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Relationship of Waist Circumference, Waist Hip Ratio and Body Mass Index as Predictors of Obesity in Adult Nigerians

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Abstract: Body Mass Index (BMI) has been considered a gold standard for defining overweight and obesity. BMI is an indicator of overall adiposity while Waist Circumference (WC) and Waist-to-Hip Ratio (WHR) are indicators for abdominal adiposity. To determine which of these indices-WC and WHR compared with BMI as the gold standard, is the best predictor of obesity in healthy adult Nigerians. Four hundred apparently healthy civil servants were recruited for the study by stratified random sampling. WC, WHR and BMI were determined using standard methods. Data were available for 400 healthy subjects (196 males and 204 females). WC was found to have a strong predictive capacity for obesity but this was only in female subjects (sensitivity 100%). The Negative predictive value was also 100% which implies accurate exclusion of female subjects who don't have obesity. WHR showed poor predictive ability for obesity in both sexes (Positive predictive value 33.3% in male and 54.8% in female) though sensitivity and negative predictive value were relatively high and better amongst the females than male. In women, significant correlation exist between BMI and WC ($p<0.001$), BMI and WHR ($p<0.01$), WC and WHR ($p<0.01$) whereas, in men, the correlation was only significant for BMI and WC ($p<0.01$). This study strongly suggests that WC has a better predictive index for obesity than WHR.

Key words: Body mass index, waist circumference, waist-hip-ratio, obesity

INTRODUCTION

Due to the seriousness of the problem of obesity and the rise in prevalence, there is an intensive search for even simpler, more precise and more sensitive methods to adequately diagnose excess body fat, associating it with key health problems, to ultimately foster the implementation of preventive and intervention measures (Chan *et al*., 2003).

Simple clinical anthropometric measurements, such as Waist Circumference (WC), Waist-to-Hip Ratio (WHR) and Body Mass Index (BMI), may be conveniently used to assess regional adiposity (Deurenberg and Yap, 1999). Body Mass Index (BMI) has gained international acceptance as a standard for recognition and classification of overweight and obesity. It is used by various health care professionals as an initial screen to identify individuals at risk for problems related to being overweight or underweight (Kuczmarski and Flegal, 2000).

There is almost complete consensus regarding the usefulness of BMI as a screening tool. The only exception to this is for individuals who have very high muscle mass (body builders) or have recently lost muscle mass (as with advanced cancer or starvation). For these individuals, direct measuring of body fat through densitometry (underwater body fat analysis or the "Bod Pod") should be used to quantify body fat (Kuczmarski and Flegal, 2000).

Waist Hip Ratio (WHR) is a method for assessing abdominal fat. This is important because increased total abdominal fat places individuals at higher risk for chronic illness regardless of their weight or BMI (Kuczmarski and Flegal, 2000). However, WHR is not new. There is research using WHR as a tool for health risk assessment at least as long ago as 1990 (Kaye *et al*., 1990).

Measuring Waist Circumference (WC) alone is a simpler way of assessing for abdominal fat and has been shown by more recent research to be superior to WHR in determining health risks (Kuczmarski and Flegal, 2000).

There has been some conflicting data regarding the relative merits of WHR verses WC, but the current scientific consensus favors the use of WC. WHR is particularly inaccurate in women (Rankinen *et al*., 1999). The National Institute of Health and the United State Department of Agriculture recommend the combined use of BMI and Waist circumference (NHLBI, 1998; USDA, 2005). This information is then made useful in health assessment by then looking at individual risk factors such as personal and family history, race, gender, ethnicity, diet and other personal characteristics (NHLBI, 1998). The combined information of all three of these tools (BMI, WC and health history) is more helpful than information from any one alone.

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The general objective of this study was to investigate the relationship between anthropometric measures of obesity (WC, WHR and BMI), using BMI as a gold standard, among senior civil servants in Asaba, capital city of Delta state, Nigeria, while the specific objective was to ascertain which of these clinical markers was the best predictor of obesity among the study population.

MATERIALS AND METHODS

Four hundred apparently healthy senior civil servants were recruited from different professional groups by stratified random sampling. Their professions included doctors, nurses, lawyers, bankers, police officers and administrators. Only healthy men and women, between 29 and 58 years of age, were included in the analysis. They consisted of 196 males and 204 females. Written informed consent was obtained from all participants and the study was approved by the Federal Medical Centre, Asaba Ethics Committee.

Weight and height were measured by trained nurses. The measurement was carried out with a standard hospital weighing balance and height measure in light clothing without shoes, jackets, caps and heavy ornaments (SMIC Health Scale, Made in China).

Subjects were asked to stand erect on the scale with both arms at the sides. The weight was recorded to the nearest 0.1 kg and height to the nearest 0.1 m (Jelliffee, 1966).

Height was measured as the distance from the top of the head to the bottom of the feet (no shoes). These measurements were then used to calculate the body mass index (BMI = weight (kg)/height^2). Waist circumference (cm) was taken with a tape measure as the point midway between the costal margin and iliac crest in the mid-axillary line, with the subject standing and breathing normally. Hip circumference (cm) was measured at the widest point around the greater trochanter. The waist-to-hip ratio was calculated as the waist measurement divided by the hip measurement.

- **Waist circumference guidelines:**
  Men $\leq$ 40 inches (102 cm); Women $\leq$ 35 inches (88 cm)
- **Waist hip ratio guidelines:**
  Men $\leq$ 0.95 Women $\leq$ 0.80
- **BMI Classification:**
  <18.5 = Underweight
  18.5-24.9 = Normal
  25-29.9 = Overweight
  30-34.9 = Class I Obesity
  35-39.9 = Class II Obesity
  $\geq$40 Class III / Extreme obesity

Data was stored in computer and analyzed using version 11.5 of the SPSS (Statistical Package for Social Science). Sensitivity, specificity, positive and negative predictive values and their 95% confidence intervals were calculated to evaluate whether WC and WHR appropriately identified individuals with obesity (BMI $\geq$ 30). Z-test was used to test possible correlation between the screening tools (BMI, WC, WHR). Statistical significance was accepted at p<0.05.

RESULTS

Four hundred subjects enrolled for this study. Their ages ranged from 29 years to 58 years, with a mean of 41.59±8.22 years. There were 204 females and 196 males, making a male: female ratio of 1:1.04.

Table 1 shows a significant comparison of WC with BMI among male subjects (p<0.001). The specificity and Negative Predictive Value (NPV) were fairly high (92.3%, 91.1% respectively) whereas, the sensitivity and Positive Predictive Value (PPV) were low (65%, 68.4% respectively).

Table 2 also depicts a significant relationship between WC and BMI in females (p<0.001). While the sensitivity and NPV were excellent (100%), the specificity (66.1%) and PPV (68.3%) were lower than the values in males.

The comparison of BMI and WHR among male subjects in Table 3 showed a significant relationship (p<0.05). The PPV was very low (33.3%) while the NPV was fairly high (89.3%). The sensitivity and specificity were 70% and 64.1% respectively.

Table 1: Predictive ability of WC compared with BMI in male subjects

	BMI		
WC	Obese	Not obese	Total
Obese	26	12	38
Not obese	14	144	158
Total	40	156	196

WC = Waist Circumference; BMI = Body Mass Index; X^2 = 7.35, p<0.001. Sensitivity = 65%; Specificity = 92.3%; Predictive value of +ve test = 68.4%; Predictive value of -ve test = 91.9%

Table 2: Predictive ability of WC compared with BMI in female subjects

	BMI		
WC	Obese	Not obese	Total
Obese	86	40	126
Not obese	0	78	78
Total	86	118	204

WC = Waist Circumference; BMI = Body Mass Index; X^2 = 45.7, p<0.001. Sensitivity = 100%; Specificity = 66.1%; Predictive value of +ve test = 68.3%; Predictive value of -ve test = 100%

Table 3: Predictive ability of WHR compared with BMI in male subjects

	BMI		
WHR	Obese	Not obese	Total
Obese	28	56	84
Not obese	12	100	112
Total	40	156	196

WHR = Waist Hip Ratio; BMI = Body Mass Index; X^2 = 7.5, p<0.05. Sensitivity = 70%; Specificity = 64.1%; Predictive value of +ve test = 33.3%; Predictive value of -ve test = 89.3%

Table 4: Predictive ability of WHR compared with BMI in female subjects

WHR	BMI Obese	Not obese	Total
Obese	80	66	146
Not obese	6	52	58
Total	86	118	204

WHR = Waist Hip Ratio; BMI=Body Mass Index; X^2 = 16.6, p<0.01. Sensitivity = 93%; Specificity = 44.1%; Predictive value of +ve test = 54.8%; Predictive value of –ve test = 89.7%

Table 5: Correlation between the diagnostic parameters in females

Diagnostic parameters	Correlation Coefficient (r)	Z test	p-value
BMI versus WC	r = +0.81	13.8	p<0.001*
BMI versus WHR	r = +0.36	3.9	p<0.01*
BMI versus WC	r = +0.48	5.5	p<0.01*

* = Significantly different

Table 6: Correlation between the diagnostic parameters in males

Diagnostic parameters	Correlation Coefficient (r)	Z test	p-value
BMI versus WC	r = +0.6	7.3	p<0.01*
BMI versus WHR	r = +0.04	0.4	p>0.5
BMI versus WC	r = -0.03	0.3	p>0.5

* = Significantly different

Table 4 also shows a significantly relationship (p<0.01) between WHR and BMI in female subjects. The sensitivity (93%), PPV (54.8%) and NPV (89.7%) were higher compared with the male counterparts.

Table 5 demonstrated a strong correlation between the screening tools in females- BMI Vs WC (p<0.001), BMI Vs WHR and WC Vs WHR (p<0.01).

In Table 6, the screening tools were not significantly correlated (p>0.05) except between BMI and WC (p<0.01).

DISCUSSION

This study showed that WC has a strong predictive capacity for global obesity in female and also accurately rules out those females who don't have obesity (sensitivity 100%, negative predictive value 100%).

The high negative predictive value demonstrates that the non-obese females were correctly identified by WC. While this predictive capacity was relatively lower in males, it still possessed a fairly strong ability to exclude males who are not obese (Negative Predictive Value = 91.1%). This relationship between WC and BMI was very significant (X^2 = 33.1, p<0.001) in both sexes.

This study has also shown that while the relationship between BMI and WHR was statistically significant, WHR exhibited a poor predictive ability for obesity in both sexes. The index cannot accurately exclude obesity in clients (low sensitivity and specificity).

The strong correlation between these indices in females compared to males was interestingly noted.

Obesity in women is a matter of great concern because more than half of the subjects studied were obese. Obesity among women is likely to be rooted in the social norms and gender roles in our societies. Women are seen mainly as child bearers and rearers, confined to their homes due to their pressing household duties with little chance for recreational or sporting activities.

In male only WC and BMI were significantly correlated. Other parameters BMI Vs WHR and WHR Vs WC were not statistically correlated. This is similar to the findings of Kamel *et al.* (2000) who found that in 22 obese women, WC and WHR were equally correlated with total intra-abdominal fat. However, in men there was no correlation with WC or WHR.

The correlational analysis in this study suggests that in obese men, WC is a better predictor of the distribution of adipose tissue among several fat compartments in the abdominal region than WHR index.

This also buttresses the importance of WC as a preferred index over WHR in detecting global obesity (Ferland *et al.*, 1989; Pouliot *et al.*, 1994).

A study of (210 men and 200 women) in India (Kaushik, 2006) confirmed the preference of WC over WHR as predictive index for obesity. In their study, three indices- Waist Circumference (WC), Waist-Hip Ratio (WHR) and Conicity Index (CI) were undertaken to determine which measure of abdominal adiposity best relates with Body Mass Index (BMI). It was shown that, in both sexes, WC had the strongest partial (age controlled) correlations with BMI (Men = 0.56, Women = 0.80).

Thus WC can be used as an excellent screening tool in medical practice. Moreover, it is an easy, convenient and single measurement in assessing regional obesity unlike WHR which requires two measurements waist and hip circumference which may contribute to summative measurement error.

In conclusion, this study provides strong evidence that WC is preferable over WHR in studies dealing with BMI among adult females. Our results confirm the importance of the waist circumference as a surrogate marker of global obesity especially in women.

Concerted effort should be made by health professionals to check the waist circumference of adult patients, even when apparently healthy, with a view to early detection and initiation for adequate therapy of obesity.

Further studies on the determinants of female obesity such as nutritional norms and practices are urgently required to obtain a full picture of the burden of overweight and obesity in women.

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