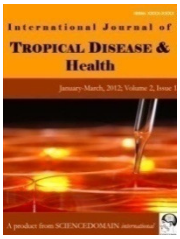

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Prevalent Components of Metabolic Syndrome and Their Correlates in Apparently Healthy Individuals in Sub-saharan Africa

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Authors' contributions

The authors contributed to the intellectual content of this paper and have met the following requirements: a) Significant contributions to the concept and design, data acquisition, analysis and interpretation; b) Drafting and reviewing the article for intellectual content; c)final approval of the article for publication.

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ABSTRACT

Aim: To assess the prevalent components of metabolic syndrome (MSC) and their related determinants of lipid metabolism in the Nigerian for early diagnosis, prevention

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and management of the metabolic syndrome (MS) and its associated diseases.
Study Design: Cohort study.
Place and Duration of Study: Department of Chemical Pathology, College of Medicine, University of Ibadan, Ibadan between March and August 2010.
Methodology: 534 apparently healthy Nigerian traders aged 18–105 years were participants of a cohort study. The IDF (2005) criteria was used for MS diagnosis. Anthropometric indices and blood pressure (BP) were obtained by standard methods. Fasting plasma glucose, total cholesterol (TC), triglycerides (TG) and high density lipoprotein cholesterol (HDLC) were determined by enzymatic methods while low density lipoprotein cholesterol (LDLC) was calculated. Data analysed were statistically significant at $P<0.05$.
Results: 60.1% of traders had 2 and 3MSC. 0.6%, 1.1% and 9.6% of traders had all 5MSC, ≥3MSC without elevated waist circumference (WC) and zero MSC respectively. Elevated WC, reduced HDLC and high BP were more frequent MSC representing 70.2%, 63.1% and 47.9% while FPG and TG were less frequent representing 11.2% and 2.2% of traders respectively. This pattern was similar in MS and non-MS groups. 25.3% of males and only 2.2% of females had no MSC. Reduced HDLC and elevated WC were the most frequent MSC in males and females respectively. All metabolic risk factors (MRF) except TC were significantly different in comparison between MS and non-MS groups as well as among traders with 0-5 MSC. WHR was the only parameter that correlated significantly with all MRF.
Conclusion: Elevated waist circumference, reduced high density lipoprotein cholesterol, and high blood pressure may be prevalent metabolic syndrome components and important in managing metabolic syndrome in Nigeria. Regional specific cut-offs for these components for the African population is needed.

Keywords: Metabolic syndrome; cardiovascular disease; measures of adiposity; lipids; type2 diabetes mellitus; metabolic syndrome components; gender; African.

1. INTRODUCTION

Escalating overnutrition in the continuing presence of undernutrition characterise many resource poor settings [1] including Nigeria. The prevalence of 23.4% of obesity and 33.1% of metabolic syndrome (MS) have been reported in the face of 3.3% of undernutrition in an apparently healthy population in Nigeria [2,3]. The prevalence of MS in Africa is thought to be due to departure from traditional African to western lifestyles [4].

Obesity is a natural consequence of overnutrition and sedentary lifestyle. Persistent obesity dysregulates metabolic processes including action of insulin on glucose-lipid-free fatty acid metabolism and severely affects processes controlling blood glucose, blood pressure, and lipids. The resultant cluster of conditions: dysglycemia, dyslipidemia, hypertension, and procoagulant state known as MS culminates in cardiovascular disease (CVD) and type2 diabetes mellitus (DM2) [1]. Dyslipoproteinaemia, a cardinal feature of the MS is also thought to be the major mediator of atherogenicity observed in MS [5,6]. A recent study in obese individuals in Nigeria showed dyslipidemia and hypertension but not hyperglycemia [2]. Metabolic alterations were also observed in different stages of hypertension, which was associated with MS [3]. Fabian et al. [7] observed significant correlations between leptin levels and measures of adiposity in individuals with MS. The increased leptin level was postulated as a compensatory mechanism for both the maintenance of blood pressure and weight loss.

Overweight and obesity progress to MS through pathophysiological mechanisms, which are still largely unclear. Recent mechanisms put forward are the inflammatory state and oxidative stress with more complications than were earlier imagined. Firstly, it is hypothesised that overfeeding is the starting signal of obesity, which results in a proinflammatory state starting in the metabolic cells (adipocyte, hepatocyte, or myocyte) and also recruiting immune cells with the consequent release of inflammatory cytokines (TNF-α, IL-6, adiponectin, etc.). This inflammatory process may lead to complications such as hypertension, atherosclerosis, dyslipidaemia, insulin resistance, and diabetes mellitus which characterize metabolic syndrome [8].

Secondly, oxidative stress, a condition in which an imbalance results between the production and inactivation of reactive oxygen species characterize MS [9], its components and progression [10]. Reactive oxygen species, short-lived molecules are highly reactive derivatives of oxygen metabolism. They play an essential role in multiple physiological systems such as gene expression and signal transduction but contribute to cellular dysfunction under conditions of oxidative stress. Oxidative stress is thought to play a major role in the pathogenesis of ageing and a variety of human diseases, including atherosclerosis, diabetes, hypertension, Alzheimer's disease, kidney disease and cancer [9,10]. We observed that short-term dietary intervention improved cardiovascular risk, inflammation and oxidative stress indices in Nigerians with MS in our recent study [11].

These complications of MS are overwhelming and necessitate early identification of specific biomarkers for early diagnosis, prevention and management of the syndrome particularly in a region that is battling with undernutrition and overnutrition in addition to communicable diseases. Variations exist in MS components (MSC) in different racial and ethnic populations [12,13]. However, studies addressing important components of MS in our geographical region are sparse and conducted in diabetics [14]. Improving specific components relevant to our population through dietary and lifestyle modification [11] will reduce the prevalence of MS as well as its associated diseases. This study is intended to assess the most important MSC and their related determinants of lipid metabolism in the Nigerian.

2. METHODOLOGY

2.1 Study Design

The study was a cohort study conducted over a period of 6 months and ethical approval was obtained from the Joint Ethical Committee of the University of Ibadan/University College Hospital, Ibadan, Nigeria (UI/UCH).

2.2 Participants

534 (170 males and 364 females) apparently healthy traders from a local market in Bodija, Ibadan aged 18–105 years participated in this study. In collaboration with leaders of their market association who were adequately informed about the study in their local language, Yoruba; recruitment of the participants was done by consecutive selection of all apparently healthy traders without DM2 (from their pre-test questionaire) that gave informed consent. Selection was not based on any other criteria. They were part of a cohort study on Risk Assessment of DM in Individuals with MS in Ibadan, South-West, Nigeria, conducted in the Department of Chemical Pathology, College of Medicine, UI [3]. Methods used were shown elsewhere [2,7,15].

2.3 Diagnosis of Metabolic Syndrome

MS was diagnosed using the International Diabetes Federation diagnostic criteria [12]. The criteria include central obesity (WC) (male: ≥94cm, female: ≥80cm) and any two of raised triglycerides: ≥150mg/dL (1.7mmol/L), reduced HDL cholesterol (males: <40mg/dL, females: <50mg/dL, raised blood pressure (≥130/≥85mmHg), or raised fasting plasma glucose (FPG) (≥100mg/dL).

2.4 Components of Metabolic Syndrome

These were parameters contained in the International Diabetes Federation diagnostic criteria for metabolic syndrome-raised waist circumference (WC), raised triglycerides (TG), reduced high density lipoprotein cholesterol (HDLC), high blood pressure (BP), and raised fasting plasma glucose [12].

2.5 Measures of Adiposity and Lipids

Adiposity measures included: body weight, height, body mass index (BMI), hip circumference (HC), waist hip ratio (WHR), waist height ratio (WHT) and percentage body fat (PBF). Lipids (other than HDLC and TG-components of MS) included total cholesterol (TC) and low density lipoprotein cholesterol (LDLC) [2].

2.6 Sample Collection

6ml of venous blood sample was aseptically obtained by venopuncture from the participants after an overnight fast (10-14h). 4ml was dispensed into potassium ethylene diamine tetra acetic acid (K3EDTA) tube for the determination of lipid profile (TC, TG and HDLC). 2ml was dispensed into fluoride oxalate tube for FPG estimation. All samples were centrifuged at 500g for 5min after which plasma/serum were aspirated in small aliquots into clean vials and stored at -20℃ until analyses were done.

2.7 Statistical Analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS) software 15.0 version. Analysis of variance (ANOVA), Post Hoc and Student's t test were used for comparison of quantitative variables. Pearson's correlation co-efficient was used to find relationship two quantitative variables. Two-tailed independent t-test of significance at 95% confidence limit with $P<.05$ was considered significant for the variables.

3. RESULTS AND DISCUSSION

3.1 Components of Metabolic Syndrome

The MS, a useful and simple clinical concept is said to enhance the early detection of DM2 and CVD [16]. Visceral obesity and insulin resistance are considered the main features determining the negative cardiovascular profile in metabolic syndrome [8]. The IDF has five components-abdominal (visceral) obesity, BP, low HDLC levels, elevated TG levels and elevated FPG levels in the criteria for MS diagnosis [12]. New research suggests that risk factors specific to a particular racial or ethnic population may be important [13]. Table 1 shows frequency of traders with MSC. In the population we studied, majority of the traders

(60%) had 2 and 3 MSC. 1% of traders had all 5 MSC while only 10% of traders had no MSC. Elevated WC, reduced HDLC and high BP were more frequent MSC representing 70%, 63% and 48% while FPG and TG were less frequent representing 11% and 2% of traders respectively. Similar findings were made in individuals with MS and without MS (non-MS). However, six (1%) of the traders had ≥3 MSC without elevated WC (a mandatory index by the IDF criteria for MS diagnosis). Ogbera in Lagos, Nigeria among diabetics reported elevated WC as the commonest component while elevated TG was the least component similar to our findings [14].

Table 1. Frequency of individual components of the metabolic syndrome in 534 apparently healthy traders

nMSc	n	WC	BP	TG	HDLC	FPG
0	51 (9.6)	0	0	0	0	0
1	137 (25.7)	56	18	1	60	2
2	163 (30.5)	142	74	0	103	7
3	158 (29.6)	153	139	3	149	30
4	22 (4.1)	21	22	5	22	18
5	3 (0.6)	3	3	3	3	3
Total	534(100)	375(70.2)	256(47.9)	12(2.2)	337(63.1)	60(11.2)

Values in frequency, percentage is in parentheses, nMSC=number of metabolic syndrome components, %=percentage, elevated WC=waist circumference, BP=elevated blood pressure, TG=high triglycerides, reduced HDLC=high density lipoprotein cholesterol, elevated FPG=fasting plasma glucose, n=number of participants

Correlations of TG with all metabolic factors except HDLC, height and PBF were however, significant and positive (P<.03) in our study. Although elevated WC, reduced HDLC and high BP were also the most frequent components of MS in Brazil, the most frequent combination was arterial hypertension and increased waist circumference followed by low HDLC [17] implicating regional variations in MSC. Correlations of SBP and WC with all metabolic factors except HDLC were significant while correlations of DBP with all metabolic factors were significant except HDLC, FPG and height (P≤0.04). The correlations of height with SBP and WC were negative. WC reflects abdominal fat, which contains higher amounts of visceral fat and is said to correlate with parameters of lipid profile. Visceral fat is made by liver, turned into cholesterol, and released into the bloodstream where it forms plaque on the artery walls, resulting in high blood pressure and cardiovascular disease [18]. In a similar study by our group in different stages of hypertension, 36.3% of apparently healthy traders had hypertension associated with MS [3].

Detecting MS is a simple method of evaluating individuals at high risk of diabetes [17] as differences in FPG levels were significant among individuals with varying nMSC Tables 2,3. Among apparently healthy individuals in Japan, hypertension and increased FPG were independent risk factors for MS with hypertension being the most frequent component [19]. However, less than 15% of individuals had elevated FPG, the 4th frequent component of MS observed in our present study. FPG correlated significantly and positively with only SBP, WC, TG and WHR but negatively with HDLC (P<0.03).

Reduced HDLC level is a MSC in the IDF criteria [12] used in this study. Our previous studies in the same population as this study showed similar levels of HDLC, FPG and TG in overweight/obese groups compared with normal weight controls while HDLC was the only metabolic component that was similar in comparison of different hypertension stages [2,3]. The ineffectiveness of high HDLC levels in inhibiting the development of atherosclerosis in a

mammal with severe hypercholesterolaemia has been demonstrated [20]. The observed reduction of HDLC levels in MS compared with non-MS as well as increased nMSC compared with lower nMSC in this present study is surprising. Moreover reduced HDLC was the second most frequent MSC affecting 63% of traders. However, our findings are consistent with Gordon et al. [21] in the Framingham study, which had long shown the cardioprotective effect of HDLC. Significant and positive correlations of HDLC with PBF and TC but negative correlations with FPG and WHR were observed (P ≤ .049) in this present study. Significant and negative correlation of HDLC with WHR has been reported [18]. Our observations are contrary to observed increases of serum HDLC levels with age, body mass index, blood pressure and fasting glucose levels in normotensive participants in China [22] as well as reports on HDLC as most frequently associated component of BP [23].

3.2 Metabolic Risk factors

Garg et al. [18] observed that TC, LDLC, TG and LDL/HDL ratio had significant positive correlations with anthropometric measures, which significantly and positively correlated with each other. Table 2 shows comparison of metabolic risk factors among traders with 0-5 components of metabolic syndrome (MSC) using ANOVA. All metabolic factors except TC were significant (P < .001). Post hoc tests showed that most comparisons between components were significant (P <.047). Comparison of metabolic factors between traders with MS and non-MS also showed significant differences (P <.001) in all factors tested except TC Table 3 similar to findings on Table 2. The similar levels of TC among individuals with varying nMSC and between MS and non-MS groups may suggest that TC is not an important risk factor for MS. However, TC correlated positively and significantly with all metabolic factors except FPG and height (P ≤ .04) Table 4. The accumulation of small LDLC particle size (calculated as TG to HDLC ratio) has been implicated in MS [23]. In our present study, LDLC correlated positively with all metabolic factors except HDLC, FPG (components of MS) and height (P ≤ .04) Table 5. However, LDLC levels may be important in our region as it was significantly higher in MS than non-MS groups as well as in groups with higher compared with lower MSC.

The sensitivities of many anthropometric indices are reportedly low. Thus a reassessment of the effectiveness of obesity indices in evaluating metabolic risks especially their suitability as a single mandatory component of metabolic syndrome has been advocated [24]. Several approaches have been used to measure obesity. PBF and BMI measure general obesity, HC measures subcutaneous adipose tissue while waist-hip ratio (WHR) and waist-to-height ratio (WHT) together with WC measure abdominal fat [2,25-28]. Although BMI, WC, WHR, WHT are independently associated with cardiovascular and metabolic risk, a combination of general and central adiposity has been recommended [25,27,28]. These measures were higher in obese than normal weight traders as well as hypertensive compared normotensive groups in our previous studies [2,3].

An increased WHR may reflect either a relative abundance of abdominal fat (increased WC) or a relative lack of gluteal muscle (decreased hip circumference) [18]. In our present study, WHR was the only parameter that correlated significantly with all metabolic factors (*P* <.02). These correlations were positive except that of WHT with HDLC and height Table 5. WHT, an improved index over WC was reported as a simple and practical index for assessing central fat distribution and metabolic risk in men and women [24,29]. In this present study, WHT, BMI and body weight correlated significantly with all metabolic factors except HDLC and FPG (*P* < .03). These correlations were positive except that of height with BMI and WHT. BMI appears to account for factors such as body fat distribution, particularly abdominal obesity, and cannot distinguish between lean and fat body mass [18].

Table 2. Comparison of metabolic factors among traders with 0-5 components of metabolic syndrome

Parameters	No of MS Components					Total	F	*P*
	0	1	2	3	>3			
N	51	137	163	158	25	534		
MSC								
SBP (mmHg)	114.1(6.4)	115.8(14.9)	126.8(21.5)	143.5(24.8)	151.8(17.8)	128.9(23.5)	51.3	<.001*
DBP (mmHg)	72.9(4.6)	74.6(8.5)	79.4(11.1)	86.7(14.0)	93.2(11.1)	80.4(12.4)	36.9	<.001*
WC (cm)	80.4(6.2)	86.9(12.7)	95.5(11.3)	101.2(11.5)	104.7(15.4	94.0(13.6)	51.6	<.001*
HDLC (mg/dl)	51.1(10.5)	46.9(15.0)	43.9(16.5)	35.1(11.5)	30.9(11.6)	42.1(15.2)	23.7	<.001*
FPG (mg/dl)	76.9(14.4)	80.4(9.8)	81.0(13.2)	90.7(33.7)	115.6(44.8)	85.0(24.4)	17.7	<.001*
TG (mg/dl)	67.6(30.2)	57.0(25.0)	64.0(27.3)	71.5(33.3)	98.2(49.4)	66.4(31.4)	11.6	<.001*
Non MSC								
Age (years)	34.5(7.3)	38.6(12.0)	43.9(12.5)	50.4(11.3)	50.9(11.0)	43.9(12.7)	30.3	<.001*
Height (m)	1.69(0.1)	1.65(0.1)	1.63(0.2)	1.6(0.1)	1.6(0.1)	1.63(0.1)	11.3	<.001*
Body weight (kg)	62.7(7.9	65.2(13.4)	71.3(12.7)	74.0(13.9)	77.7(19.5)	70.0(13.9)	14.5	<.001*
BMI (kg/m^2)	22.0 (2.0)	24.0(4.8)	27.0(4.7)	28.5(4.9)	29.9(5.8)	26.3(5.1)	32.9	<.001*
HC (cm)	92.2 (4.4)	96.6(11.3)	103.8(9.8)	105.8(9.7)	107.3(11.9)	101.6(11.0)	31.6	<.001*
WHT	47.7(3.6)	52.8(8.2)	58.8(7.6)	63.8(12.7)	65.2(9.0)	58.0(10.8)	45.2	<.001*
WHR	0.87(0.0)	0.90(0.1)	0.92(0.1)	0.96(0.1)	0.98(0.1)	0.92(0.1)	28.8	<.001*
PBF	18.4(5.2)	26.6(12.1)	35.1(9.9)	38.8(8.5)	40.5(7.6)	32.7(11.8	62.7	<.001*
TC (mg/dl)	143.3(30.6)	138.6(45.7)	146.6(34.5)	147.5(43.5)	143.8(47.6)	144.4(40.7)	1.1	.38
LDLC (mg/dl)	79.1(30.2)	79.1(37.4)	90.6(32.3)	98.1(38.9)	92.0(37.4)	88.8(36.5)	6.3	<.001*

*Values are in means with s.d in parentheses, n=number of traders, F=F statistics, P=probability, * = significant, MS= metabolic syndrome, MSC=metabolic syndrome component, nonMSC=non-component of metabolic syndrome, BP= blood pressure, SBP=systolic blood pressure, DBP= diastolic blood pressure, WC= waist circumference, TG= Triglyceride, FPG= fasting plasma glucose, PBF=Percentage body fat, BP=blood pressure, WHT=waist to height ratio, WHR=waist to hip ratio, TC=total cholesterol, LDLC=density lipoprotein cholesterol*

Table 3. Comparison of metabolic risk factors in traders with and without metabolic syndrome

Parameters	Non- MS	MS	Total	t	*P*
n	357	177	534		< .001*
MSC					< .001*
SBP (mmHg)	120.9 (18.4)	145.1 (24.3)	128.9 (23.5)	-12.610	< .001*
DBP (mmHg)	76.7 (9.7)	87.9 (13.8)	80.4 (12.4)	-10.868	< .001*
WC (cm)	89.8 (12.5)	102.2 (11.8)	94.0 (13.6)	-10.992	< .001*
HDLC (mg/dl)	45.7 (15.6)	34.9 (11.3)	42.1 (15.2)	8.204	< .001*
FPG (mg/dl)	80.7 (12.8)	93.5 (36.7)	85.0 (24.4)	-5.917	< .001*
TG (mg/dl)	63.0 (29.7)	73.3 (33.8)	66.4 (31.4)	-3.596	< .001*
Non MSC					< .001*
Age (years)	40.4 (12.1)	50.94 (11.0)	43.9 (12.7)	-9.765	< .001*
Height (m)	1.6 (0.1)	1.6 (0.1)	1.6 (0.1)	5.641	< .001*
Body weight (kg)	67.6 (12.8)	74.8 (14.8)	70.0 (13.9)	-5.815	< .001*
BMI (kg/m^2)	25.0 (4.8)	28.9 (5.0)	26.3 (5.2)	-8.718	< .001*
HC (cm)	99.2 (10.7)	106.4(9.9)	101.6 (11.0)	-7.455	< .001*
WHT	54.8 (8.3)	64.5 (12.1)	58.0 (10.8)	-10.808	< .001*
WHR	0.9 (0.1)	1.0 (0.1)	0.9 (0.1)	-9.815	< .001*
PBF	29.2 (11.9)	39.8 (7.6)	32.7 (11.8)	-10.739	< .001*
TC (mg/dl)	143.1 (38.8)	147.1 (44.2)	144.4 (40.7)	-1.083	0.279
LDLC (mg/dl)	84.6 (34.5)	97.4 (38.9)	88.8 (36.5)	-3.852	< .001*

*Values are in mean ±s.d, p=probability, * = significant, MS= participants with metabolic syndrome, Non-MS = participants without MS, PBF=Percentage body fat, BP=blood pressure, SBP=systolic blood pressure, DBP=diastolic blood pressure, WC=waist circumference, HC=hip circumference, BMI=body mass index, WHT=waist to height ratio, WHR=waist to hip ratio, TC=Total Cholesterol, TG=Triglycerides, FPG=fasting plasma glucose, LDLC=low density lipoprotein cholesterol, HDLC=high density lipoprotein cholesterol, n= number of participants, values are in mean ± s.d, p=probability, t = Student's t-test, *=significant, MS=metabolic syndrome, Non-MS=non-metabolic syndrome, t=student's t test*

Table 4. Correlation of measures of adiposity with metabolic parameters in 534 (all) traders

Parameters	Height	Weight	BMI	HC	WHT	WHR	PBF
	r , p	r , p	r , p	r , p	r , p	r , p	r , p
MSC							
SBP (mmHg)	-.13, .002	.21, <.001	.27, <.001	.24, <.001	.29, <.001	.27, <.001	.30, <.001
DBP (mmHg)	-.072, .10	.27, <.001	.29, <.001	.28, <.001	.29, <.001	.21, <.001	.28, <.001
WC (cm)	-. 102, .02	.86, <.001	.91, <.001	.86, <.001	.81, <.001	.69, <.001	.79, <.001
HDLC (mg/dl)	-.05, .24	.01, .74	.04, .34	.07, .10	.01, <.84	-.13, .002	.09, .049
FPG (mg/dl)	-.04, .37	.01, .18	.08, .06	.04, .39	.08, .06	.16, <.001	.08, <.06
TG (mg/dl)	.04, .35	.14, .002	.11, .01	.11, .01	.18, .007	.18, <.001	.05, .29

r= Pearson's correlation coefficient, P=probability, P< 0.05 = significant, MSC=metabolic syndrome component, non-MSC=non-component of metabolic syndrome, BP= blood pressure, SBP=systolic blood pressure, DBP= diastolic blood pressure, WC= waist circumference, TG= triglyceride, FPG= fasting plasma glucose, PBF=Percentage body fat, BP=blood pressure, WHT=waist to height ratio, WHR=waist to hip ratio, TC=total cholesterol, LDLC=density lipoprotein cholesterol

Height significantly correlated negatively with SDP, WC, WHT, WHR and PBF but positively with age, body weight and BMI (P<.03). HC correlated significantly with all metabolic factors except HDLC, FPG and height (P<.02). Only the correlation between HC and height was negative. PBF correlated with all metabolic factors except FPG and TG (P<.02). These correlations were positive except that of PBF and height (P≤0.049) Table 4. Age correlated significantly and positively with all metabolic factors except HDLC (P<.03). Stratifying data into age groups, 25-34, 35-44, 45-54, 55-64 and ≥65 years showed 6 (6%), 46(25%), 58(48%), 45(66%) and 22(55%) with MS in a total of 105,182, 122, 68, 40 individuals respectively. The association of age and MS has been reported in our region [14,30] and is predominant among the elderly in the Western world [31].

3.3 Gender Differences in Components of Metabolic Syndrome and Risk Factors

In both gender (85% in men and 87% in women) of apparently healthy individuals in Japan, hypertension and increased FPG were independent risk factors for MS with hypertension being the most frequent component [19]. Contrarily, in our present study, differences in frequency of individuals with MSC were observed between males and females Table 6. Most of the males (39%) had only 1 MSC while most of the females (38%) had 3 MSC. 3 (1%) traders (all females) had all 5 MSC while only 10% of traders (25% of males and only 2% of females) had no MSC. Table 6 shows frequency of MSC in males and females in the study. In both sexes, reduced HDLC, raised BP, and WC were the most frequent components of MS in all traders with MS and non-MS. However, reduced HDLC was the most frequent MSC in males while elevated WC was the most frequent component in females. These findings were similar in traders with non-MS. In patients with DM2, Ogbera observed that HDLC was the MSC that differed significantly in both sexes [14]. In traders with MS, both males and females had similar pattern of observation on Table 1 with elevated WC being the most frequent followed by reduced HDLC and high BP probably due to the inclusion of the mandatory elevated WC by IDF (12) which might have biased the observation in males with MS. The need for ethnic-specific cut-off values for waist circumference in the IDF for people of African descent has been suggested [30].

Gender-specific differences have been demonstrated by different workers and MS appears to be more common in females [26]. An association of hypertension and obesity with female gender was observed in our previous studies [2,3]. CVD is the leading cause of death in women in the Western world and hormonal signaling has been implicated in the regulation of cardio protective mechanisms. Premenopausal women are at significantly lower risk of heart disease compared with men, but the risk greatly increases with the onset of menopause [31,32]. Elucidation of the mechanisms involved in preventing the development of coronary artery disease and protecting the myocardium against the deleterious consequences of myocardial ischaemia remains an important research goal [33]. Oestrogen is a female hormone and is thought to prevent the development of atherosclerosis through favourable effects on an intact endothelium and direct protective effect against ischemia/reperfusion injury [31,32,33]. However, recent evidence suggests that hormone replacement therapy actually increases risk of CVD [31]. Thus prothrombotic and possibly proinflammatory effects of oestrogens may predominate and prove harmful once the vascular endothelium is damaged [32]. Male gender is a known a risk factor for CVD and testosterone, the main male sex hormone, is therefore believed to be responsible for the deleterious effect of the male. Functional androgen receptors are present in the heart and testosterone acts directly at the myocardium suggesting that testosterone confers cardio protection by direct action on the myocardium.

Table 5. Correlation of Age, TC and LDLC with and metabolic parameters in 534 (all) traders

Parameters	Age	TC	LDLC
	r, p	r, p	r, p
SBP(mmHg)	.44, <.001	.13, .003	.11, .02
DBP(mmHg)	.32, <.001	.09, .04	.09, .04
WC(cm)	.32, <.001	.17, <.001	.18, <.001
HDLC(mg/dl)	-.08, .06	.36, <.001	-.01, .88
FPG(mg/dl)	.04, .31	. 03, .54	.05, .28
TG(mg/dl)	.12, .004	.28, <.001	.18, .<.001

r= Pearson's correlation coefficient, P=probability, P<0.05 = significant, MSC=metabolic syndrome component, non-MSC=non-component of metabolic syndrome, BP= blood pressure, SBP=systolic blood pressure, DBP= diastolic blood pressure, WC= waist circumference, TG= triglyceride, FPG= fasting plasma glucose, PBF=Percentage body fat, BP=blood pressure, WHT=waist to height ratio, WHR=waist to hip ratio, TC=total cholesterol, LDLC=density lipoprotein cholesterol

Table 6. Frequency of individual components of the metabolic syndrome in 534 apparently healthy male and female traders

nMSC	N (%)		WC		BP		TG		HDLC		FPG		All Frequency (%)
	M	F	M	F	M	F	M	F	M	F	M	F	
0	43(25.5)	8(2.2)	0	0	0	0	0	0	0	0	0	0	51 (9.6)
1	67(39.4)	70(19.2)	8	48	17	1	1	0	39	21	2	0	137 (25.7)
2	39(22.9)	124(34.1)	24	118	21	53	0	0	29	74	4	3	163 (30.5)
3	19(11.2	139(38.2)	14	139	16	123	2	1	18	131	7	23	158 (29.6)
4	2(1.2)	20(5.5	2	19	2	20	0	5	2	20	2	16	22 (4.1)
5	0(0)	3(0.8)	0	3	0	3	0	3	0	3	0	3	3 (0.6)
Total	170(100)	364(100)	48	327	56	200	3	9	88	249	15	45	534 (100)

values in frequency, percentage is in parentheses, nMSC= number of metabolic syndrome components, %=percentage, elevated WC=waist circumference, BP= elevated blood pressure, TG= high triglycerides, reduced HDLC=high density lipoprotein cholesterol, elevated FPG=fasting plasma glucose, n=number of participants, percentage of males vs females with WC, BP, TG, HDLC, FPG are 28.2 vs 89.8, 32.9 vs 54.9; 1.8 vs 2,4; 51.8 vs 68.4; 8.8 vs 12.4 respectively

However, low testosterone levels in patients with ischemic heart diseases and alleviation of observed symptoms with testosterone treatment have been reported [4]. Our previous study [15] showed significantly lower levels of testosterone in males with MS and DM2.

Although the sample size of males with MS in the study was small (16) compared with 170 with non-MS, comparison between groups showed significant differences *(P*<.02) in all metabolic factors except height, TG, TC and LDLC (*P*>.44). In the comparison of females with MS (161) and non-MS (203), significant differences were observed in all metabolic factors (*P*<.002) except height and TC (*P*>.11). Comparison of metabolic factors in individuals with MS showed significantly lower difference in height (*P*<.001) but higher difference in PBF (*P*<.001) in females compared with males. In comparison between males and females with non-MS, all factors were significant except age, BP, body weight, WHR, FPG and LDLC (*P*>0.17). These findings suggest that male gender may be protective of CVD and probably DM2 in the Nigerian indicating further investigation of hormone signaling mechanisms in individuals with MS, CVD and DM2.

4. CONCLUSION

Elevated WC, reduced HDLC and high BP are prevalent MSC in Nigerians and may enhance the determination of negative cardiovascular profile in MS. WHR, a non-MSC may be important in the detection of MS in Nigerians since it correlated with all MRF. These MRF may be specific to the Nigerian and could aid in the early detection and management of CVD and probably DM2. The high percentage (90%) with 1-5 MSC as well as differences observed in all metabolic risk factors except TC amongst individuals with varying nMSC are alarming and calls for metabolic screening of Nigerians. The six (1%) of the traders with ≥3 MSC without elevated WC is worthy of note as reduced HDLC and not elevated WC appears more frequent in males. Gender differences should be considered in the management of individuals with MS. Our findings emphasize the need for specific cut-offs not only for MSC but also for other metabolic risk factors in the African. The higher prevalence of females with MSC than males may implicate hormone signaling suggesting that testosterone and not oestrogen may be cardio protective but requires further studies. Although elevated FBG and TG were the least MSC in this study, they should be included in screening programmes in order to include the few with these components. HDLC and FPG appear to correlate with few metabolic risk factors and may explain some unclear underlying mechanisms.

CONSENT

We declare that informed consent was obtained from all the participants in the study after detailed explanation of the study.

ETHICAL APPROVAL

We hereby declare that the study protocol was examined and approved by the University of Ibadan /University College Hospital, Ibadan ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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