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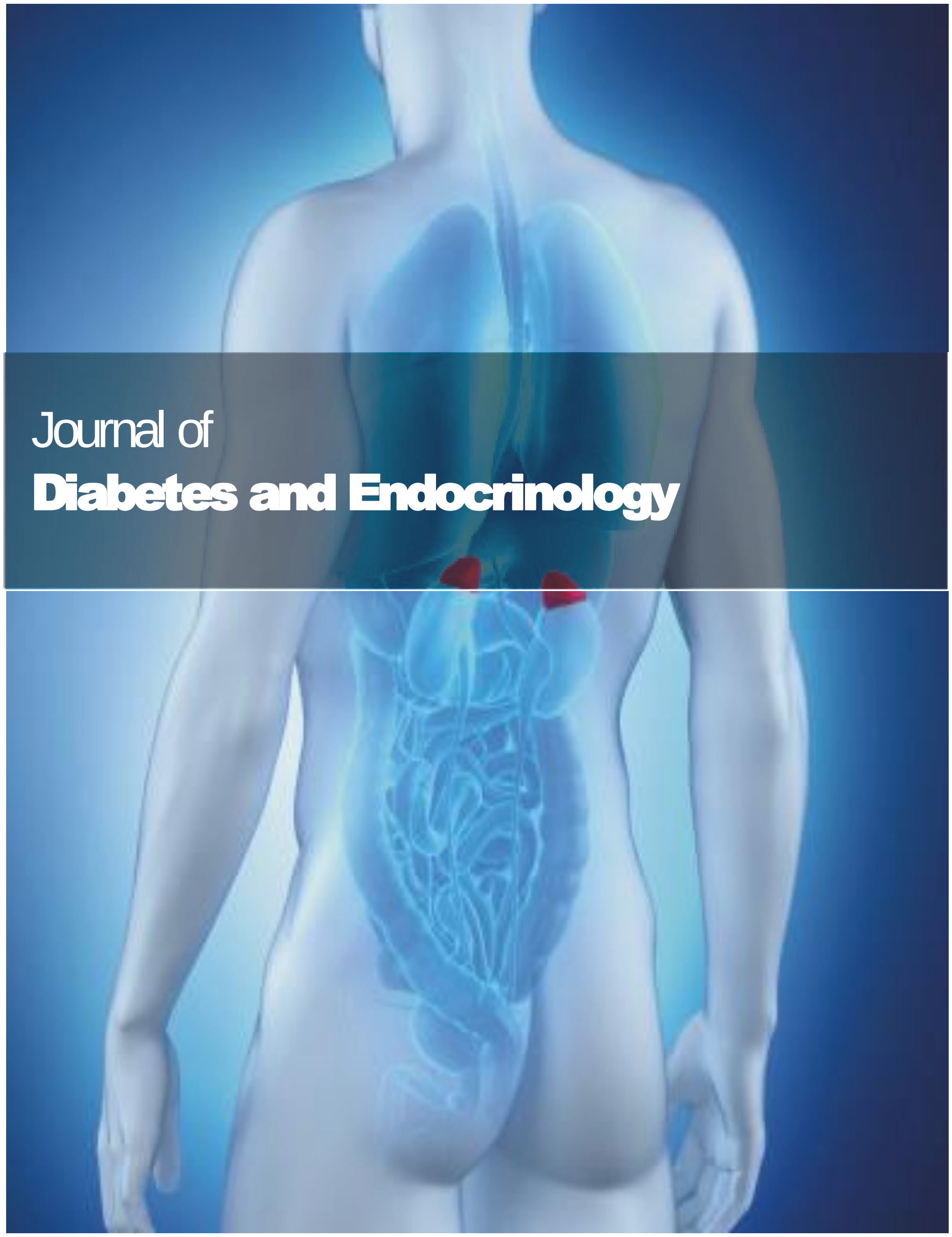

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Full Length Research Paper

Lower BMI cut-off than the World Health Organization-based classification is appropriate for Nigerians

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Universally, Body Mass Index (BMI) is used to diagnose obesity, and is associated with cardiovascular disease, as well as significant morbidity and mortality. Because the effect of obesity on health risk is influenced by ethnic background, age, and gender, using a universal BMI cut-off has been questioned by some authorities or workers. Reports on appropriate BMI for Nigerians are scanty. Results of a cross-sectional study involving residents of Ado Ekiti, Nigeria, and neighboring towns and villages who participated in a health screening were analyzed. BMI cut-off which identifies the presence of hypertension and hypercholesterolemia was determined with Receiver Operating Characteristics curve. Five hundred and fifty-two (552) participants comprise of 230 (41.7%) men aged 38.8±15.6 years and 322 (58.3%) women aged 40.7±15.4 years. More women (27.7%) than men (8.8%) had obesity (p<0.001). Hypercholesterolemia was more prevalent in women (7.1%) than men (3.9%), p=0.014. Prevalence of hypertension was 24.8 and 22.0% in men and women, respectively. Overall, the prevalence of overweight/obesity and hypertension increases with age (p<0.001). The optimal BMI cut-off for men and women were 24.1kg/m^2 (AUC= 0.619 [95% CI, 0.535 to 0.704], p= 0.007: SS, 70.2% and SP 56.6%) and 28.9 kg/m^2 (AUC: 0.690 [95% CI, 0.548 to 0.831], p= 0.016: SS, 64.3% and SP 67.5%), respectively. Lower BMI cut-off than the WHO-based classification is appropriate for Nigerians. The BMI cut-off for identifying cardiovascular disease is different for men and women.

Key words: Body mass index, cardiovascular disease, obesity, cut-off, Nigeria.

INTRODUCTION

Raised blood pressure is prevalent in 40% of adult population globally, and it is a major cardiovascular risk resulting in significant morbidity and mortality (WHO, 2013). Worldwide, hypertension-related complications accounted for 9.4 million deaths yearly and this represents the highest mortality from non-communicable diseases (WHO, 2013). Hypercholesterolaemia is a risk factor for coronary heart disease and stroke (Peters et al., 2016), and both high blood pressure and high total cholesterol can act in concert to increase cardiovascular related death (Satoh et al., 2015).

Obesity is now recognized as a distinct disease, and its prevalence continue to increase worldwide (Jensen et al., 2014). Both underweight and overweight/obesity are

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known to influence health adversely (Angelantonio et al., 2016). Universally, Body Mass Index (BMI) is used to diagnose obesity, and is associated with cardiovascular disease, as well as significant morbidity and mortality (Flegal et al., 2013). Increasing BMI is associated with increasing systolic and diastolic blood pressures, and this association has been shown by both cross-sectional and prospective studies, such that for a given increase in BMI, there is a corresponding rise in blood pressure (Wilsgaard et al., 2000, Gupta and Kapoor, 2012; Pan et al., 2013; Ren et al., 2016). Similarly, BMI is positively associated with elevated total LDL cholesterol (Fukui, 2000; Szczygielska et al., 2003). Thus a given BMI can be used to predict elevated blood pressure and cholesterol.

Accurate diagnosis of obesity is very important since it will determine those who will be enrolled for management or screening of cardiovascular diseases. The BMI classification released by WHO is being used to diagnose general obesity in most countries of the world (WHO, 2000b) because, the effect of obesity on health risk is influenced by ethnic background, age, and gender, using a universal BMI cut-off for different age, ethnic groups and gender which have been questioned by some authorities (Pan et al., 2013; Misra, 2015; Heymsfield et al., 2016; Hunma et al., 2016). In recognition of this, different waist circumference (another surrogate measure of obesity or body fat) cut-off has been proposed for different gender and regions in the world (Alberti et al., 2005).

Due to observations that the World Health Organization (WHO) recommended, BMI cut-off underestimate obesity in certain populations, further studies in different ethnic groups were also suggested (Clark et al., 2016). In response to Asian studies, the WHO recommended lower BMI cut-off for Asia-Pacific region (WHO, 2000a). Recent studies among Asians suggested a different BMI cut-off for that region (Cheong et al., 2013; Ren et al., 2016; Papier et al., 2017). Some authors even found different BMI cut-off for people within the same country (Pan et al., 2013). Indeed community-specific BMI was recommended by some workers (Kishore et al., 2011).

Reports on appropriate BMI for Nigerians are scanty, and the need to derive one was advocated by some authors (Egbe et al., 2013). One study suggested that, lower cut-off identified hypertension and prehypertension, but was conducted in South-East Nigeria, and limited by one cardiovascular risk factor (Ononamadu et al., 2017). Whether their findings are applicable to western Nigeria is unknown.

Is the recommended WHO BMI cut-off appropriate for Nigerians? If so, is it appropriate for both men and women? The aim of this study is to determine the appropriate gender-specific BMI cut-off for South-Western Nigerians. We hypothesize that the WHO recommended BMI category is not applicable for Nigerians. Primarily, we hypothesize that lower BMI cut-off is appropriate for Nigerians and the BMI cut-off is different for men and women.

MATERIALS AND METHODS

In order to test these hypotheses, data of a health survey conducted in 2011 in Ado-Ekiti, Ekiti State, Nigeria, was analyzed. Approval was obtained from Ethic and Research Committee of Ekiti State University Teaching Hospital, Ado-Ekiti (EKSUTH/A67/2017/011/003) for this study. The study involved residents of Ado-Ekiti, Nigeria, and neighboring towns and villages.

Out of the 865 people who participated in the cross sectional study, the result of 552 participants with complete data of interest was analyzed. Ado Ekiti is a state capital city in the South Western part of Nigeria. It is an urban settlement with a current estimated population of about 366,280 38. The major occupations of the residents are trading, semi-skilled work, and government workers. The participants were mobilized through local radio and television public announcements, and handbills. The health survey obtained demographic and health-related data that included clinical measures of blood pressure, weight, and height. Fasting plasma cholesterol was also determined.

Clinical measurements

Body weight and height were assessed to the nearest 0.1 kg and 0.1 m respectively with all subjects standing without shoes, heavy outer garments and headgear. Weight was measured using a standardized bathroom scale, while the height was measured with a stadiometer. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters. BMI status was categorized as follows: Underweight < 18.5 kg/m^2; normal 18.5 to 24.9 kg/m^2; overweight 25 to 29.9 kg/m^2; obese ≥30 kg/m^2 (WHO, 2000b). Obesity was further classified into class 1 (30 to 34.9kg/m^2), 2 (35.0 to 39.9kg/m^2) and 3 (≥40kg/m^2).

The blood pressure was measured from the left upper arm with the participants in sitting position. Accussons' mercury sphygmomanometer attached to appropriate cuff sizes was used. The first and fifth Koroktoff sounds were taken as the systolic and diastolic blood pressures, respectively. Hypertension was defined as blood pressure ≥140l90 mmHg (Chobanian et al., 2003).

Biochemical assays

After an overnight fast, 5 ml of blood was taken into heparinized bottles for evaluation of total cholesterol. The blood samples were centrifuged, and the separated plasma was stored in an on-site refrigerator. Total cholesterol was determined by photometry method with Mindray chemistry analyzer (BS 200, China). Total Cholesterol was categorized into 3: normal (<5.17 mmol/L), borderline (5.17 to 6.18 mmol/L) and high (≥6.21 mmol/L) (NCEP ATP III, 2001).

Statistical analysis

Data analyses were done with the statistical package for social sciences (IBM SPSS) version 20.0 (Chicago, Illinois, USA). Continuous and categorical data were expressed as means (SD) and percentages, respectively. Student's t-test was used to compare continuous variables while Pearson's Chi-square was used to compare categorical variables. Receiver Operative Characteristics curves were generated for BMI and hypertension alone, hypercholesterolemia alone, and both cardiovascular risk

Table 1. Clinical characteristics of the participants.

Characteristics	Total (N=552)	Male (N=230)	Female (N=322)	P
Age	39.88(15.49)	38.78(15.59)	40.66(15.39)	0.159
Weight	69.25(12.59)	69.50(10.99)	69.01(13.63)	0.678
Height	1.62(0.09)	1.68(0.088)	1.58(0.07)	0.000
BMI	26.51(6.96)	25.14(8.43)	27.49(5.48)	0.000
SBP	132.16(21.90)	134.53(19.97)	130.46(23.06)	0.031
DBP	78.84(12.24)	79.18(12.37)	78.60(12.17)	0.583
Total cholesterol (mmol/L)	4.09(1.32)	3.95(1.21)	4.19(1.39)	0.029

Keys: BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Table 2. Prevalence of obesity, hypertension and hypercholesterolemia in relation to gender among the participants.

Variable	All [n (%)]	Male [n (%)]	Female [n (%)]	X^2	p (95% CI)
Body Mass Index				47.7	0.000(0.000-0.005)
Underweight	9(1.6)	4(1.7)	5(1.6)		
Normal weight	242(43.8)	135(58.7)	107(33.2)		
Overweight	192(34.8)	71(30.9)	121(37.6)		
Class 1	71(12.9)	16(7.0)	55(17.1)		
Class 2	26(4.7)	2(0.9)	24(7.5)		
Class 3	12(2.2)	2(0.9)	10(3.1)		
Total	552(100.0)	230(100.0)	322(100.0)		
Blood pressure				0.563	0.453
Normal	424(76.8)	173(75.2)	251(78.0)		
High	128(23.2)	57(24.8)	71(22.0)		
Total	552(100.0)	230(100.0)	322(100.0)		
Hypercholesterolemia				8.2	0.014(0.005-0.024)
Normal	458(83.0)	186(80.9)	272(84.5)		
Borderline	62(11.2)	35(15.2)	27(8.4)		
High	32(5.8)	9(3.9)	23(7.1)		
Total	552(100.0)	230(100.0)	322(100.0)		

factors. The area under curve (AUC) on Receiver Operative Characteristics (ROC) curve was used to determine the BMI cut-off which predicts hypertension and hypercholesterolemia. The values that maximize the specificity and sensitivity were taken as the cut-offs. The procedure was done for both men and women together, and then separately. The level of significance was set at p<0.05.

RESULTS

Five hundred and fifty-two (552) comprising 230 (41.7%) male and 322 (58.3%) female participants with results of total cholesterol out of 865 people who participated in the health screening were included in the analysis. The mean age and diastolic blood pressure were similar between the genders.

The men had a significantly higher mean systolic blood pressure (134.53±19.97 mmHg vs 130.46±23.06 mmHg, p=0.031), while the women had higher mean BMI (27.49±5.48 kgm^2 vs 25.14±8.43 kgm^2, p<0.001), and total cholesterol (4.19±1.39 mmol/L vs 3.95±1.21mmol/L, p=0.029) (Table 1). Table 2 shows the prevalence of CVD risk factors among the participants. More women than men had overweight (37.6% vs 30.9%, p<0.001), obesity (27.7% vs 8.8%, p<0.001) and hypercholesterolemia (7.1% vs 3.9%, p=0.014). Prevalence of hypertension in men and women was 24.8 and 22.0%, respectively.

Overall, as the age of the participants increases, the prevalence of overweight and obesity increases (p<0.001). Among the men, the prevalence of overweight increases up till the 7th decade and then declines while the prevalence of class 1 obesity increases from 3rd up

Table 3. Prevalence of obesity in relation to age and gender among the participants.

Characteristics		Age (years)								x²(p)
		18-29	20-39	40-49	50-59	60-69	70-79	≥80	Total	
Under-weight {n (%)}	All	4(2.3)	1(0.8)	2(1.9)	1(1.6)	0(0.0)	1(4.5)	0(0.0)	9(1.6)	80.2(0.000)
	Male	2(2.4)	0(0.0)	1(10.0)	0(0.0)	0(0.0)	1(10.0)	0(0.0)	4(1.7)	48.5(0.018)
	Female	2(2.2)	1(1.4)	1(1.4)	1(2.8)	0(0.0)	0(0.0)	0(0.0)	5(1.6)	65.2(0.000)
Normal weight {n (%)}	All	112(63.3	59(45.4)	23(22.3)	22(35.5)	12(23.1)	10(45.5)	4(66.7)	242(43.8)	
	Male	63(75.0)	31(55.4)	13(38.2)	15(57.7)	6(35.3)	6(60.0)	1(33.3)	135(58.7)	-
	Female	49(52.7)	28(37.8)	10(14.5)	7(19.4)	6(14.1)	4(33.3)	3(100.0)	107(33.2)	
Overweight {n (%)}	All	45(25.4)	41(31.5)	49(47.6)	21(33.9)	29(55.8)	6(27.3)	1(16.7)	192(34.8)	
	Male	18(21.4)	20(35.7)	12(35.3)	10(38.5)	9(52.9)	1(10.0)	133.3()	71(30.9)	-
	Female	27(29.0)	21(28.4)	37(53.6)	11(30.6)	20(57.1)	5(41.7)	0(0.0)	121(37.6)	
Class 1 obesity {n (%)}	All	12(6.8)	21(16.2)	16(15.5)	10(16.1)	6(11.5)	5(22.7)	1(16.7)	71(12.9)	
	Male	0(0.0)	3(5.4)	7(20.6)	1(3.8)	2(11.8)	2(20.0)	1(33.3)	16(7.0)	-
	Female	12(12.9)	18(23.4)	9(13.0)	9(25.0)	4(11.4)	3(25.0)	0(0.0)	55(17.1)	
Class 2 Obesity {n (%)}	All	3(1.7)	5(3.8)	10(9.7)	5(8.1)	3(5.8)	0(0.0)	0(0.0)	26(4.7)	
	Male	0(0.0)	1(1.8)	1(2.9)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(0.9)	-
	Female	3(3.2)	4(5.4)	9(13.0)	5(13.9)	3(8.6)	0(0.0)	0(0.0)	24(7.5)	
Class 3 Obesity {n (%)}	All	1(0.6)	3(2.3)	3(2.9)	3(4.8)	2(3.8)	0(0.0)	0(0.0)	12(2.2)	
	Male	1(1.2)	1(1.8)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(0.9)	-
	Female	0(0.0)	2(2.7)	3(4.3)	3(8.3)	2(5.7)	0(0.0)	0(0.0)	10(3.1)	

till the 5th decade, and then from 7th to the 9thdecade. Among the females, prevalence of class 2 and 3 obesity increases with age up till the 6th decade, (Table 3).

Generally, the prevalence of hypertension increased with age (p<0.001). Among men, the increase was apparent up till the 6th decade, while in the women, it was apparent till the 7th decade. Among men, hypercholesterolemia increased with age. Overall and among women, hypercholesterolemia was most prevalent in the 6th decade, (Table 4). The ROC curves of BMI and CVD risk factors for all the participants, men and women are shown in Figures 1 to 3. The areas under curve are summarized in Table 5. The AUROC curve was greater for hypertension than hypercholesterolemia. But the AUROC curve was greatest when both hypercholesterolemia and hypertension were combined: All participants (0.62 [95% CI, 0.52 to 0.72], p=0.024), Men (0.62 [95% CI, 0.48 to 0.76], p=0.100), and Women (0.69[95% CI, 0.55-0.83], p=0.016). Table 6 shows the BMI cut-off values of body mass index that are predictive of hypertension and hypercholesterolemia with their corresponding sensitivities (Sens) and specificities (Specs). The BMI cut-off was greater in women compared to men. The BMI cut-off values ranged from 24.1 to 25.7 kg/m^2 (Sens= 57.4 to 75.8%, Specs= 43.4 to 52.2%) for all the participants, 24.1 to 25.6 kg/m^2

Table 4. Prevalence of hypertension and hypercholesterolemia in relation to age and gender among the participants.

Characteristics		Age (years)								
		18-29	20-39	40-49	50-59	60-69	70-79	≥80	Total	x^2(p)
Blood pressure										
Normal {n (%)}	All	165(93.2)	107(82.3)	70(68.0)	38(61.3)	26(50.0)	15(68.2)	3(50.0)	424(76.8)	66.2(0.000)
	Male	76(90.5)	40(71.4)	22(64.7)	16(61.5)	11(64.7)	7(70.0)	1(33.3)	173(75.2)	19.5(0.003)
	Female	89(95.7)	57(90.5)	48(69.6)	22(61.1)	15(42.9)	8(66.7)	2(66.7)	251(78.0)	58.8(0.000)
High {n (%)}	All	12(6.8)	23(17.7)	33(32.0)	24(38.7)	26(50.0)	7(31.8)	3(50.0)	128(23.2)	
	Male	8(9.5)	16(28.6)	12(35.3)	10(38.5)	6(35.3)	3(30.0)	2(66.7)	57(24.8)	
	Female	4(4.3)	7(9.5)	21(30.4)	14(38.9)	20(57.1)	4(33.3)	1(33.3)	71(22.0)	
Total cholesterol										
Normal {n (%)}	All	156(88.1)	106(81.5)	83(80.6)	45(72.6)	46(88.5)	16(72.7)	6(100.0)	458(83.0)	18.9(0.092)
	Male	75(89.3)	43(76.8)	26(76.5)	17(65.4)	14(82.4)	8(80.0)	3(100.0)	186(80.9)	14.5(0.271)
	Female	81(87.1)	63(85.1)	57(82.6)	28(77.8)	32(91.4)	8(66.7)	3(100.0)	272(84.5)	16.5(0.167)
Borderline {n (%)}	All	12(6.8)	16(12.3)	13(12.6)	12(19.4)	3(5.8)	6(27.3)	0(0.0)	62(11.2)	
	Male	8(9.5)	11(19.6)	6(17.6)	7(26.9)	1(5.9)	2(20.0)	0(0.0)	35(15.2)	
	Female	4(4.3)	5(6.8)	7(10.1)	5(13.9)	2(5.7)	4(33.3)	0(0.0)	27(8.4)	
High {n (%)}	All	9(5.1)	8(6.2)	7(6.8)	5(8.1)	3(5.8)	0(0.0)	0(0.0)	32(5.8)	
	Male	1(1.2)	2(3.6)	2(5.9)	2(7.7)	2(11.8)	0(0.0)	0(0.0)	9(3.9)	
	Female	8(8.6)	6(8.1)	5(7.2)	3(8.3)	1(2.9)	0(0.0)	0(0.0)	23(7.1)	

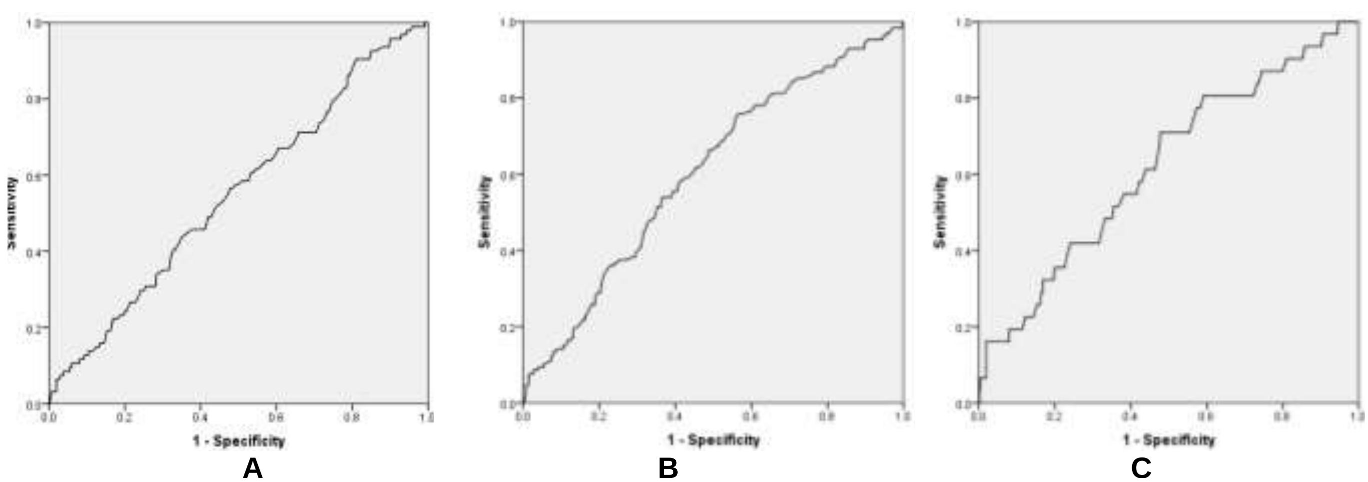

Figure 1. Receiver operating characteristics curve for BMI in relation to [A] hypercholesterolemia, [B] hypertension and [C] hypercholesterolemia and hypertension in all the participants. Areas of the curve are summarised in Table 5.

(Sens= 38.6 to 70.6%, Specs= 52.1 to 67.7%) for men, and 25.3 to 28.9 kg/m^2 (Sens=60.0 to 80.3%, Specs= 41.0 to 67.5%) for women. When the two CVD risk factors were combined, the BMI cut-off values are 27.5 kg/m^2 (Sens= 71.0%, Specs=52.2%) for all participants, 24.3 kg/m^2 (Sens=70.6%, Specs= 52.1%) for men, and 28.9 kg/m^2 (Sens= 64.3%, Specs=67.5%) for women.

DISCUSSION

Obesity has now been recognized as a distinct disease

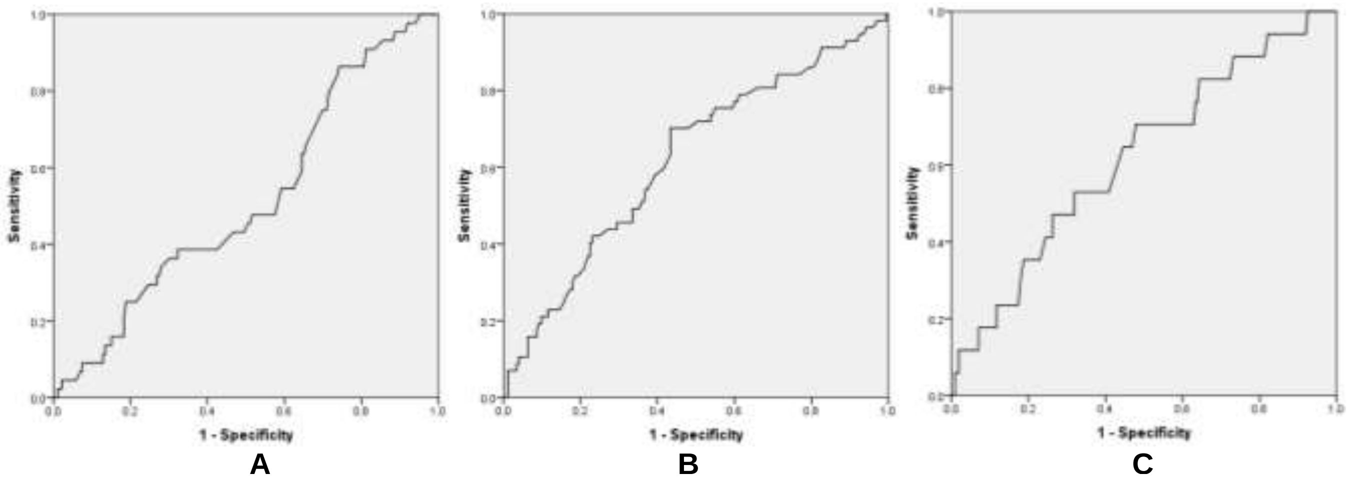

Figure 2. Receiver operating characteristics curve for BMI in relation to [A] hypercholesterolemia, [B] hypertension and [C] hypercholesterolemia and hypertension in men. Areas of the curve are summarised in Table 5.

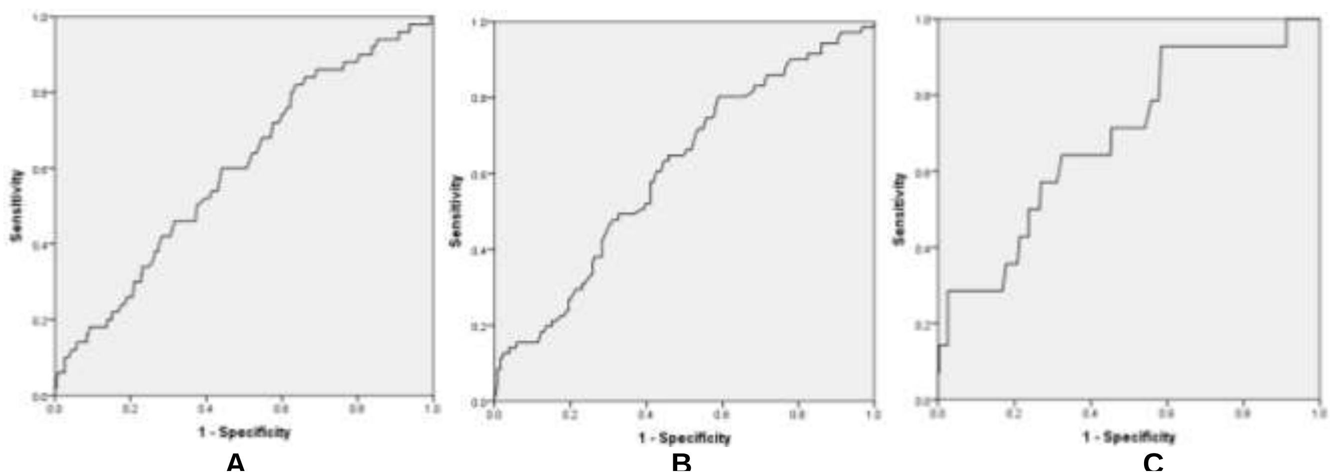

Figure 3. Receiver operating characteristics curve for BMI in relation to [A] hypercholesterolemia, [B] hypertension and [C] hypercholesterolemia and hypertension in women. Areas of the curve are summarised in Table 5.

(Jensen et al., 2014). The rising prevalence of obesity with its attendant morbidity and mortality is a major public health concern. Increased body mass index is associated with hypertension, hypercholesterolemia, diabetes mellitus, stroke, coronary artery disease, cancers and other health challenges. Screening for some of these diseases based on the presence of obesity or BMI value was recommended by relevant bodies (ADA, 2017; IDF, 2017). Accurate diagnosis of obesity is very important since it will determine those who will be screened for some of the above non-communicable diseases, those who will be eligible for prevention (e.g antiplatelets for stroke) or enrolled for obesity management. Because body composition differs with ethnic background, ethnic-specific cut-offs for measures of obesity, including BMI have been advocated (Deurenberg and Deurenberg-Yap, 2003).

The WHO definition (WHO, 2000a), which was based on studies in Caucasians did not address this in African population, thus necessitating the need for studies to determine the appropriate BMI for our population. Moreover, the universal validity/applicability of WHO BMI cut-off have been questioned by some authors (Pan et al., 2013; Misra, 2015; Heymsfield et al., 2016; Hunma et al., 2016). Thus, many authors either found or recommended a different BMI cut-off from WHO recommendation (Cheong et al., 2013; Pan et al., 2013; Zeng et al., 2014).

The above studies were conducted in Asian whereas Blacks were also shown to develop diabetes at earlier BMI than whites (Chiu et al., 2011). Furthermore, the relationship between body fat and BMI (a surrogate measure of body fat) is also dependent on gender (Kautzky-Willer et al., 2016), such that different body fat%

Table 5. Areas under the receiver operating characteristic curves for body mass index and cardiovascular risk factors, and the 95% confidence intervals.

Obesity	Total cholesterol			Hypertension			Total cholesterol and hypertension		
	AUC	95% CI	p	AUC	95% CI	p	AUC	95% CI	p
All	0.55	0.49-0.61	0.133	0.60	0.55-0.66	<0.001	0.62	0.52-0.72	0.024
Men	0.52	0.42-0.61	0.760	0.62	0.54-0.70	0.007	0.62	0.48-0.76	0.100
Women	0.60	0.51-0.68	0.030	0.61	0.54-0.68	0.005	0.69	0.55-0.83	0.016

AUC, area under receiver operating characteristics curve.

Table 6. Cut-off values of body mass index that are predictive of hypertension and hypercholesterolemia with their sensitivities and specificities.

Variables	BMI Cut-off values(kg/m^2)	Sensitivity (%)	Specificity (%)
All participants			
Hypercholesterolemia	25.5	57.4	50.9
Hypertension	24.1	75.8	43.4
Hypercholesterolemia and hypertension	25.7	71.0	52.2
Men			
Hypercholesterolemia	25.6	38.6	67.7
Hypertension	24.1	70.2	56.6
Hypercholesterolemia and hypertension	24.3	70.6	52.1
Women			
Hypercholesterolemia	27.2	60.0	55.9
Hypertension	25.3	80.3	41.0
Hypercholesterolemia and hypertension	28.9	64.3	67.5

BMI, body mass index.

for men and women were recommended for obesity definition by WHO (WHO, 2004). This suggest that, there should be sex or gender specific BMI cut-off for definition of obesity, unlike the uniform recommendation that is being used currently.

Prevalence of CVD risk factors

The prevalence of obesity in this population was high, especially among the women. Other workers also found a higher prevalence of obesity in women compared to men in Nigeria (Egbe et al., 2014; Ononamadu et al., 2017). Reasons for this include low activity level, biological factors, and cultural practices. Hypertension was equally prevalent among men and women in this population, while hypercholesterolemia was relatively low in this population. This may not be unconnected with the fact that Africans are known to have low cholesterol for genetic reasons (Sliwa et al., 2012; Bentley and Rotimi, 2017).

The occurrence of the CVD risk factors in this study increased with age. This is similar to what was previously documented, and is due to the pathophysiological and physical changes that are associated with aging (Egbe et al., 2014). Furthermore, changes in one age-related risk factor may also affect the other. For example, overweight and obesity which increases with age may predispose to hypertension and hypercholesterolemia.

BMI cut-off for identifying CVD risk factors

The optimal BMI cut-off for all the participants using total cholesterol alone, hypertension alone or total cholesterol plus hypertension as cardiovascular risk factors ranged between 24.1 to 25.7 kg/m^2. The AUC was largest when both hypertension and total cholesterol were combined as CVD risk factors. The BMI cut-off in this case, was 25.7 kg/m^2. This is less than the recommended WHO cut-off of 30kgm^2, which was derived from studies conducted among Whites (WHO, 2000a). Other researchers reported similar findings.

A study from eastern Nigeria found that, BMI of between 24.44 to 24.49 kgm^2 predicted hypertension in the participants (Ononamadu et al., 2017). In a study, Midha et al (2014) examined the BMI and waist circumference cut-offs that predicted hypertension among 801 participants, and found that BMI of 24.5 to 24.9 kgm^2 predicted high blood pressure in Indians. Similar to our study, the design of theirs was cross-sectional and the authors used ROC analysis. Ren at al. (2016) prospectively determined the anthropometric cut-offs which predicted incident hypertension over a 5-year interval among the Chinese, and found that a BMI of between 23.53 to 24.25 kgm^2 was appropriate for that population. Another Chinese study that looked at predictive ability of obesity indices to predict hypertension, diabetes and dyslipidemia found a BMI cu-off of 24 kgm2 to predict CVD risk factors in both men and women (Yu et al., 2016). A retrospective study which compared BMI cut-off values for identifying hypertension (and diabetes) among four ethnic groups in the United States revealed different values (Wong et al., 2014). Among three ethnic groups (excluding the Hispanic Whites), the cut-off value that predicted hypertension was lowest (22.0 kgm^2) in Asians and highest (28 kgm^2) in the Blacks.

Blacks and Asians have been recognized to be more insulin resistant than whites for the same BMI, and to have a greater % body fat for same BMI (Palaniappan et al., 2002; Rahman et al., 2009). This means that lower BMI in blacks, compared to whites will result in the same body fat. Insulin resistance correlates positively with BMI and %body fat while both %body fat and BMI correlates with each other (Ranasinghe et al., 2013, Akindele et al., 2016, Yoon et al., 2016). Since IR mediates the cardiovascular diseases associated with obesity, it is not unexpected for blacks to have a lower BMI cut-off compared to Whites (Castro et al., 2014). In other words, a smaller BMI should give comparable CVD risk. Indeed some authors reported that, Blacks develop diabetes at a lower age and BMI compared to Whites (Chiu et al., 2011). This is similar to observations that Asians develop hypertension and diabetes mellitus at a lower BMI compared to other ethnic groups (Wong et al., 2014). For this reason, Asians have lower recommended BMI cut-off compared to Whites (WHO, 2000b). The prevalence of obesity has changed significantly after the WHO obesity classification was published about 17 years ago. Additionally, the diagnostic cut-offs for CVD risk factors such as hypertension and diabetes mellitus have been reviewed since then. It is therefore necessary to review the BMI cut-off for obesity definition.

Separate analysis for men and women also resulted in a lower BMI cut-off of 24.1 to 28.9 kg/m^2. Similar to the result of combined analysis, the ROC with the largest AUC was obtained when two CVD risk factors were considered. The BMI cut-off values in this study are different for two genders, unlike the uniform recommendation by the WHO (WHO, 2000a). In men, the BMI cut-off was 24.3 kg/m^2, while in women the cut-off was greater at 28.9 kg/m^2. The AUC in men when hypertension alone was the risk factor was similar to what was obtained with two CVD risk factors. Also, it gave a similar BMI cut-off (24.1 kg/m^2) with a comparable sensitivity but was more specific.

While some studies found a similar BMI cut-off value for men and women (Pan et al., 2013; Araneta et al., 2015; Yu et al., 2016), others found different values, and in these cases women tend to have higher cut-off values than men (Gupta and Kapoor, 2012; Cheong et al., 2013; Ren at al., 2016). Interestingly, one of these studies had a similar design, sample size, and mean age as ours; and consistent with our findings, the BMI cut-off was 28.8 kgm^2 for women while the cut-off for men was just 1.5 points lower than ours (Gupta and Kapoor, 2012). However, in contrast to the above, some workers reported a higher BMI cut-off in men compared to women, although their BMI differ by just 1.0 point (Zeng et al., 2014). Unlike our study, the men in their study had higher values for all the anthropometric indices, blood pressure, total cholesterol and other CVD risk factors.

Sex differences in the relationship between BMI and health risk is recognized (Clark et al., 2016). Men have been shown to develop diabetes at a younger age compared to women (Logue et al., 2011; Kautzky-Willer et al., 2016). Since obesity increases with age, this may mean that men develop CVDs at a lower BMI, suggesting that the cut-off should be lower in men. This is consistent with our findings. Different BMI cut-off values for men and women may be expected since other measures obesity such as waist circumference and waist-to-hip ratio have gender-specific values. The importance of gender specificity for BMI was vividly shown by a study that sought to validate the WHO BMI cut-off values among Mauritius (Hunma et al., 2016).

The result from this study suggests that the participants are likely to develop hypertension and hypercholesterolemia at a lower BMI than the WHO cut-off. Screening for these CVD risk factors should therefore be undertaken earlier in order to give room for diagnosis before complications set in. Although more people are likely to be screened with this approach, the cost of screening for hypertension and hypercholesterolemia will be justified considering the cost of treating preventable complications such as stroke, acute myocardial infarction or renal failure.

Limitations

This study is limited by location and cross-sectional design. There is need for nationwide, preferably a longitudinal study in order to confirm our findings.

Conclusion

Lower BMI cut-off than the WHO-based classification is appropriate for Nigerians. The BMI cut-off for identifying cardiovascular disease is different for men and women. A larger and nationwide study should be conducted to confirm these findings.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

Abbreviations: AUC, Area Under Curve; **BMI,** body mass index; **CVD,** cardiovascular disease; **DBP,** diastolic blood pressure; **SBP,** systolic blood pressure; **ROC,** receiver operating characteristic curve; **WHO,** World Health Organization.

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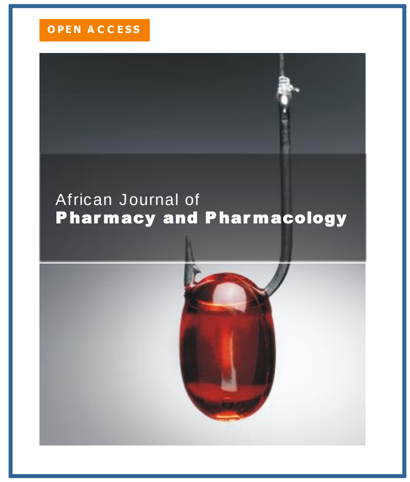

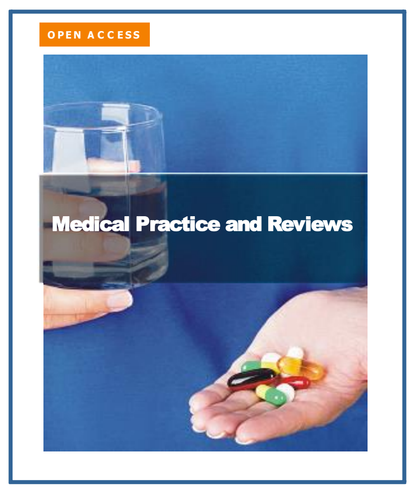

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