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Correlation of obesity indices with metabolic syndrome among Igbos in Enugu and their optimal cut-off points

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Abstract

Background: Metabolic syndrome also known as insulin resistance syndrome or Syndrome X, represents an association of risk factors for cardiovascular disease and type 2 diabetes mellitus. Its central diagnostic criteria include obesity, impaired fasting glucose, low HDL-cholesterol; elevated triglycerides levels and high blood pressure. Insulin resistance is believed to be the main cause of Metabolic Syndrome and is connected to the level of visceral or intra-abdominal adipose tissue, which could be assessed either by calculating body mass index or by measuring waist circumference.

Objectives: This study aimed at determining the correlation of indices of obesity with metabolic syndrome among Igbos in Enugu and their optimal cut-off points.

Method: This was a cross-sectional community-based descriptive survey carried out in Enugu Metropolis involving 469 apparently healthy adult volunteers age range 18-75 screened for metabolic syndrome using the Joint Interim Statement definition. Stratified random sampling technique was used in the selection of participants. The data obtained were coded and analyzed into percentages, mean and standard deviation using the Statistical Package for Social Sciences (SPSS), version 23. t-test was used to compare continuous variables for associations, while Youden index and Receiver Operating Characteristic analysis were used to determine optimal cut-off point of the obesity indices that best balances sensitivity and specificity of the obesity indices. Pearson correlation coefficient was used to examine correlation between obesity indices and cardiovascular risks. Statistical significance is set at $p< 0.05$ and 95% confidence interval.

Result: The study revealed that all indices of obesity showed positive correlation with metabolic syndrome. BMI showed the least strength of correlation while WC is the best discriminator for predicting Metabolic Syndrome however, the optimal cut-off point of the obesity indices differ from the standard cut-off points.

Conclusion: All the obesity indices used in the study showed positive correlation with metabolic syndrome however, WC is to be preferred in screening for metabolic syndrome. The optimal cut-off point obtained can be applied specifically for Igbos in Enugu

Keywords: Obesity; Metabolic syndrome; Igbos; Enugu; Insulin resistance; Youden index

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1. Introduction

Metabolic syndrome (MetS), also known as insulin resistance (IR) syndrome or Syndrome X, represents an association of risk factors for cardiovascular (CV) disease (CVD) and type 2 diabetes mellitus (T2DM) [1]. The definition of MetS may slightly differ depending on the society that described it, its central diagnostic criteria include impaired fasting glucose, low HDL-cholesterol, elevated triglycerides levels and high blood pressure. Insulin resistance (IR) is believed to be the main cause of MetS and is connected to the level of visceral or intra-abdominal adipose tissue, which could be assessed either by calculating body mass index or by measuring waist circumference [2]. Insulin resistance is the most accepted unifying theory explaining the pathophysiology of the metabolic syndrome. Nevertheless, epidemiologic studies show that a reasonable proportion of patients with the metabolic syndrome do not have evidence of insulin resistance, and the correlation between insulin resistance and individual components of the syndrome is weak to moderate while its implication in hypertension appears to be even weaker than its role in causing hyperglycemia and dyslipidemia [3].

The role of obesity in the pathophysiology of metabolic syndrome is better appreciated by recognizing the endocrine function of adipose tissues especially abdominal fat that is more metabolically active than the fat located elsewhere in the body. Obesity is also characterized by a low-grade systemic chronic inflammatory state. This chronic inflammation leads to changes in adipose tissue, inflammatory cells, tissue destruction and an increase in the level of plasma inflammatory markers and inflammatory cells in circulation [4]. In the adipose tissue, an excessive caloric uptake by adipocytes induces the release of numerous inflammatory mediators, such as tumor necrosis factor α (TNFα) and interleukin 6 (IL-6), these in turn stimulate C-reactive protein (CRP) release while on the other hand, adiponectin secretion is reduced, and all these processes result in a pro-inflammatory environment. In addition to the raise in cytokine production, obesity is characterized by increased adhesion molecule levels, which, along with the mentioned cytokines, stimulate tissue-specific macrophage recruitment which ultimately induces IR and impaired vascular reactivity [5].

As the global burden of obesity increases, a rise in the prevalence of metabolic syndrome and its comorbidities such as various cancers, PCOS, Nonalcoholic fatty liver disease; Obstructive sleep apnea, Hypogonadism and subfertility; Lipodystrophy and Microvascular disease can be safely assumed [6-8]. The prevalence of MetS frequently coincides with the prevalence of obesity and type 2 diabetes, where about one third of US adults have MetS. Nearly 25% of the globe grown population are suffering from MetS, its occurrence is rising in children in Western nations, particularly because of lifestyle alterations [9]. The global prevalence could be estimated to be about one quarter of the world population and more than a billion people in the world are affected by MetS. The prevalence estimates differ depending on the criteria used to define MetS for instance, a national survey in Iran in 2007 showed MetS prevalence of 34.7% based on ATP III criteria, 37.4% based on IDF definition, and 41.6% based on ATP III/AHA/NHLBI criteria.

In another Middle Eastern country, Tunisia, prevalence was 45.5% based on IDF criteria but 24.3% based on ATP III criteria however, in Middle Eastern countries, prevalence was much higher among women than men [10]. In the United States among adults aged 18 years or older, prevalence rose by more than 35% from 1988–1994 to 2007–2012, increasing from 25.3% to 34.2% [11], while 24.09% and 23.02% using IDF and NCEP definitions was seen in Enugu by Odumeh et al [12].

Studies have shown strong correlation between central obesity indices and metabolic syndrome with some suggesting waist circumference while others suggest waist hip ratio or waist to height ratio as more reliable predictor of metabolic syndrome in some cases. A study by Shen et al [13] in African-American women showed that WC had the highest correlation with metabolic syndrome compare to other indices of obesity. Similar conclusion was reached in a study by Hirschler et al [14] which noted a significant correlation between WC and all the components of the metabolic syndrome in children, while a study of Iranian adult population demonstrated the superiority of WC in predicting metabolic syndrome regardless of age-group and gender [15]. Similarly, WC was also noted to be superior to other indices of obesity in predicting metabolic syndrome among Qatari adult population in a study by Bener et al [16] in 2013. Another study among a Chinese population by Wang et al [17] also noted better MetS predicting power of WC compare to WHR; similar result was also obtained by Cheong et al [18] in a Malaysian population where WC was shown to be a better predictor of MetS than WHR.

While most studies in the literature reported greater predicting power of WC, some showed equal predictive power of the obesity indices. A study by Liu et al[19] in a Chinese population showed equal MetS predictive power of all the obesity indices used whereas, another study in Mexico by Rodea-Montero et al [20] among adolescent population asserted the superiority of WtHR in predicting metabolic syndrome a finding that is contrary to the one in a study by Agredo-Zúñiga et al [21] in Colombia where WHtR was found not be an important adiposity marker for metabolic

syndrome. Nevertheless, another study by Rodrigues et al [22] in Brazil opined that WHtR is the simplest and best obesity index in predicting metabolic in their study population.

Body mass index (BMI) an earlier and more traditional index of obesity can also predict metabolic syndrome but not as efficiently as central obesity indices which contain more metabolically active adipose tissue. Many studies have shown that increased BMI is associated with increased risk of metabolic syndrome and type-2 diabetes [23-26]. While most studies agreed that other measures of obesity especially central obesity indices are superior to BMI in predicting metabolic syndrome, the study by Ryan et al [27] showed no difference in the predictive power of waist circumference and body mass index. However, another study by Jung et al [28] among adolescents in Germany showed BMI to have the best predictive power in identifying metabolic syndrome. Most recent studies revealed that IR may also be present in non-obese patients, and considered visceral adiposity to be the main effector of MetS' pathology therefore, this study aimed at determining the correlation of indices of obesity with metabolic syndrome and the optimal cut-off point of these indices in Enugu.

2. Material and methods

This was a cross-sectional community-based descriptive survey carried out in Enugu Metropolis. A total of 469 apparently healthy subjects with no physical deformity were selected in this study using stratified random technique. The cohort consists of 264 females (56%) and 205 males (44%) with age range 18-75 years. Ethical approval was obtained from the Ethical Committee of Enugu state University Teaching Hospital, in accordance with the declaration of Helsinki while informed verbal and written consents were secured and only those who volunteered took part in the study.

A brief medical assessment was carried out on each participant followed by anthropometric measurements, blood pressure check and venous blood sample collection. The main findings were filled into the study questionnaire, measurements were carried out as provided in the WHO STEPS instrument on surveillance of behavioral risk factors (version 2). All the measurements were conducted in strict privacy where the participants were neither heard nor seen by other people. Only participants of Igbo ethnic nationality who have stayed up to a year in Enugu and within the age range of 18-75 were included in the study. Physically challenged persons, pregnant women, those with clinical evidence of abdominal mass or ascites; malignancy, active or chronic liver disease, chronic kidney disease; history of alcohol or drug abuse, hormone replacement therapy and epileptics were excluded from the study. Anthropometric measurements were carried out by us and with the help of trained research nurses and students while phlebotomists were recruited for blood sample collection.

2.1. Anthropometric measurements

2.1.1. Weight and height

Participant weight and height was measured with a stadiometer ((SECA: Model Seca culta 786 Mechanical Column Scale with Large Round Dial. Hamburg Germany), in accordance to the World Health Organization (WHO) multinational monitoring of trends and determinants in cardiovascular disease criteria. To measure height and weight, the participants were lightly dressed and asked to take off their shoes (and with heels together, toes apart, ensuring that weight is evenly distributed on both feet) hat or head ties, stand with back to the tape measure, and hold their head in a position where he/she can look straight at a spot head high on the opposite wall. A flat rule was placed on the participant's head, so that their hair (if present) was pressed flat. Height was measured to the nearest centimeter, at the level where the flat rule touches the rigid rule while the weight is simultaneously readout to the nearest 0.1kg [29].

2.1.2. Waist circumference

The subject is dressed as for the height measurement and is standing erect. He/she was asked to roll up the shirt/sweater, to undo the belt and/or open and lower the trouser/skirt waistband, so that one can palpate the hip area to identify the measurement reference points. The measure was taken at the midpoint between the lowest rib and the iliac crest. The measuring tape was placed perpendicular to the long axis of the body and horizontal to the floor, with sufficient tension to avoid slipping off but without compressing the skin. The measurement was made at the end of a normal expiration to the nearest 0.1cm [30].

2.1.3. Hip circumference

Hip circumference was measured at the widest point of the buttocks. Standard tailor measuring tape, maximum length 150 cm was used for hip measurement. The subject stands erect, the weight evenly distributed on both feet. The tape

was placed at the maximum extension of the buttocks, horizontal to the floor, with sufficient tension to avoid slipping off. The tape was held a bit tighter but without compressing the buttocks. The zero end of the tape was held under the measurement value recorded to the nearest 0.1cm [31].

2.2. Body mass index

Body mass index (BMI) was calculated by dividing the weight in kilogram by the square of the height in meter (Weight(Kg)÷Height(m^2))

2.3. Waist – hip ratio

Waist–hip ratio or waist-to-hip ratio (WHR) is the ratio of the circumference of the waist to that of the hip. This was calculated as waist measurement divided by hip measurement (WC ÷ Hip C).

2.4. Waist-to-height ratio

Waist-to-height ratio (WHtR) is the ratio of the circumference of the waist to that of the height (WC÷Height)

2.5. Blood pressure measurement

Blood pressure was measured using beurer [BM 28 HSD-Medaval: OBL Beurer GmbH, Germany] automatic blood pressure monitoring kit. Prior to the measurement, the participant was seated and rested for 5 minutes in sitting position on a chair that supported the back comfortably. The left arm muscles were relaxed and the forearm supported with the cubital fossa at the heart level. A cuff of suitable size was applied evenly to the exposed arm with care taken not to make it too tight by sliding a finger freely between the cuff and the skin.

2.6. Blood sample collection/biochemistry

The participants were fasted for at least 12h before blood collection. They were rested for at least 10min in a quiet room before taking a sample. A 5ml sample was collected from each participant from an antecubital vein in the right arm and stored in fluoride and plain bottles. The samples were transported to the Laboratory for analysis. The enzymatic method was used in the analysis of serum TG and glucose, while HDL-C was assessed using precipitation method [32-34]. Metabolic syndrome was defined using the joint IDF/NHLBI/AHA criteria (JIS).

2.7. Data analysis

The data obtained were coded and analyzed into percentages, mean and standard deviation using the Statistical Package for Social Sciences (SPSS), version 23. t-test was used to compare continuous variables for associations, while Youden index and Receiver Operating Characteristic analysis were used to determine optimal cut-off point of the obesity indices that best balances sensitivity and specificity of the obesity indices. Pearson correlation coefficient was used to examine correlation between obesity indices and cardiovascular risks. Statistical significance is set at $p< 0.05$ and 95% confidence interval

3. Results

Table 1 Baseline characteristics of study participants

Characteristics	Total(N=469)	Male(n=205)	Female(n=264)	*P*-value
Anthropometric indices				
Weight (kg)	74.12 ± 15.65	73.71±13.77	74.35 ± 16.95	0.657
Height (cm)	168.99±10.20	176.19±9.68	163.41 ± 6.40	<0.001
BMI (kg/m^2)	26.18 ± 6.24	23.92 ± 5.17	27.90 ± 6.43	<0.001
Waist circumference (cm)	89.09 ± 14.82	83.98±11.33	92.97 ± 15.94	<0.001
Hip circumference (cm)	102.68±12.67	97.72±10.27	106.48 ± 13.02	<0.001
WHR	0.87 ± 0.07	0.86 ± 0.06	0.87 ± 0.08	0.072
WHtR	0.53 ± 0.10	0.48 ± 0.07	0.57 ± 0.10	<0.001

Table 1. Showed the anthropometric indices of the study population, here no significant difference was seen between the weight and WHtR of the females and males, but the rest of the anthropometric indices were found to be significantly higher in the females.

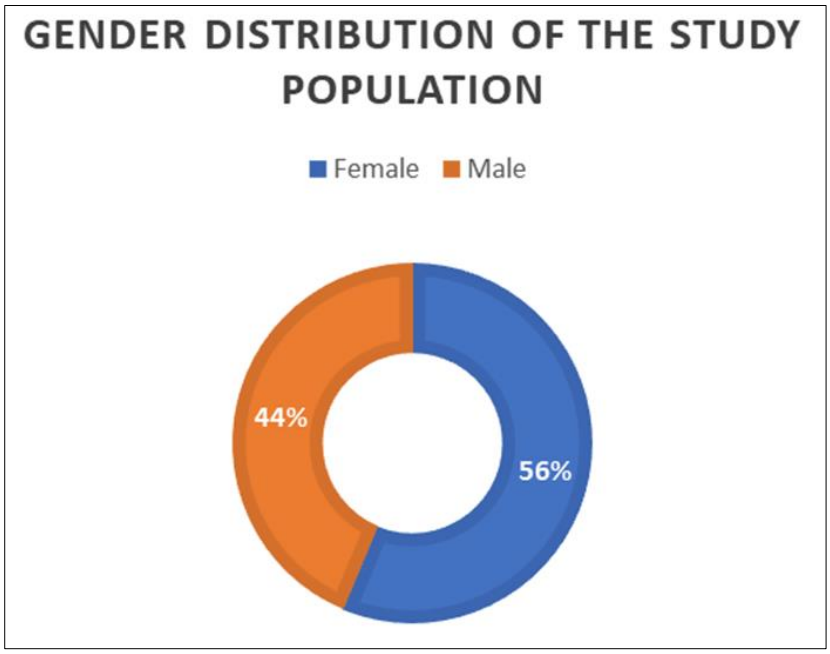

Figure 1 Doughnut chart showing gender distribution of the study population. It shows that 44% or 205 participants were males while the rest 56% or 264 were females

Table 2 Correlation coefficients (95% CIs) between anthropometric indices, metabolic risk factors and metabolic syndrome

	BMI	**WC**	**HC**	**WHR**	**WHtR**
Overall (N = 469)					
Systolic BP	0.33 (0.25, 0.41)***	0.41 (0.33, 0.49)***	0.33 (0.25, 0.41)***	0.32 (0.24, 0.40)***	0.40 (0.32, 0.47)***
Diastolic BP	0.35 (0.27, 0.43)***	0.36 (0.27, 0.43)***	0.34 (0.25, 0.42)***	0.20 (0.12, 0.29)***	0.33 (0.25, 0.41)***
Fasting Glucose	0.26 (0.17, 0.34)***	0.34 (0.26, 0.42)***	0.23 (0.14, 0.31)***	0.32 (0.24, 0.40)***	0.33 (0.25, 0.41)***
Total Cholesterol	−0.03 (−0.12, 0.06)	−0.02 (−0.11, 0.07)	0.04 (−0.06, 0.13)	−0.08 (−0.17, 0.01)	−0.02 (−0.11, 0.07)
Triglycerides	0.19 (0.11, 0.28)***	0.29 (0.21, 0.37)***	0.24 (0.15, 0.32)***	0.23 (0.14, 0.31)***	0.31 (0.22, 0.39)***
HDL–Cholesterol	−0.09 (−0.18, 0.01)	−0.16 (−0.25, −0.07)*	−0.05 (−0.14, 0.04)	−0.22 (−0.30, −0.13)***	−0.16 (−0.24, −0.07)***
VLDL Cholesterol	0.10 (−0.01, 0.21)	0.14 (0.03, 0.24)***	0.09 (−0.02, 0.20)	0.14 (0.03, 0.25)*	0.15 (0.04, 0.26)**
MetS	0.41 (0.33, 0.48)***	0.54 (0.48, 0.60)***	0.38 (0.30, 0.46)***	0.50 (0.43, 0.56)***	0.57 (0.51, 0.63)***
Male (n = 205)					
Systolic BP	0.24 (0.11, 0.37)***	0.39 (0.27, 0.50)***	0.34 (0.22, 0.46)***	0.24 (0.10, 0.36)***	0.36 (0.24, 0.48)***
Diastolic BP	0.28 (0.15, 0.40)***	0.36 (0.24, 0.48)***	0.37 (0.25, 0.48)***	0.15 (0.01, 0.28)*	0.34 (0.21, 0.46)***
Fasting Glucose	0.22 (0.08, 0.35)**	0.31 (0.18, 0.43)***	0.17 (0.04, 0.30)*	0.29 (0.16, 0.41)***	0.32 (0.19, 0.44)***
Total Cholesterol	0.04 (−0.10, 0.17)	0.01 (−0.12, 0.15)	0.07 (−0.07, 0.20)	−0.07 (−0.20, 0.07)	0.02 (−0.12, 0.16)
Triglycerides	0.27 (0.14, 0.39)***	0.34 (0.22, 0.46)***	0.26 (0.13, 0.38)***	0.27 (0.13, 0.39)***	0.36 (0.24, 0.48)***
HDL–Cholesterol	0.05 (−0.09, 0.19)	−0.02 (−0.15, 0.12)	0.06 (−0.07, 0.20)	−0.11 (−0.24, 0.03)	−0.06 (−0.19, 0.08)
VLDL Cholesterol	0.12 (−0.05, 0.27)	0.13 (−0.03, 0.29)	0.07 (−0.09, 0.23)	0.16 (−0.01, 0.31)	0.16 (0.01, 0.32)*
MetS	0.32 (0.19, 0.43)***	0.46 (0.34, 0.56)***	0.25 (0.12, 0.37)***	0.47 (0.36, 0.57)***	0.49 (0.38, 0.59)***
Female (n = 264)					
Systolic BP	0.40 (0.29, 0.50)***	0.45 (0.34, 0.54)***	0.35 (0.24, 0.45)	0.37 (0.26, 0.47)***	0.47 (0.37, 0.56)***
Diastolic BP	0.45 (0.35, 0.54)***	0.40 (0.29, 0.50)***	0.36 (0.25, 0.46)	0.26 (0.14, 0.37)***	0.42 (0.31, 0.51)***
Fasting Glucose	0.22 (0.11, 0.34)***	0.32 (0.21, 0.43)***	0.20 (0.08, 0.31)	0.34 (0.23, 0.44)***	0.29 (0.18, 0.40)***
Total Cholesterol	−0.07 (−0.19, 0.05)	−0.03 (−0.16, 0.09)	0.02 (−0.10, 0.14)	−0.09 (−0.20, 0.04)	−0.04 (−0.17, 0.08)

Triglycerides	0.14 (0.01, 0.25)*	0.27 (0.15, 0.37)***	0.22 (0.10, 0.33)	0.21 (0.09, 0.32)***	0.29 (0.18, 0.40)***
HDL–Cholesterol	–0.20 (–0.31, –0.08)**	–0.27 (–0.38, –0.15)***	–0.15 (–0.26, –0.03)	–0.29 (–0.40, –0.17)***	–0.27 (–0.38, –0.15)***
VLDL Cholesterol	0.11 (–0.05, 0.25)	0.17 (0.02, 0.32)*	0.14 (–0.02, 0.28)	0.14 (–0.01, 0.29)	0.20 (0.05, 0.34)*
MetS	0.37 (0.26, 0.47)***	0.52 (0.42, 0.60)	0.34 (0.23, 0.45)***	0.51 (0.41, 0.59)***	0.52 (0.43, 0.61)***

*P <0.05 Table 2. Showed that metabolic risk factors and metabolic syndrome are positively correlated with obesity indices except for HDL-Cholesterol which is mostly negatively correlated with the obesity indices. BMI showed the weakest association with these factors. ;**P <0.01; ***P <0.001

Table 3 Cut-off Points and results for analyses of receiver operating characteristics curve and Youden index for BMI, WC, WHR and WHtR Predictive of metabolic abnormality

	Cut-off	**SN (95% CI)**	**SP (95% CI)**	**YI**	**LR**	**ROC AUC**	**PPV (%)**	**NPV (%)**
Male								
BMI	> 26.73	65 (44, 83)	87 (81, 91)	0.52	4.90	0.75 (0.69, 0.81)	42 (31, 53)	95 (91, 97)
WC	> 91.00	81 (61, 93)	89 (84, 94)	0.70	7.65	0.81 (0.75, 0.86)	53 (41, 64)	97 (94, 99)
WHR	> 0.93	62 (41, 80)	94 (90, 97)	0.56	11.08	0.83 (0.77, 0.88)	62 (45, 76)	94 (91, 97)
WHtR	> 0.54	73 (52, 88)	90 (85, 94)	0.63	7.31	0.82 (0.76, 0.87)	51 (39, 63)	96 (93, 98)
Female								
BMI	> 27.25	70 (60, 78)	69 (61, 76)	0.39	2.24	0.72 (0.66, 0.77)	59 (52, 65)	78 (72, 83)
WC	> 92.00	79 (70, 87)	71 (64, 78)	0.51	2.78	0.82 (0.77, 0.87)	64 (58, 70)	85 (79, 89)
WHR	> 0.88	72 (62, 80)	76 (69, 83)	0.48	3.03	0.80 (0.75, 0.85)	66 (59, 72)	81 (76, 85)
WHtR	> 0.58	71 (61, 79)	80 (73, 86)	0.51	3.55	0.83 (0.78, 0.87)	69 (62, 76)	81 (76, 85)

SN; sensitivity, SP; specificity, YI; Youden index, LR; likelihood ratio, PPV; positive predictive value, NPV; negative predictive value, BMI; body mass index, WC; waist circumference, WHR; waist-hip ratio, WHtR; waist-height ratio.; From the table, optimal cut-off for BMI is >26.73kg/m2 and 27.25 kg/m2; for WC is >91.00cm and >92cm; for WHR is 0.93 and 0.88; for WHtR is 0.54 and 0.58 for male and female respectively. WC showed the highest sensitivity in both genders in identifying metabolic syndrome among the indices of obesity used but its AUC value is less than WHR and WHtR in males, and less than only WHtR among the females.

4. Discussion

In this study 469 apparently healthy participants from age range 18-75 were recruited, the cohort consists of 264 females (56%) and 205 males (44%). The mean anthropometric indices of the participants showed that there is no significant difference in weight between the genders while, males are significantly taller than the females in this study population. Body mass index, waist circumference, hip circumference and waist height ratio were found to be significantly higher in the females compare to the males while no significant difference was seen in WHR between the genders.

It was also noted from the study that, systolic blood pressure correlated strongly and positively ($p<0.001$) with all the obesity indices in the general population same as in the males but in the females, no significant association was seen with hip circumference while diastolic blood pressure is also strongly and positively correlated with all obesity indices in the general study population and the males, it also showed no association with hip circumference in the females. Fasting blood sugar also correlates positively with all obesity indices but shows no association with waist circumference in the females. Total cholesterol correlated negatively with all obesity indices in both genders, while triglycerides are strongly and positively correlated with obesity indices except with hip circumference in the females. HDL-cholesterol showed strong negative correlation with all obesity indices in the females except for HC, stronger with WHR and WHtR than WC in the general population, while VLDL cholesterol is only positively correlated to WC, WHR and WHtR. The behavior of HC is not surprising as it is not used as measure of obesity. Generally speaking, MetS showed strong positive correlation with all the obesity indices except for hip circumference which however, is not used to assess obesity.

The study revealed that optimal cutoff values for men and women were >26.73kg/m2 and 27.25 kg/m2 for BMI, >91.00cm and >92cm for WC, 0.93 and 0.88 for WHR, and 0.51 and 0.54 and 0.58 for WHtR respectively. The study further disclosed that all obesity indices correlate positively with metabolic syndrome and that WHR in males and WHtR in females appeared to be better discriminators than the other obesity indices in predicting metabolic syndrome with wider areas under the curve (AUC) which was 0.83 for both genders. Among males, WC showed the highest sensitivity and specificity also highest Youden index while in the females, WC also showed the highest sensitivity, but the highest specificity was shown by WHtR. Youden index in the female was equal for WC and WHtR, the lower youden index value of BMI in the females suggests inferior diagnostic value in the diagnosis of metabolic syndrome. The optimal BMI cutoff values in this study is greater than the universal cutoff of ≥25kg/m^2 in both genders, WC optimal cutoff in the participants was less than JIS cutoff for Subsaharan African in the male which is 94cm but greater than that of the female which is 80cm. The optimal WHR in our study is less the the WHO cutoff for WHR in the male but greater in the female which is 0.88 against 0.80 by WHO while the optimal cutoff for WHtR is greater than the universal 0.5 in both genders. This finding suggests that male Igbos are prone to develop metabolic abnormalities at lower adiposity than is known for Subsaharan Africans, a finding that can be of great benefit for medical practitioners in our clinics.

The findings in our study is very similar the the one obtained in a study by Khader et al [35] among Jordanian adults in which WC cutoff values was found to vary from 88.5 to 91.8 cm in men and from 84.5 to 88.5 cm in women, BMI cutoff values ranged from 26.2 to 27.2 kg/m2 in men and from 27.2 to 30.0 kg/m2 in women; WHR cutoff values varied from 0.88 to 0.90 in men and from 80.0 to 0.83 in women, while WHtR cutoff values varied from 0.50 to 0.51 in men and women somewhat less than the WHtR values obtained in our study.

In another study in poland, by Głuszek et al [36] found WHtR ratio of 0.549 and 0.532 for male and female respectively very similar to our figures in the present study. In Mexicans, BMI values of 22kg/m^2 to 24 kg/m^2 in both sexes and WC values of 75 to 80 cm in men and 70 to 80 cm in women were found to be associated with increased risk of DM and MetS with WC being a better discriminator than BMI, whereas in an Iranian population, optimal cutoff points in predicting metabolic syndrome were found to be BMI: 26 kg/m2 and 27.5 kg, WC: 89.5 cm and 83.5 cm for males and females respectively, again WC was found to be a better discriminator for MetS just like in our study[37, 38]. In a Chilean study, optimal WC for predicting MetS was 92·3 cm and 87·6 cm for men and women respectively, the male cutoff point being less than that of IDF while the female is significantly more than that of IDF whereas, in Saudi Arabia, the optimal cutoff values for identifying the risk of metabolic syndrome using WC, WHR, and BMI were 92 cm, 0.89, and 25 kg/m2 and 87 cm, 0.81 and 28 kg/m2 for men and women respectively[39,40].

Though most studies including ours considered WC to be be the best discriminator for metabolic syndrome however, the best anthropometric parameter for identifying metabolic syndrome is still controversial and varied widely depending on the population and ethnicity in question [41, 42]. While WHR was considered a better indicator for cardiovascular risk factors compared to BMI in Australia, Canada, and Japan [43-45], WHtR was considered the best discriminator of metabolic syndrome in Mexican adolescents, adult Chinese and Korean populations compare to other surrogates of obesity [20,46-47], though BMI seen as the least sensitive predictor of metabolic syndrome among the

anthropometric indices was reported in one study to be of equal predictive efficacy with BMI SDS, Fat-Free Mass Index (FFMI), Fat Mass Index (FMI), Tri-Ponderal Mass Index (TMI), Waist-to-Height ratio (WHtR) and Body Mass Fat Index (BMFI) in children and adolescents [48].

5. Conclusion

This study has shown that all the obesity indices considered in the study population showed positive correlation with metabolic syndrome, it also demonstrated that WC with the greatest sensitivity, specificity and Younden index should be preferred as a discriminator for metabolic syndrome screening among Igbos. The study also unveiled the optimal cut-off point for the obesity indices among Igbos in Enugu which matches the highest sensitivity and specificity of the obesity indices in detecting metabolic syndrome.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

The authors have no conflict of interest to declare.

Statement of ethical approval

The study was duly approved by the Ethical Committee of the Enugu State University of Science and Technology Teaching Hospital Enugu. Informed written consent was obtained from all participants that were included in the study.

Statement of informed consent

Written informed consent was obtained from all participants included in the study.

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