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Performance of waist circumference and proposed cutoff levels for defining overweight and obesity in Nigerians

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Abstract

Background:

Waist circumference (WC) is a simple tool for measuring central obesity in routine clinic settings. Gender- and ethnic-specific optimal cutoff points for WC are encouraged for populations lacking such data.

Objectives:

To derive WC cutoff values, predictive of overweight and obesity in Nigerians and to evaluate the performance of currently recommended values.

Subjects and Methods:

Apparently, healthy urban dwellers from six cities spread across Nigeria were selected for this cross-sectional study. Biophysical profiles such as blood pressure and anthropometric indices were measured according to the World Health Organization's STEPs instrument protocol. Receiver operating characteristics curve analysis was used to determine the optimal cutoff levels using the decision rule of maximum (sensitivity + specificity). The level of significance was set at $P < 0.05$.

Results:

A total of 6089 subjects (3234 males and 2855 females) were recruited for the study. WC demonstrated a high area under the curve in both genders. Selected cutoff points ranged from 83 to 96 cm with high sensitivities and specificities.

Conclusions:

The currently recommended gender-specific WC cutoff values proved inappropriate in this study group, but WC remains a reliable tool for measuring obesity.

Keywords: Cutoff levels, Nigerians, obesity, waist circumference, Circonférence de la taille, les Nigérians, l'obésité, les niveaux de coupure

Introduction

The prevalence of obesity with its attendant morbidity and mortality from cardiovascular diseases (CVDs) is globally on the increase, and this trend now involves not only developed nations but also developing ones comprising mainly of low- and middle-income countries.[1] Early classification of individuals for risks of overweight or obesity offers enormous benefits to the individual, his/her family and the society at large.[2] The benefits are largely due to the opportunities such early detection provides for reversal of the negative consequences of overweight/obesity. Central obesity which refers to the accumulation of fat within the intra-abdominal cavity is a key component in the definition of the metabolic syndrome along with many other cardiometabolic risk factors.[3,4] The syndrome is composed of several cardiovascular risk factors including overweight, obesity and diabetes mellitus, or abnormal glucose tolerance.[5]

Obesity is measured by several common tools such as waist circumference (WC), waist-to-hip ratio (WHR), waist-to-height ratio, and body mass index (BMI). WC and WHR are common tools for measuring central obesity while BMI measures generalized obesity. WC and WHR were found to be significantly associated with the risk of incident CVD events in both males and females.[6,7] WC however is simple and widely accepted for measuring central obesity being devoid of any calculations. Hence, it is very easy to use in a routine clinic setting. Furthermore, WC has been demonstrated to have a better performance than some other tools such as the WHR.[8,9,10,11] Molarius *et al*.,[12] assessing the varying sensitivity of WC action levels to identify subjects with overweight or obesity in 19 populations, concluded that the optimal screening cutoff points for WC should be population specific. Studies conducted among Europeans, Indians, Japanese, Taiwanese, Chinese, North Africans, Koreans, and Iranians yielded different optimal WC cutoff values for the identification of individuals with cardiovascular risk factors.[13,14,15,16,17,18,19,20] Therefore, the importance of ethnic- and gender-specific cutoff values for WC was a key criteria in the International Diabetes Federation's (IDF's) definition of metabolic syndrome with different cutoff values specified for different populations.[4] As a result of lack of data for Sub-Saharan Africans, it was recommended that the European cutoff values be used until more specific data become available for these populations.[4] Most of the studies conducted in Nigeria made use of available recommendations which were all derived from Caucasians due to the absence of data on the cutoff levels of anthropometric indices of obesity for Sub-Saharan Africans or a nationally applicable values for Nigerians.

Pursuant to the gap highlighted in the IDF's recommendations for Sub-Saharan Africa, this study attempted to derive possible gender-sensitive WC cutoff values for Nigerian subjects. The aim of this study therefore was to determine WC cutoff values predictive of overweight and obesity in Nigerian subjects and to evaluate the performances of currently recommended WC cutoff values commonly in use as recommended by IDF and the National Cholesterol Education Program (NCEP).

Subjects and Methods

The study was a multicenter, cross-sectional, observational study which involved apparently healthy adult subjects residing in six urban communities (one community per geo-political zone) across Nigeria. Subjects were defined as apparently healthy (no known history of hypertension, diabetes, or use of drugs for any of these two common cardiovascular ailments) based on self-report by the subjects. The communities involved each had a tertiary healthcare facility (teaching hospital) situated in it and formed the base facility where some of the investigators were practicing as healthcare providers. Nigeria is a multi-ethnic, culturally diverse nation with six geo-political zones, of about 170 million people. The climate in Nigeria spans from the savannah in the Northern regions to tropical rain forest in the Southern regions. The urban communities were Sokoto, Maiduguri, Jos, Sagamu, Enugu, and Calabar. Ethical clearance was obtained from the Institutional Review Board in each of the tertiary healthcare facility.

Selection of subjects was by a two-stage sampling technique. In stage one, investigators were required to select some wards by simple random sampling technique. In stage two, due consent of ward heads or counselors was obtained, and households were selected by cluster sampling. Adults within the households were invited to a convenient location (mostly primary schools) within each of the wards for recruitment after due consent was given. The opportunity was also used to give them some health enlightenment campaigns to help them appreciate some of their health parameters and implications.

Data collection and anthropometric measurements were done using the standardized methods stipulated in the World Health Organization (WHO) STEP-wise approach to chronic disease risk factor Surveillance Instrument version 2.0.[21,22] Medically trained assistants were recruited to assist with data collection and measurements. Measurements done included blood pressure, weight, height, and WC, and hip circumference (HC). Privacy was provided as some of the classrooms were separated for use by different genders. Assistants were also assigned to corresponding genders to enhance privacy. This was necessary because weight and height measurements were done with subjects in light clothing. Weight in kilograms was measured to the nearest 0.5 kg with subjects in light clothing and without shoes using a calibrated bathroom scale (Soehnle Inc., Nassau, Germany) positioned on a flat even surface. Height was measured to the nearest 0.1 cm using a stadiometer with subjects removing foot wears and headgears. The BMI was calculated using the weight in kilograms and the square of the height in meters.

WC in centimeter was measured at the end of expiration to the nearest 0.1 cm using a nonstretchable tape at a point mid-way between the margin of the lowest rib and the iliac crest in the horizontal level. The HC (in cm) was measured to the nearest 0.1 cm at the horizontal level of maximum circumference around the buttocks (posteriorly) and the pubic symphysis (anteriorly). Blood pressure was measured in millimeter of mercury (mmHg) to the nearest 2 mmHg on the right arm using a standard mercury sphygmomanometer (Accosons, A.C. Cossor and Son Surgical Ltd., London, England) with subjects seated and having had at least 5 min of rest. Systolic blood pressure (SBP) was recorded at Korotkoff Phase I while diastolic blood pressure (DBP) was recorded at Phase V. Two measurements were recorded 3 min apart and the average taken as the mean blood pressure.

Using the BMI, the subjects were grouped as underweight, normal weight, overweight, and obese. This was according to BMI of 18.5 kg/m^2, 18.5–24.9 kg/m^2, 25–29.9 kg/m^2, and ≥30 kg/m^2, respectively.[23] The use of BMI for risk categorization in this study, similar to the study by Han *et al*.[13] was based on the following evidence: (1) IDF recommends that where BMI is above 30 kg/m^2, central obesity can be assumed such that measurement of WC may no longer be necessary.[4] (2) Classification of medical risk by weight status using BMI has gained wide acceptance and usage.[24] (3) The index has been shown to correlate with percentage body fat in the young and middle-aged adults.[25] Recommended gender-specific WC classifications were based on the cutoff values recommended for use by the IDF (≥94 cm for males and ≥80 cm for females)[4] and the NCEP (WC ≥102 cm for males and ≥88 cm for females).[26]

Statistical analysis was performed using IBM Statistical Package for Social Sciences (SPSS, IBM Corp., Amonk, NY; released 2011) version 20. Student's *t*-test and analysis of variance were used for comparison of means between two groups and multiple groups, respectively. Comparison of proportions was done using Chi-square analysis (test of association). Correlation between continuous variables was determined using Pearson's correlation while receiver operating characteristics curve analyses were used to determine the performance of WC (measured by area under the curve [AUC]) as a tool while optimal cutoff levels were determined using the decision rule of maximal (sensitivity + specificity) of WC.[27] The AUC is the probability that a positive event is classified as positive by the test given all possible values of the test. Sensitivity (or true positive rate) is the proportion of positive cases that are well detected by the test and specificity (or true negative rate) is the proportion of negative cases that are well detected by the test. The level of significance was set at $P < 0.05$.

Results

A total of 6098 subjects (3243 [53.1%] males and 2855 [46.9%] females) were involved in the study. The distribution of the body weight among these subjects using the BMI classes was as follows: Underweight (266 [4.4%]), normal weight (2815 [46.2%]), overweight (1927 [31.6%]), and obesity (1090 [17.9%]). Excess of weight (overweight and obesity) was common, involving a total of 49.5% of the subjects, but overweight was more common. The group on the average consisted of middle-aged, prehypertensive, and overweight subjects [Table 1]. There was a clear association between BMI categories and the clinical parameters as suggested by the mean values [Table 1]. As BMI category increased, WC, WHR, and blood pressure also increased. The height however did not show a clear trend.

Using Pearson's correlation analysis, a strong, positive, and significant correlation was observed between BMI and WC for the whole group ($r = 0.72$; $P < 0.0001$).

Gender differences in the anthropometric and clinical characteristics of the study population

The study group made up of 6098 subjects comprised 3243 (53.2%) males and 2855 (46.8%) females, giving an overall male: female ratio of 1.2:1. In the whole group, a greater proportion of subjects in the obese category were females (60.3%) while the males dominated the normal weight (60.1%) and overweight (51%) categories [Figure 1]. Male dominance among the underweight category (50.8%) was also observed. Chi-square analysis showed a significant association between gender and obesity proportions among the subjects ($P < 0.0001$). Strong and positive correlation was equally observed between WC and BMI (males: $r = 0.72$ and females: $r = 0.73$; $P < 0.0001$).

Table 2 shows the clinical characteristics and proportions of overweight/obesity of the study subjects by gender. The female subjects were older and shorter than the male subjects. The mean values of indices of obesity (BMI and WC) were higher among the females by approximately two units each ($P < 0.0001$). The overall prevalence of overweight and obesity was 31.6% (95% confidence interval [95% CI]: 30.5–32.8), and 17.9% (95% CI: 16.9–18.7), respectively, but prevalence rates were relatively higher among the female subjects.

Waist circumference cutoff values

WC performed significantly well in both male and female overweight and obese subjects as shown by high (>80%) AUC [Figure 2]. AUC was however higher for obese subjects [Table 3].

The optimal cutoff thresholds selected were gender-specific using decision rule of maximum (sensitivity + specificity). These various probable thresholds with their performance characteristics are shown in Tables 4 and 5 for overweight and obesity, respectively. Generally, males had higher thresholds but there was a very narrow margin of difference (1 cm) in the optimal cutoff threshold selected for overweight male (84 cm) and female (83 cm) subjects [Table 4]. Margin of difference was similarly narrow between optimal cutoff thresholds selected for obesity in males (96 cm) and females (95 cm) as shown in Table 5. The sensitivities and specificities with 95% CIs were high. The selected optimal values differed from existing recommended thresholds which either had low or high sensitivities and specificities.

Discussion

This study with a multicenter spread examined WC cutoff values that predict overweight/obesity in Nigerians.

Prevalence and gender distribution of body weight

In this study, gender-specific prevalence rates of overweight and obesity were significantly higher among the female subjects (33.1% vs. 30.3% and 23.0% vs. 13.4%, respectively), a pattern that agreed with both a similar study in Nigeria and the WHO report on obesity.[28,29] A meta-analysis on prevalence and time trends in obesity among adult West African populations also reported a similar pattern.[30] Apart from genetic and hormonal differences, this observation may also be associated with men being generally more active than women, who mostly engage in sedentary occupations such as market trading.[31] Furthermore, female participants in this study were older than their male counterparts and aging has been shown to be associated with changes in body composition.[32] These changes tend to encourage the development of obesity as a result of progressive decrease in fat-free mass and increase in fat mass. In this study, the overweight/obese subjects were also older than the others.

Compared to an earlier report by the WHO, the prevalence of obesity in this study suggests an increase in the burden of obesity as was similarly noted in the study by Abubakari *et al*.[30] The rising prevalence of obesity may be attributed largely to the adoption of westernized lifestyles by Nigerians most commonly seen among urban dwellers. For instance, some studies reported physical inactivity among many adult Nigerians.[31,33]

Significantly, subjects with generalized obesity (BMI ≥30 kg/m^2) were older, had higher WC, SBP, and DBP compared with the overweight or normal individuals. BMI correlates positively with WC and hypertension.[8,11,34,35] This study also revealed a strong and positive correlation between these two measures of obesity. This may support the IDF's recommendation that in the diagnosis of metabolic syndrome, central obesity can be assumed if BMI is >30 kg/m^2.[4] Obesity is known to influence several physiologic mechanisms such as the activation of the sympathetic nervous system, alteration in renal sodium handling, increased plasma renin activity, angiotensinogen, angiotensin II and aldosterone.[36] These mechanisms are known to play different roles in the regulation of blood pressure and thus, could account for the increase in both SBP and DBP across increasing BMI categories observed in this study.

Waist circumference cutoff values for identifying overweight and obesity

The WC cutoff selected for overweight (83 cm) and obesity (95 cm) in women were marginally lower than those selected for overweight (84 cm) and obese (96 cm) men. This pattern, whereby men have higher cutoff is in agreement with the pattern seen in the recommendation by the IDF.[4] Most definitions for the metabolic syndrome also recommend higher WC for the males.[4,26] This gender pattern may be accounted for by the fact that men tend to deposit fat in the abdomen (upper body or android obesity) while women deposit fat more on the hips (lower body or gynoid obesity). These patterns of body fat deposition are thought to be influenced by sex hormones which not only influence the pattern of body fat distribution but also the burden of obesity in women.[37] This study also revealed higher prevalence of overweight and obesity among the females. An Iranian study found WC cutoff for identifying CVD to be higher in women than men; this is at variance with our observation in this study.[20] Two action levels (levels 1 and 2) which corresponded to BMI ≥25 kg/m^2 and 30 kg/m^2) were defined for Caucasians by Han *et al*.[13] At action level 1, WC of 94 cm for men was higher than the 84 cm selected in this study while WC of 80 cm for women was lower than 83 cm selected in our study. At action level 2, WC of 96 cm and 95 cm selected were, respectively, less and higher than 102 cm and 88 cm recommended in the Caucasian study. This shows that degrees of fat deposition may vary among populations.[35] This is likely to be determined not only by genetics and hormonal influences but also by their lifestyle. Studies of fat distribution among Nigerians are barely nonexistent but Adams-Campbell *et al*.[38] showed that Nigerian women had more upper body obesity than both black and white US women. This however involved groups of very young people (mean age range: 18.6–22.4 years). In a similar study by the same group of workers, African-Americans were shown to more likely be obese and overweight than Nigerian counterparts, but there appeared to be no significant difference in the distribution of body fat and abdominal fat between the groups for either gender.[39] BMI classification was according to classification by the National Center for Health Statistics which differed from the WHO classification that was used in this index study.

The WC cutoff for identifying obesity in men in this study is higher than that recommended by the IDF.[4] The IDF value was based on studies conducted among the Caucasians rather than Africans.[13] The NCEP Adult Treatment Panel III also recommended a higher WC than that recommended by the IDF for the identification of metabolic syndrome in men.[26] Some workers on the other hand found that a lower WC than that recommended by IDF identified men with CVDs in contrast to the threshold of 100 cm selected to predict insulin resistance in a Caucasian population.[14,15,16,17,18,19,20,40] The WC cutoff for identifying obesity in women is higher in this study than that recommended by IDF. For women, different patterns have been observed. While some workers found the same cutoff value recommended by IDF[14,17,41] other workers found lower[16] and higher[15,18,19,20] values similar to the pattern observed in this study.

Selection of optimal thresholds for physiological variables to classify risk exposure can be done by several ways depending on the population being studied and the variable of interest. For instance, pure physiological parameters obeying the laws of normal distribution in a population can be decided using 95% reference interval. When health risks are being studied with potentials for preventive benefits, it requires that the population or sample be classified based on a risk status using an appropriate or gold standard test where such is available and affordable. Under such scenario, decisions based on trade-offs between sensitivity and specificity may better reveal performance characteristics of possible thresholds. Hence, such a scenario was used in this study. Sensitivity (equivalent to the true positive rate) defines the proportion of positive cases that are well detected by the test while specificity (also called true negative rate) defines the proportion of negative cases that are well detected by the test. In other words, sensitivity and specificity measure how the test is effective when used on positive and negative individuals, respectively. The test is perfect for positive or negative individuals when sensitivity or specificity is 1, respectively. When it is 0.5, it can be interpreted as being similar to drawing randomly whereas if it is < 0.5, it suggests a counter performance. Some other characteristics may be employed if prevalence and cost are significant. Different WC cutoff values were selected or derived in this study as determined by their sensitivities and specificities. When recommended values are applied to this sample, specificities were lower than that of the selected cutoff values while sensitivities also dropped as the possible criterion increased. The recommended values were generally inappropriate for this sample and hence not selected for either having a high but low specificity or vice versa.

Conclusions

The WC cutoff for identifying obesity in this Nigerian population is higher than the value recommended for use in Sub-Saharan Africa, and the currently recommended values may be said to be inappropriate for both Nigerian men and women. Although we recognize that this study is the first to attempt this definition for Nigerians, with a multicenter and national spread, it should be noted that this is a cross-sectional study. Therefore, the findings from this study will need to be validated by further studies.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Figures and Tables

Table 1

Mean clinical parameters of the participants according to the body mass index categories

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*Differences in mean for all the variables using ANOVA were significant at $P<0.0001$. ANOVA=Analysis of variance, SBP=Systolic blood pressure, DBP=Diastolic blood pressure, BMI=Body mass index, WHR=Waist-to-hip ratio, WC=Waist circumference, SD=Standard deviation, HC=Hip circumference

Figure 1

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Gender distribution across body mass index categories

Table 2

Clinical characteristics of the population by gender

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*Differences significant at $P<0.001$ except as further indicated by other special characters, [†]$P=0.004$, [§]$P\leq0.02$, [‡]Difference not significant ($P=0.078$). SBP=Systolic blood pressure, DBP=Diastolic blood pressure, BMI=Body mass index, WHR=Waist-to-hip ratio, WC=Waist circumference, SD=Standard deviation, CI=Confidence interval, HC=Hip circumference

Figure 2

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Receiver operating characteristics plots showing the area under the curve for overweight male (a), overweight female (b), obese male, (c) and obese female (d) subjects. Sensitivity = true positive rate, 1 - specificity = false positive rate

Table 3

Summary of the performance of waist circumference in overweight and obese subjects

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AUC=Area under the curve, SE=Standard error, CI=Confidence interval

Table 4

Thresholds of waist circumference with performance characteristics for overweight in males and females

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*Optimal threshold selected. CI=Confidence interval

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Table 5

Thresholds of waist circumference with performance characteristics for obesity in male and female subjects

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*Optimal threshold selected, †Recommended value according to IDF, ‡Recommended value according NCEP (exact or the closest value generated). CI=Confidence interval, IDF=International Diabetes Federation, NCEP=National Cholesterol Education Program