2. Correlation of testicular volumes with Hip circumference is as shown in table 4. The right testicular volume using the third formula showed negative correlation with the hip circumference and is significant. The other volumes were not significant (table 4).

Table 5: Correlation of testicular volumes with Waist-Hip ratio (WHR).

WHR / Testicular volume	Correlation	Level of significance	
Left testicular vol. formula 1	-0.160	0.075	
Left testicular vol. formula 2	-0.020	0.821	
Left testicular vol. formula 3	-0.156	0.082	
Right testicular vol. formula 1	-0.042	0.644	
Right testicular vol. formula 2	-0.372	0.000	*
Right testicular vol. formula 3	-0.035	0.699	
Comb. testicular vol. formula 1	-0.082	0.361	
Comb. testicular vol. formula 2	-0.176	0.049	*
Comb. testicular vol. formula 3	-0.112	0.213	

3. Correlation of testicular volumes with Waist-Hip ratio (WHR) is as shown in table 5. The right testicular volume and the combined volumes using the second formula showed negative correlation with the WHR and both were significant. The other volumes showed no significant correlation (table 5).

Table 6: Correlation of testicular volumes with Conicity index.

Conicity index / Testicular volume	Correlation	Level of significance	
Left testicular vol. formula 1	-0.149	0.097	
Left testicular vol. formula 2	-0.167	0.062	
Left testicular vol. formula 3	-0.147	0.102	
Right testicular vol. formula 1	-0.129	0.152	
Right testicular vol. formula 2	-0.449	0.000	*
Right testicular vol. formula 3	-0.163	0.070	
Comb. testicular vol. formula 1	-0.118	0.190	
Comb. testicular vol. formula 2	-0.178	0.047	*
Comb. testicular vol. formula 3	-0.326	0.000	*

4. Correlation of testicular volumes with Conicity index is as shown in table 6. The right testicular volume using the second formula and the combined volumes using the second and third formulae showed negative correlation with the conicity index and were all significant. The other volumes showed no significant correlation (table 6).

DISCUSSION:

The age of the subjects in this study ranged from 19 to 29 years with a mean of 23.48±2.26. This is comparable to the age in similar study by Bahk et al[41]on 1139 normal young men in military service with range of 19-27 years and mean of 23.52±2.74. It also compares to the mean age of 23.02±2.53 in the study by Lim et al[2] of 1,002 young adult Korean men to investigate the relationship between testicular volume and body weight, height, and body mass index (BMI). Kiridi et al[43] working to establish the normal testicular volume in healthy Nigerian adults age range 18-64 years got a mean of 31.6±9.9 years. They worked among a wider age group 18-64 quite different from ours 19-29. It is established that the testis achieved its maximal size by 18 years and remains so until 8o years when it starts decreasing in size.[43-45]

In the current study, the testicular volumes showed significant variations using the three formulae. However, using the Lambert's formula which is said to be the most accurate,[8,18,20,27] the right testicular volume ranged from 11.56 to 37.92 ml with mean of 21.20±5.28 ml; the left testicular volume ranged from 13.65 to 35.20 ml with 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 (table 1). The above values are significantly higher than the values obtained by Kiridi et al[43] in their study where the mean testicular volume for their study population was 15.6±5.3ml and 16.3±5.4ml on the right and 15.0±5.9ml on the left. This finding may be due to the fact that the age range in the current study was relatively younger as shown above. Bahk et al[41] reported a mean testicular volume of 18.13±3.85 ml in right and 18.37±3.62 ml in left while Lim et al[42] reported mean testicular volume was 18.26±3.21 ml on the right 18.09±3.79 ml on the left. The values in the above two studies done on Korean men were also lower than the values obtained in the current study. This may be due to lower body frame of Korean males and also negates the assertion by Kiridi et al[43] 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 only showed little variation from the left (table1). This correlates with the finding by Bahk et al[41] and Lim et al. [42]

Conicity Index, which evaluates waist circumference in relation to height and weight, appears to have a prognostic value similar to that of WHR in adults to assess truncal adiposity.[33] In the current study, the right testicular volume using the second formula showed negative correlation with waist circumference and was significant while the other volumes showed no significant correlation (table 3). Similarly, the right testicular volume using the third (Lambert's) formula showed negative correlation with the hip circumference and was significant, the other volumes were not significant (table 4). Also, the right testicular volume and the combined volumes using the second formula showed negative correlation with the WHR and both were significant

(table 5). The other volumes showed no significant correlation. In a similar manner, the right testicular volume using the second formula and the combined volumes using the second and third formulae showed negative correlation with the conicity index and were all significant (table 6). The other volumes showed no significant correlation. From the above discussion, the waist circumference, the hip circumference, the WHR and conicity index have an indirect relationship with testicular volume, one can also extrapolate that testicular volume has an indirect relationship with obesity.

A number of studies have tried to examine the association between obesity and levels of sex steroid hormones in the body.[29,32,39,40] It has been known for some time that obese males exhibit altered levels of circulating sex steroids; decreased levels of total testosterone (T) and sex hormone binding globulin (SHBG) and increased estrogens levels.[39] A hypothesized mechanism for these changes involves the aromatase enzyme, capable of converting C19 steroid precursors into C18 estrogens, and present in adipose tissue. Increased amounts of adipose tissue would lead to increased conversion of testosterone to estrogen. This is consistent with higher estrogen levels reported to be associated with obesity.[39] Such peripheral steroid conversion would result in decreased testosterone levels and increased estrogen including estradiol levels. This is supported by Sapino et al[46] who demonstrated atrophy of the seminiferous tubules and marked reduction in the ley dig cells of transsexuals after a period of oestrogen administration.

Haffner et al[40] in their study to examine the association of total testosterone, free testosterone, oestradiol, dehydroepiandrosterone sulphate (DHEAS) and sex hormone binding globulin (SHBG) to waist-to-hip ratio (WHR) and conicity index in 178 men from the San Antonio Heart Study. They found that the conicity index and WHR were significantly inversely related to DHEAS and free testosterone. SHBG was only weakly associated with body mass index. After adjustment for age and body mass index, DHEAS remained inversely correlated with WHR and conicity index. These findings were however not extrapolated to involve the testicular volumes.

CONCLUSION

Ultrasound measured testicular volume showed weak negative correlation with the Waist circumference, Hip circumference, Waist-Hip Ratio (WHR), and Conicity Index in Nigerian adults. Further large series study is needed to support these findings.

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