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Association Between Abdominal Obesity and Some Selected Non-Communicable Diseases Among Adults in Calabar Metropolis, Cross River State, Nigeria

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ABSTRACT

Background: Fat accumulation around the abdomen is an important consideration in obesity studies and management. Generalized obesity indices alone without considering abdominal obesity are not sufficient in the study and treatment of obesity and the related escalating cases of preventable non-communicable diseases globally.
Objective: This study assessed the relationship between abdominal obesity and some selected non-communicable diseases such as generalized obesity, hypertension, and type 2 diabetes among adults in Calabar Metropolis.
Materials and methods: A multistage sampling technique was used to select 500 participants (20-70 years). The cross-sectional descriptive study adapted the WHO STEPwise questionnaire for surveillance of non-communicable diseases. Data were analyzed using descriptive and inferential statistics including frequency, percentages, chi-square, correlation, and logistic regression; significant differences were established at $p<0.05$.
Results: 51% of the participants were single while 44.8% were married. It was found that 27.8% and 56.9% of males, as well as 31.1% and 41.1% of females who were diagnosed with hypertension, had high and very high waist circumferences respectively compared to fewer males and females who were undiagnosed with hypertension. There was a correlation between waist circumference and diastolic blood pressure ($r= -0.102$, $p=0.022$) as well as with random blood glucose ($r=0.123$, $p=0.006$). The males had higher odds to develop hypertension (OR=2.754; CI=1.776-4.270) and fewer odds to develop abdominal obesity compared to the females.
Conclusion: There were strong associations between hypertension, type 2 diabetes, generalized obesity, and waist circumference of the participants. More individuals with high waist circumferences had hypertension. Men were less likely to have abdominal obesity in relation to high blood pressure compared to women. There should be appropriate interventions for the individuals who were already diagnosed with the various NCDs while those at risk of developing the disorders should be identified within the population for proper counseling.

Keywords: *Abdominal obesity, hypertension, type 2 diabetes, waist circumference*

INTRODUCTION

Non-communicable diseases (NCDs) are a global health problem. Several risk factors such as age, heredity, and lifestyle (physical activity, use of tobacco, and alcohol intake) are linked to different types of NCDs (1-2). Generalized obesity is the overall distribution of the accumulated fat in the body, which categorizes obesity in adults into three, namely: - grade one (BMI of 30.0-34.9 kg/m^2), grade two (BMI of 35.0-39.9 kg/m^2) and grade three also known as morbid obesity (BMI $\geq$40.0 kg/m^2) (1) with the attending limitations and varying degrees of the corresponding metabolic diseases. Abdominal obesity is the accumulation of fat mass around the abdomen and central part of the body characterized by either high waist circumference or high waist-hip ratio. Fat distribution is not the same in men and women leading to the categorization of abdominal obesity into android and gynaecoid. Whereas the android type has fat distributed predominantly in the upper abdomen above the waist, the gynecoid type is situated at the lower abdomen including buttocks, hips, and thighs (2). However, with the current trend of generalized and abdominal obesity, individuals are observed to have fat accumulated in both the upper and lower parts of the body regardless of gender. Fat accumulation around and above the waist referred also to as apple-shaped obesity tends to be deadlier than fat accumulation around the hips and thighs referred to as pear-shaped obesity (2-4).

It has also been suggested that reducing the number of fat cells in the lower body hyperplastic tissue tends to be more difficult when compared with reducing upper body or trunkal obesity often favoured by hypertrophy; supporting the differences in the functionality of fat cells with their distribution in the body (2). Thus, the subcutaneous trunkal fat or abdominal fat and visceral fat within the abdominal cavity constitute the percentage of body fat related to high risk in health (2).

The World Health Organization (5) defined diabetes mellitus as a persistent disease condition arising from insufficient insulin secretion by the pancreas or due to the body's ineffective utilization of insulin; diagnosed with a consistent Fasting Blood Glucose (FBG) value of 7mmol/l and above. Diabetes has been described as one of the prominent diseases of public health importance and high-risk NCDs mapped out for adequate intervention globally considering its continuous rising prevalence of it over several decades (5). Hypertension, on the other hand, has been described as consistent systolic blood pressure (SBP) of 140mmHg and higher cum diastolic blood pressure (DBP) of 90mmHg and higher (6). It is documented that the normal measures of both SBP and DBP are particularly relevant in the physiological roles of such important organs as the heart, brain, and kidneys as well as the physiological state of the entire body system (6).

Studies have provided evidence directly linking abdominal obesity to different metabolic disorders such as insulin resistance, hyperinsulinaemia, type 2 diabetes mellitus, hyperlipidaemia, and hypertension due to lipolytically sensitive abdominal depots supplying excessive free fatty acids to muscle tissues that have reduced ability of oxidation (2, 7). Amole *et al* (8) stated in their study on "the prevalence of abdominal obesity and hypertension among adults in Ogbomoso, Nigeria" reported that the high rate of abdominal obesity found among Ogbomoso people was significantly associated with hypertension. It was equally found that overweight and obesity are major risk factors for cardiometabolic disorders such as CVDs, diabetes, and chronic kidney failure (9). In Iloh *et al* (10) the leading metabolic disorders were hypertension, reduced high-density lipoprotein (HDL)—cholesterol, increased low-density lipoprotein (LDL)—cholesterol, hypercholesterolaemia, hypertriglyceridemia, and diabetes mellitus. However, Bluher *et al* (11) reported that the co-morbidities of obesity had a more direct relationship with abdominal obesity and visceral fat tissue compared with the total body fat. This study, therefore, investigated the relationship between abdominal obesity and selected NCDs in Calabar Metropolis, Nigeria.

MATERIALS AND METHODS

Study design and population

This cross-sectional descriptive study selected adult males and females aged 20 to 70 years living in Calabar Municipality and Calabar South Local Government Areas of the Metropolis. Disabled and immobilized adults, as well as pregnant and breastfeeding mothers, were not included in the study.

Sample size determination and sampling procedure

The sample size was calculated with Cochrain's formula, $n = [t^2 \times p\ (1\text{-}p)]/m^2$
described by Bartlette *et al* (12), using the prevalence of obesity in urban Nigeria (17.0%) as reported by Okafor *et al* (9) and at 95% confidence level and 5% precision. A total of 500 respondents were sampled.
A multistage sampling technique was applied to a sampling frame of 22 wards in Calabar Metropolis. A total of nine wards, four wards from Calabar Municipality and five wards from Calabar South, being the two local governments making up the metropolis, were randomly sampled. A table of random numbers was utilized to select 40 households from each of the nine wards, with every other household sampled in every third street of the ward using the Independent National Electoral Commission's list of wards and pooling units. From each of the 360 households selected, eligible individuals were sampled.

Recruitment and training of research assistants

Four undergraduate students were recruited as research assistants for the study. The assistants were trained on the standard techniques and procedures for the data collection on NCDs and related conditions using the adapted World Health Organization STEPwise approach (13).

Ethical considerations and informed consent

Ethical approval for the study was obtained from the committee in charge at the University of Calabar Teaching Hospital (UCTH), Calabar. The ethical approval number was: UCTH/HREC/33/568. High ethical standards were maintained throughout the course of the study. An informed consent form was signed by each participant after a detailed explanation of the objectives, significance, and procedure of the study was given to them.

Equipment for measurements

The equipment used for the research was a digital weighing scale, digital blood pressure (BP) apparatus (OMRON brand), digital blood glucose monitoring apparatus (glucometer) with lancets and strips (ACCU-CHEK), electronic weighing scale (HN289 Digital Scale made by OMRON HEALTHCARE Co., Ltd., Muko, Kyoto, Japan), stadiometer (OMRON) and non-stretchable measuring tapes.

Anthropometric measurements
The participants' weights were measured using the electronic weighing scale. The measurements were taken in line with the standard procedures outlined by WHO (14). The heights of the participants were measured with the stadiometer, while the waist and hip circumferences were measured with the inelastic tape. The readings were taken in accordance with the NHANES and WHO protocols (1, 15). The waist-hip ratio (WHR) was calculated as waist measurement divided by hip measurement (14).

Blood glucose assessment
Blood glucose level was assessed by measuring the random blood glucose (RBG) of the participants using a digital glucose monitoring apparatus with the lancets and strips. The RBG was preferred in this study because of its convenience in its application as an instant biochemical procedure (16).

Blood pressure assessment
Blood pressure (BP) was assessed by measuring the SBP and DBP using the digital BP apparatus, with the standard procedures recommended by the WHO (17) employed.

Data and statistical analysis
The calculation of the body mass index (BMI) was carried out in line with the standard formula given by the WHO (1), approximating two decimal places in kg/m^2. A BMI of $\geq$30 kg/m^2 is defined as obesity and 25 – 29.9 kg/m^2 is defined as overweight (1). The WC readings of above 102cm for men and above 88cm for women according to WHO (14) were further categorized and compared with the WHR calculations (>0.90 for males and >0.85 for females) according to the WHO (18).

The definition of high blood pressure (HBP) or hypertension was given as the mean SBP of 140 mmHg or more and/or DBP of 90 mmHg or more, as well as the use of drug treatment for hypertension according to Chobanian *et al* (19). The average of two random blood glucose (RBG) values of 200 mg/dl (11.1 mmol/L) or higher and/or self-reported use of drug treatment for diabetes as described by Hendriks *et al* (16) was diagnostic of type 2 diabetes judging from the recommendations of the American Diabetes Association (ADA) (20).

Coding, entering, and summarizing the generated data were done using the Statistical Package for Social Sciences (SPSS version 22.0). The analysis of the data was carried out with the aid of such descriptive statistics as frequency and percentage as well as inferential statistics such as chi-square, correlation, and logistic regression; considering the significance at $p<0.05$.

RESULTS

Socio-demographic characteristics of the study participants
One-half (51%) of the population was single, while 44.8% were married and 1.6% of the participants were either separated or divorced as shown in Table 1. The age distribution of the participants showed that the young adults (20-39 years) constituted the highest percentage (66.6%), while the older adults made up 9.8% of the total study population. The proportion of the participants who had post-secondary education qualifications was 50.2%, the proportion of those who had O'Level was 43.0 %, while the group with very little or no education constituted 6.8% of the population. Self-employed participants were 33.4%, the unemployed were 32.6%, and civil/public servants were 29.2%, with the least of the category being other forms of employment (4.8 %).

Table 1: Socio-demographic attributes of the participants

Characteristics	Sex		Total
	Male F (%)	Female F (%)	F (%)
Sex	**230** (46.0)	**270**(54.0)	**500**(100.0)
Age Groups (Years)			
20 – 39	152(66.1)	181(67.0)	333(66.6)
40 – 59	61(26.5)	57(21.1)	118(23.6)
60 and above	17(7.4)	32(11.9)	49(9.8)
Total	**230(100.0)**	**270(100.0)**	**500(100.0)**
Marital Status			
Single	113(49.1)	142(52.6)	255(51.0)
Married	109(47.4)	115(42.6)	224(44.8)
Separated	0(0)	6(2.2)	6(1.2)
Divorced	0(0)	2(0.7)	2(0.4)
Widowed	8(3.5)	5(1.9)	13(2.6)
Total	**230(100.0)**	**270(100.0)**	**500(100.0)**
Educational Level			
No formal education	0(0)	4(1.5)	4(0.8)
Primary education	16(7.0)	14(5.2)	30(6.0)
Secondary education	83(36.1)	132(48.9)	215(43.0)
Diploma, NCE, TTC, NTI	7(3.0)	21(7.8)	28(5.6)
HND, first degree	34(14.8)	63(23.3)	97(19.4)
Postgraduate degree	90(39.1)	36(13.3)	126(25.2)
Total	**230(100.0)**	**270(100.0)**	**500(100.0)**
Employment Status			
Unemployed	54(23.5)	109(40.4)	163(32.6)
Self-employed	73(31.7)	94(34.8)	167(33.4)
Civil/public servant	91(41.3)	51(18.9)	146(29.2)
Others	8(3.5)	16(5.9)	24(4.8)
Total	**230(100.0)**	**270(100.0)**	**500(100.0)**

F = frequency

Association between NCDs and abdominal obesity in the sample

Table 2 presents the data on the association between NCDs (hypertension, type 2 diabetes, and generalized obesity) and the WC of the participants. The result showed that 27.8% and 56.9% of males, as well as 31.1% and 41.1% of females who were diagnosed with hypertension, had high and very high WCs respectively compared to 14.6% and 3.1% of males as well as 10.0% and 38.8% females respectively, who were not diagnosed with hypertension. All the participants who were diagnosed with diabetes, irrespective of gender, had either high or very high WC. Both SBP and DBP were significantly associated with WC; 35.4% and 49.2% of males, as well as 12.5% and 71.9% of females with high systolic blood pressure (HSBP), had high and very high WCs respectively. Similarly, 38.7% and 49.3% of males, as well as 4.0% and 80% of females with high diastolic blood pressure (HDBP), had high and very high WCs respectively. Among the females, all the participants with high blood glucose (HBG) had very high WC. BMI is associated significantly ($p<0.01$) with WC.

Table 2: Association between non-communicable diseases (NCDs) and abdominal obesity in the sample

NCD Characteristic		Men Waist circumference Normal (<94cm)	High (94-102cm)	V. High (>102cm)	N	Women Waist circumference Normal (<80cm)	High (80-88m)	V. High (>88cm)	N
Hypertension	Diagnosed	15.3	27.8	56.9	**72**	27.9	31.1	41.0	**61**
	Undiagnosed	82.3	14.6	3.1	**158**	51.2	10.0	38.8	**209**
		X^2 = 126.356; df = 2; p<0.01				X^2 = 80.254; df = 2; p<0.01			
Diabetes	Diagnosed	0.0	27.8	72.2	**18**	0.0	37.5	62.5	**8**
	Undiagnosed	66.5	17.9	15.6	**212**	47.3	14.1	38.6	**262**
		X^2 = 28.533; df = 2; p<0.01				X^2 = 12.071; df = 2; p<0.01			
Systolic Blood Pressure	NSBP	79.4	12.1	8.5	**165**	50.0	15.1	34.9	**238**
	HSBP	15.4	35.4	49.2	**65**	15.6	12.5	71.9	**32**
		X^2 = 87.485; df = 2; p<0.01				X^2 = 12.207; df = 2; p<0.01			
Diastolic Blood Pressure	NDBP	85.2	9.0	5.8	**155**	49.0	15.9	35.1	**245**
	HDBP	12.0	38.7	49.3	**75**	16.0	4.0	80.0	**25**
		X^2 = 107.767; df = 2; p<0.01				X^2 = 17.846; df = 2; p<0.01			
RBG	NBS	61.3	18.7	20.0	**230**	46.6	15.0	38.4	**266**
	HBS	0.0	0.0	0.0	**0**	0.0	0.0	100.0	**4**
		X^2 = na				X^2 = 5.938; df = 2; p<0.05			
BMI	Underweight	100.0	0.0	0.0	**14**	100.0	0.0	0.0	**26**
	Normal	95.1	4.9	0.0	**81**	87.2	8.5	4.3	**94**
	Overweight	60.0	35.3	4.7	**85**	18.8	37.5	43.7	**80**
	Obese	2.0	18.0	80.0	**50**	0.0	2.9	97.1	**70**
		X^2 = 195.739; df = 6; p<0.01				X^2 = 241.200; df = 6; p<0.01			

NSB = normal systolic blood pressure (<140mmHg); HSBP = high systolic blood pressure (≥ 140mmHg)
RBG = random blood glucose; NDBP = normal diastolic blood pressure (< 90mmHg)
BMI = body mass index; HDBP = high diastolic blood pressure (≥ 90mmHg)
NBG = normal blood glucose (< 200mg/dl); HBG = high blood glucose (diabetes) (≥ 200mg/dl)
N = total number

Correlation between obesity and non-communicable diseases among the participants

Table 3 presents the result of the correlation analysis between obesity as a risk factor and the selected NCDs (hypertension and type 2 diabetes) among the participants which indicated that BMI had strong correlations with HBP (r=0.413) at p<0.01, but had no significant association with RBG. Waist circumference had correlations with DBP (r= -0.102, p=0.022) and RBG (r=0.123, p=0.006), but had no significant relationship with SBP. The strong and positive correlation between AO marker (WC) and RBG was strong and positive. On the other hand, WHR had strong positive correlations with RBG (r=0.118, p=0.008), but there was no significant association with both SBP and DBP.

Logistic regression analysis of the socio-demographic attributes, high blood pressure (as observed or measured), and abdominal obesity in the sample

Male participants were approximately three times more likely to have high blood pressure (OR=2.754; CI=1.776-4.270) and 0.459 times less likely to have abdominal obesity (AO) compared to the female respondents at p<0.05, as shown in Table 4. The older adults (participants aged 60 and older) were 29.03 times more likely to develop HBP (OR=29.029; CI=13.853-60.831) and 19.72 times more likely to have AO (OR=19.722; CI=9.663-40.255) at p<0.05 compared to the middle-aged and younger adults. Being married only had a significant odd ratio with AO; while being married, separated, divorced, or widowed all had significant odds with hypertension, suggesting that being married, on one hand, increased the likelihood of AO, and on the other hand, being married, being separated, divorced or widowed increased the likelihood of developing hypertension.

Table 3: Correlation between obesity and non-communicable diseases (hypertension and type 2 diabetes) in the sample

Obesity Classification		SBP	DBP	RBG
BMI	**Pearson Correlation**	0.413**	0.413**	0.027
	Sig. (2-tailed) (p)	0.000	0.000	0.550
	N	**500**	**500**	**500**
WC	**Pearson Correlation**	-0.064	-0.102*	0.123**
	Sig. (2-tailed) (p)	0.154	0.022	0.006
	N	**500**	**500**	**500**
WHR	**Pearson Correlation**	-0.014	-0.052	0.118**
	Sig. (2-tailed) (p)	0.761	0.244	0.008
	N	**500**	**500**	**500**

**. Correlation is significant at 0.01 level (2-tailed); *. Correlation is significant at 0.05 level (2-tailed).
SBP = systolic blood pressure; DBP = diastolic blood pressure; RBG = random blood glucose
BMI = body mass index; WC = waist circumference; WHR = waist-hip ratio

Table 4: Logistic regression analysis of the socio-demographic characteristics, high blood pressure (as observed or measured), and abdominal obesity in the population

Variables		**High blood pressure observed**			**Abdominal obesity**		
		OR	**p-value**	**95% CI**	**OR**	**p-value**	**95% CI**
Sex	Female	Ref.					
	Male	2.754	<0.05	1.776-4.270	0.459	<0.05	0.310-0.681
Marital status	Single	Ref.					
	Married	7.034	<0.05	4.049-12.222	28.007	<0.05	14.488-54.143
	Separated	2E+10	<0.05	0.000	4E+10	0.999	0.000
	Divorced	2E+10	<0.05	0.000	4E+10	0.999	0.000
	Widowed	21.067	<0.05	6.246-71.056	4E+10	0.999	0.000
Age group	20-39 years	Ref.					
	40-59 years	6.939	<0.05	4.084-11.790	14.994	<0.05	9.040-24.867
	60 years and above	29.029	<0.05	13.853-60.831	19.722	<0.05	9.663-40.255
Education	No formal education	Ref.			Ref.		
	Primary	0.000	0.999	0.000	0.000	0.999	0.000
	Secondary	0.000	0.999	0.000	0.000	0.999	0.000
	Diploma	0.000	0.999	0.000	0.000	0.999	0.000
	HND	0.000	0.999	0.000	0.000	0.999	0.000
	Postgraduate	0.000	0.999	0.000	0.000	0.999	0.000

P-value is significant at <0.05
OR = odd ratio
CI = confidence interval

DISCUSSION

There was more single than married or divorced/separated individual members of the population with a high percentage of the population being unemployed, self-employed or in the few available civil/public service jobs. Other development and social indicators in the study support the classification of most urban and rural areas of Nigeria as well as very many other nations of Africa as underdeveloped and developing economies according to the World Bank (21).

Some socio-economic factors associated with health such as income, education and housing have a huge effect on human behaviours which can predetermine the incidence of diseases like hypertension (22). Unemployment or fear of unemployment can aggravate the stress levels which can in turn influence HBP in such individuals (22). It is further highlighted that environmental factors may interfere with the early diagnosis and management of hypertension owing to inadequate healthcare which could aggravate the complications associated with the disease (22). In the present study, there were high proportions of unemployed and self-employed members of the population whose socio-economic situation might have been responsible for the recorded prevalence of hypertension and the associated conditions. However, socio-demographic attributes were not found to be predisposing factors toward the development of type 2 diabetes in this study. Men were less likely to have AO in relation to HBP compared to women. Being obese was significantly associated with the development of co-morbidities as compared to the normal weight population in a study conducted by Agrawal and Agrawal (23). The regression analysis in the present study, however, showed that men were less likely to have AO in relation to HBP, suggesting that although there was more AO among the women, more men were found to have hypertension (and type 2 diabetes based on prevalence report).

Hypertension has been described as a global public health condition that increases the challenge of heart disease, stroke and renal failure as well as disability and untimely death prevalent in developing and underdeveloped nations of the world notable with poor health facilities (22). In the current study, associations between hypertension, type 2 diabetes, generalized obesity and waist circumference of the participants were strong. There were associations between all the NCD parameters (except RBG) and the waist circumferences of both male and female respondents, hence being diagnosed with hypertension and diabetes. High SBP and DBP as well as increased BMI were identified to be directly associated with abdominal obesity in both genders of the study population. Whereas there was an association observed between RBG and WC of the females, there was no applicable chi-square analysis for the association between RBG and WC of the males because fewer or no male was observed to have high blood glucose among the population tested for blood glucose. More males and females who were diagnosed with hypertension had more abdominal overweight and obesity compared to fewer males and females who were undiagnosed with hypertension, while all the males and females who were diagnosed with diabetes had either abdominal overweight or obesity. All the female respondents with high blood glucose (HBG) in the study had abdominal obesity. Shukla *et al* (24) reported a significant association of obesity with hypertension, angina, diabetes, and arthritis among the Chinese, Russians, and South Africans; while among the Indians, obesity was basically associated with hypertension and diabetes. It was reported in another study that obese respondents had a higher likelihood of developing hypertension than did the respondents with healthy BMI (25). Thus, the results of the current study correspond to the findings of some previous studies.

Correlation analysis between obesity as a risk factor and hypertension and type 2 diabetes prevalence among the participants indicated that BMI had strong correlations with hypertension but had no significant association with RBG. The reason for the non-correlation of BMI with RBG could be because a few proportions of the population identified to have high RBG. For the abdominal obesity assessment, WC had negative correlations with DBP and positive correlations with RBG but had no relationship with SBP. The correlation between WC and DBP was a negative or inverse relationship, while the correlation with RBG was strong and positive. This suggested that as WC increased, DBP decreased, and vice versa; as WC increased or decreased, RBG increased or decreased as well. On the other hand, WHR had positive correlations with RBG, but there was no relationship with both SBP and DBP. This could be as a result of the insensitivity of WHR compared with WC in assessing AO as reported by the WHO (26). The present finding is similar to Okafor *et al* (9) which showed that the correlation was positive and stronger between WC and BMI ($r=0.71$; $p<0.001$) compared to WHR ($r=0.57$; $p<0.001$). The study conducted by Onuoha *et al* (25) demonstrated a positive correlation between WHR and BP (SBP and DBP) in both genders; suggesting a positive correlation between AO and BP, particularly among the younger adults. This, however, is contrary to the result of the present study probably because of the ambiguity of WHR. Dua *et al* (27) reported a strong positive correlation between BMI and BP (SBP and DBP) among adults of the Punjabi community of Delhi in India. Similarly, BMI was strongly and positively correlated with SBP and DBP in African and Asian populations in a study conducted by Tesfaye *et al* (28); suggesting that hypertension was more common among the populations with overweight and obesity than in the healthy weight populations.

Obesity has been described as a major cause of hypertension and type 2 diabetes (31). Agrawal *et al* (29) reported that FBG, SBP, and DBP increased as BMI tilts towards overweight and obesity; hence there was a positive correlation between BMI and FBG among the population. This report is opposed to the report of the present study that BMI did not correlate with RBG, which could be a result of different blood glucose assessment techniques (FBG compared to RBG) in both studies. More so, Bakari *et al* (30) suggested racial differences as an important factor in the association between BMI and glucose intolerance. The study reported a positive correlation between RBG and BMI among females, but there was no correlation between these variables among males in the adult population of two communities in Zaria, Northern Nigeria (30). Hornby (31) documented that the SBP is the level of coercion that the heart undergoes when it contracts, while the DBP is the level of coercion expressed when the heart is in relaxation. According to Hornby (31), while SBP is usually associated with more dangers in human health, a continuous rise in DBP equally has health demerits. High SBP was reported to have predisposed individuals to reduced cognitive functions and aches symptomatic of CVD as well as bleeding in the brain suspected to have resulted in a cardiovascular accident (CVA), whereas DBP was associated with a higher risk of abdominal aortic aneurysm (inflammation of the arteries which could result in severe conditions of the metabolic system when ruptured) (31). Poirier *et al* (32) reported that even though excess fatness may contribute to hypertension in some obese patients, the mechanisms responsible for the weight-related increase in BP were still unclear; suggesting that there could be other risk factors associated with hypertension and the related type 2 diabetes rather than simply obesity.

Thomas *et al* (33) documented WC as the most notable indicator (in comparison with age, gender, BMI, and insulin resistance) of HBP among the Chinese population with normal blood glucose levels but with some established cases of hypertension. Thus, WC was found to be the major determinant of hypertension (33). Poirier *et al* (32) documented that varying factors could be responsible for elevated BP occasioned by AO regardless of insulin resistance. Although the present study is limiting in biochemical investigations of the interplay of the NCDs correlated with AO, as metabolic syndromes they are, multivariate factors are involved in the predisposition to the conditions.
The logistic regression analysis carried out showed that odd ratios of variables for hypertension were strong in terms of gender, marital status, and age. Thus, male gender, being married or once married (separated, divorced, or widowed), increasing age (older age) were socio-demographic factors responsible for the development of hypertension in the population.

CONCLUSION
The findings of this study concluded that socio-demographic factors such as male gender, being married or once married, and older age had significant associations with hypertension among the study participants. There were high proportions of unemployed and self-employed members of the population whose socio-economic situation might have been responsible for the recorded cases of hypertension and the associated conditions. However, socio-demographic attributes were not found to be predisposing factors toward the development of type 2 diabetes. There were strong associations between hypertension, type 2 diabetes, generalized obesity, and waist circumference of the participants. More males and females who were diagnosed with hypertension had more abdominal overweight and obesity compared to fewer males and females who were undiagnosed with hypertension, while all the males and females who were diagnosed with diabetes had either abdominal overweight or obesity. Men were less likely to have abdominal obesity in relation to high blood pressure compared to women, suggesting that although there was more abdominal obesity among the women, more men were found to have hypertension and type 2 diabetes based on their existing histories or diagnoses. Therefore, there should be appropriate interventions for the individuals who were already diagnosed with the various NCDs while those at risk of developing the disorders should be identified within the population for proper counseling.

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Conflict of interests
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Authors' Contributions
Conceptualization and design of the study: Ide TJP, Ndiokwelu CI and Ene-Obong HN. Data collection: Ide TJP, Essien NA, and the research assistants. Analysis of data: Ide TJP and Odo CC. Interpretation of statistical data: Ide TJP and Ndiokwelu CI and Ene-Obong HN. Drafting of the manuscript: Ide TJP. A

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