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Evaluation of insulin resistance and metabolic syndrome components in undergraduates of a Nigerian Private University

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Abstract

Background*: The incidence of metabolic syndrome (MetS) and its components is increasing globally in all age groups. This study assessed insulin resistance and the components of metabolic syndrome among undergraduates of a Nigerian private University.*

Materials and Methods*: Eighty undergraduates comprising of 38 males and 42 females, aged between 17-23 years were recruited for this study. Employing the National-Cholesterol-Education-Program—Third-Adult-Treatment-Panel (NCEP-ATPIII) and International Diabetes Federation (IDF) cut-off points for waist circumference (WC), the subjects were stratified into obese and non-obese groups. Anthropometric characteristics, blood pressure (BP), fasting plasma glucose (FPG), serum triglyceride, high density lipoprotein-cholesterol and insulin were determined by standard methods. Insulin resistance was calculated using the Homeostasis Model Assessment.*

Results*: The most and least prevalent component of MetS observed were elevated blood pressure and elevated FPG respectively. By NCEP-ATPIII definition, 20% of obese subjects had 3 MetS components, however, by IDF definition, 22.4% of obese subjects had 4 MetS components. Among the non-obese subjects, 7.5% and 9.7% had 3 MetS components by NCEP-ATPIII and IDF definitions respectively. Insulin resistance had significant positive correlation with WC, body mass index, systolic BP and diastolic BP.*

Conclusion*: Screening for metabolic risk factors is crucial in both obese and non-obese young adults as early detection can reduce the risk of developing cardiovascular disease later in life.*

Keywords: Insulin Resistance, Metabolic syndrome, Components, Undergraduates, University

Introduction

Metabolic syndrome has become a great health concern globally because of its association with cardiovascular disease, type 2 diabetes mellitus and cancer. Metabolic syndrome is generally regarded as an array of metabolic abnormalities consisting of dysglycaemia, dyslipidaemia, obesity, insulin resistance, and hypertension. (Lebovitz *et al*., 2002; Pedrinelli *et al*., 2002). Furthermore, the definition of metabolic syndrome also includes procoagulant state, increased plasminogen activator inhibitor-1(PAI-1)), vascular abnormalities (increase in urinary albumin excretion and endothelial dysfunction), inflammatory markers and hyperuricemia. (Misra *et al*., 2008; Okafor, 2012).

The pathophysiological mechanisms of metabolic syndrome still remain unclear, however, the risk factors include; obesity (especially abdominal obesity), excessive intake of calorie-rich foods, physical inactivity, aging and genetic factors. Inflammation and oxidative stress have also been linked to the components of metabolic syndrome, hence their involvement in the pathogenesis of metabolic syndrome (Sindhu *et al*., 2009; Hutcheson *et al*., 2012; Avelar *et al*., 2015).

The prevalence of metabolic syndrome varies greatly among countries and ethnic groups and increases with age (Cameron *et al*., 2004).

In Africa, the prevalence of metabolic syndrome is increasing and it is not only limited to the adults, but also common among young adults. This is believed to be caused by the adoption of western life-styles. (Okafor, 2012).

Metabolic syndrome is diagnosed based upon the number of metabolic syndrome components present in an individual. In a cohort study carried out in Ibadan, south western part of Nigeria, it was reported that 60.1% of apparently healthy traders had three of the commonest components of metabolic syndrome (Charles-Davies *et al*., 2014). Furthermore, in Nigeria using the World Health Organization (WHO) criteria, 25.1% of type 2 diabetic subjects had all the components of metabolic syndrome (Okafor, 2012). Akintunde *et al*. (2011) determined the prevalence of metabolic syndrome among Nigerian hypertensive subjects using NCEP-ATP III, WHO and IDF criteria, and they reported that 34.3%, 35% and 42.9% respectively had all the components of metabolic syndrome.

The prevalence of metabolic syndrome and the attendant complications of metabolic syndrome particularly among apparently healthy young adults in Nigeria has not been sufficiently addressed. This study is therefore designed to determine insulin resistance, the presence of metabolic syndrome components and their prevalence among apparently healthy students of a Nigerian private university using National Cholesterol Education Program-Adult treatment Panel III (NCEP-ATPIII) and International Diabetes Federation (IDF) criteria.

Materials and methods

Subjects

This cross sectional study recruited 80 apparently healthy undergraduate students in Babcock University, Ilishan Remo, Ogun state, comprising of 38 male and 42 female subjects, aged between 17-23 years. By NCEP-ATP III definition, the study participants were stratified into 40 obese and 40 non-obese subjects however, by IDF definition, there were 49 obese and 31 non-obese subjects. A semi-structured questionnaire was used to obtain demographic data and information about medical conditions, current medications, alcohol use and smoking habits.

Ethical consideration

Informed written consent was obtained from each participant that enrolled for this study and ethical clearance was granted by Babcock University Health Research Ethics Committee (BUHREC 385/16).

Defining criteria for metabolic syndrome

Metabolic syndrome was diagnosed using National Cholesterol Education Program-Adult treatment Panel III (NCEP-ATPIII) criteria (NCEP, 2001). The defining criteria was the presence of any three or more of these features: waist circumference (male: ≥102 cm, female: ≥88cm), elevated blood pressure (≥130/≥85mmHg), elevated triglycerides: ≥150mg/dL, reduced HDL-C (males: <40mg/dL, females: <50mg/dL) and elevated fasting plasma glucose (≥100mg/dL).

Employing the International Diabetes Federation (IDF) definition (Alberti *et al*, 2005), metabolic syndrome was diagnosed as the presence of three

metabolic syndrome components which must include central obesity measured as waist circumference (male: ≥ 94cm, female: ≥80cm) and any two of elevated triglycerides: ≥150 mg/dL, elevated blood pressure (≥130/ ≥85 mmHg), reduced High density Lipoprotein cholesterol (HDL-C) (males: <40mg/dL, females: <50mg/dL) and elevated fasting plasma glucose (≥100 mg/dL) (IDF, 2005).

Exclusion criteria

Subjects who were on anti-hypertensive drugs, anti-diabetic drugs, lipid-lowering drugs, hormonal contraceptives or with any known medical conditions were excluded from this study. In addition, those who refused to give consent were excluded.

Blood pressure and anthropometric measurement

Body weight was measured using a standard weighing scale and height was taken using a stadiometer. Body mass index (BMI) was calculated as the ratio of body weight (kg) to the square of height (m^2). Waist circumference (WC) was measured midpoint between the inferior margin of the last rib and the crest of the ileum using a measuring tape. The blood pressure was measured with the subject in supine position after at least 10 minutes of rest, using automated digital sphygmomanometer.

Sample collection and assay methodology

About 7 ml of venous blood was obtained from the cubital vein of each study participant, using pyrogen-free disposable vacutainer tubes, after a 12-16 hour overnight fast. About 3 ml of venous blood was collected into fluoride oxalate bottle for the assay of fasting blood glucose (FBG) which was performed within 12 hours, while 4ml was collected into plain bottle and was centrifuged at 4000rpm for 3 minutes to obtain serum which was aliquoted into small vial and stored at -20^{O}C for the determination of HDL-C, triglycerides (TG) and insulin. Serum insulin was determined based on the principle of solid-phase enzyme-linked immunosorbent assay using the kits supplied by RayBiotech, Inc. (Georgia, USA). Fasting plasma glucose, serum HDL-C and TG were determined colorimetrically using kits supplied by Randox (RANDOX Laboratories Ltd, UK). Insulin resistance (IR) was calculated using the Homeostasis Model Assessment equation (HOMA = Fasting serum insulin (mIU/L) × Fasting plasma glucose (mg/dl)/405).

Results

The study participants were 80 apparently healthy undergraduate students comprising of 38 male and 42 female subjects between the ages of 17 to 23 years (20.88±1.67 years). Among these participants, 1% reported personal history of type 2 diabetes mellitus and 3% reported personal history of hypertension. While 27% reported a family history of type 2 diabetes mellitus, 13.8% reported a family history of hypertension.

Table 1 shows the number of metabolic syndrome components in the study participants. Among the participants, 12 (30%) and 14 (28.6%) obese subjects had 2 metabolic syndrome components by NCEP-ATP III and IDF definitions respectively, 8(20%) obese subjects by NCEP-ATP III definition and 11 (22.4%) obese subjects by IDF definition, had 3 and 4 metabolic syndrome components while 3 non-obese subjects (7.5% and 9.7% by NCEP-ATP III and IDF definitions respectively) had 3 metabolic syndrome components.

Based upon gender, male participants that had 3 and 4 metabolic syndrome components were 20.8% and 15.8% by NCEP-ATP III and IDF definitions respectively while female participants that had 3 and 4 metabolic syndrome components were 12.1% and 9.6% by NCEP-ATP III and IDF definitions respectively (Table 2).

The frequency of metabolic syndrome components among the study participants is depicted in Table 3. The prevalence of elevated blood pressure was 25% (20 participants), that of reduced HDL-C was 20% (16 participants), elevated TG was 17.6% (14 participants) and elevated FPG was 6.25% (5 participants).

The anthropometric, clinical and biochemical characteristics of the study participants are summarized in table 4.

Table 5 shows correlation between insulin resistance and selected clinical and biochemical parameters. Insulin resistance had significant positive correlation with waist circumference (WC), body mass index (BMI), systolic blood pressure (SBP), diastolic blood pressure (DBP).

Table 1: Frequency and number of Metabolic syndrome components in obese and non-obese subjects using NCEP-ATPIII & IDF criteria.

	NCEP-ATPIII CRITERIA			IDF CRITERIA		
Number of Component	**Total (n=80)**	**Male (n=38)**	**Female (n=42)**	**Total (n=80)**	**Male (n=38)**	**Female (n=42)**
0	25 (31.2%)	12 (31.6%)	13 (31.0%)	33 (41.2%)	19 (50.0%)	14 (33.3%)
1	28 (35.0%)	11 (28.9%)	17 (40.5%)	21 (26.2%)	6 (15.8%)	15 (35.7%)
2	14 (17.5%)	7 (18.4%)	7 (16.7%)	16 (20.8%)	7 (18.4%)	9 (21.4%)
3	11 (3.8%)	7 (18.4%)	4 (9.5%)	8 (10.8%)	5 (13.2%)	3 (7.1%)
4	2 (2.5%)	1 (2.4%)	1 (2.6%)	2 (2.5%)	1(2.6%)	1(2.5%)

Table 2: Frequency and number of Metabolic syndrome components in study participants (based on gender) using NCEP-ATPIII & IDF criteria.

	NCEP-ATPIII Criteria			IDF Criteria		
Number of Component	**Total (n=80)**	**Obese (n=40)**	**Non-obese (n=40)**	**Total (n=80)**	**Obese (n=49)**	**Non-obese (n=31)**
0	25 (31.2%)	0(0)	25(62.5%)	24 (30.0%)	5 (10.2%)	19 (61.3%)
1	28 (35.0%)	16 (40.0%)	12 (30.0%)	26 (32.5%)	17 (34.7%)	9(29.0%)
2	14 (17.5%)	12 (30.0%)	2 (5.0%)	14 (17.5%)	14 (28.6%)	0(0)
3	11 (13.8%)	8 (20.0%)	3 (7.5%)	14 (17.5%)	11 (22.4%)	3 (9.7%)
4	2 (2.5%)	2 (5.0%)	0(0)	2 (2.5%)	2 (4.1%)	0 (0)

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Table 3: Frequency of components of Metabolic syndrome in obese and non-obese subjects using NCEP-ATPIII definition.

Metabolic syndrome Components	Obese	Non-Obese	Total	χ^2	p-Value
HBP	14 (17.5%)	6 (7.5%)	20 (25%)	4.267	0.039*
Elevated FPG	4 (5%)	1 (1.25%)	5(6.25%)	1.920	0.166
Elevated TG	11(13.8%)	3(3.8%)	14(17.6%)	5.541	0.019*
Reduced HDL-C	10(12.5%)	6(7.5%)	16(20%)	1.250	0.264

***Significant at p<0.05. HBP=High blood pressure, FPG=Fasting plasma glucose, TG= Triglyceride, HDL-C= High density lipoprotein-cholesterol**

Table 4: Anthropometric, clinical and biochemical characteristics of the study participants

Parameters	**Obese (N=40)**	**Non-Obese (N=40)**	**p – Value**
Age (years)	20.9±1.7	20.23±1.8	0.095
Height (m)	1.7±0.08	1.7±0.08	0.101
Weight (kg)	88.8±19.1	62.5±11.5	0.000*
WC(cm)	103.5±10.9	79.2±7.7	0.000*
BMI (kg/m^2)	29.1±5.7	21.7±4.3	0.000*
SBP (mmHg)	118.6±15.4	114±9.7	0.173
DBP (mmHg)	76.4±12.5	73.6±8.7	0.237
FPG (mg/dl)	84.4±11.5	81.2±9.9	0.182
TG (mg/dl)	113.6±44.5	99.4±27.1	0.089
HDL-C (mg/dl)	54.5±14.9	56.5±12.3	0.514
Insulin (mIU/L)	4.1±4.8	3.8±4.1	0.759
Insulin Resistance Index	0.86±1.0	0.79±0.89	0.771

***Significant at p<0.05. BMI= Body mass index, SBP=Systolic blood pressure, DBP=Systolic blood pressure, FPG=Fasting plasma glucose, TG= Triglyceride, HDL-C= High density lipoprotein-cholesterol.**

Table 5: Correlation between insulin resistance and selected clinical and biochemical parameters

Insulin Resistance	R	P
Weight (kg)	0.74	0.015*
WC (cm)	0.214	0.040*
BMI (kg/m^2)	0.335	0.003*
SBP (mmHg)	0.357	0.001*
DBP (mmHg)	0.340	0.002*
FPG (mg/dl)	0.022	0.846
TG (mg/dl)	0.137	0.233
HDL-C (mg/dl)	-0.145	0.205

***Significant at p<0.05. BMI= Body mass index, SBP=Systolic blood pressure, DBP=Systolic blood pressure, FPG=Fasting plasma glucose, TG= Triglyceride, HDL-C= High density lipoprotein-cholesterol.**

Table 6: Correlation between insulin resistance, NCEP- ATPIII and IDF definition for Metabolic syndrome

PARAMETERS	R	p
NCEP MetS	0.175	0.125
IDF MetS	0.228	0.04*

***Significant at p<0.05**

Table 6 shows significant positive correlation between insulin and IDF definition for metabolic syndrome.

Discussion

Metabolic syndrome continues to be one of the major public health concerns, as it confers increased risk for cardiovascular disease, type 2 diabetes mellitus and cancer (Alberti *et al*., 2009; Gallagher *et al*., 2010). Globally, metabolic syndrome has often been reported to be common among older adults and this has been attributed to the fact that ageing is associated with insulin resistance and progressive redistribution of fat stores to the intraabdominal visceral region (Iloh *et al*., 2013). However, over the decade, metabolic syndrome is no longer exclusive to the older adults, it is now becoming prevalent among young adults. The emergence of metabolic syndrome among adolescents and young adults has been attributed to global epidemic of obesity. There has been alarming increase in the incidence of obesity among adolescents and young adults due to excessive consumption of calorie-rich diets, physical inactivity (Dhingra *et al*., 2003; Santoro *et al*., 2013). Visceral obesity is believed to be the driving force for metabolic syndrome (Song *et al*., 2006). In Nigeria, it has been reported by several studies that the prevalence of obesity among young and older adults is of epidemic proportions (Ejike *et al*., 2012; Ijezie *et al*., 2013; Akarolo-Anthony *et al*., 2014).

The present study, examined prevalence of metabolic syndrome components among undergraduate students of a Nigerian private university and the findings of the present study revealed that the overall prevalence of metabolic syndrome was 32.5% and 36.2% based on NCEP-ATP III and IDF definitions respectively. This disparity in the prevalence rate obtained from NCEP-ATP III and IDF definitions could be attributed to the differences in the reference range for waist circumference that was used to stratify the study participants into obese and non-obese groups. By IDF definition, we classified individuals with waist circumference greater than 94cm (male) and greater than 80cm (female) as obese and consequently the proportion of obese subjects increased. Therefore, IDF definition appears to be more sensitive than NCEP-ATP III with regards to identifying obese individuals especially among young adults and consequently the prevalence rate of metabolic syndrome among the study participants. A similar observation was reported by Awosan *et al*. (2013) that despite the close association which existed between IDF and NCEP-ATP III definitions when they were used to identify individuals with metabolic syndrome, IDF definition was adjudged more sensitive than NCEP-ATP III definition.

In this study also, metabolic syndrome was more prevalent in male participants than females by both NCEP-ATP III definition (male participants: 20.8%, female participants: 12.1%) and IDF definition (male participants: 15.8%, female participants: 9.6%). This observation supports the reports of Cameron *et al*. (2004) and Novac *et al*. (2011) on higher prevalence of metabolic syndrome in males than females. These authors noted that the high activity profile of females might be responsible for this observation. However, a study conducted by Charles-Davies *et al*. (2014) among apparently healthy adults in Sub-Saharan Africa reported a higher prevalence of metabolic syndrome among females.

The findings of this present study also revealed that among the study participants, the percentage of obese subjects with metabolic syndrome was 20% and 22.4% by NCEP-ATP III and IDF definitions respectively. This is in alliance with the studies of Weiss *et al*. (2004), Cornier *et al*. (2008) and Nasreddine *et al*. (2012) that reported high prevalence of metabolic syndrome among obese individuals. Furthermore, both NCEP-ATP III and IDF definitions identified 3 non-obese subjects (7.5% and 9.7% based on NCEP-ATP III and IDF definitions respectively) that had metabolic syndrome.

This is in agreement with the observation of Bednarek-Tupikowska *et al*. (2012) and Suliga *et al*. (2016) that reported prevalence of metabolic syndrome among non-obese individuals. This has been attributed to excess abdominal fat which is known to occur similarly in both obese and non-obese individuals (Ruderman *et al*., 1998). The excess abdominal fat is connected to decline in insulin sensitivity and dyslipidaemia. Therefore, non-obese individuals with increased abdominal fat can also exhibit features of

metabolic syndrome and therefore, are also at risk of cardiovascular disease (Katuski *et al*., 2003; Succuro *et al*., 2008 and Jennings *et al*., 2008).

The frequency of metabolic syndrome components observed, were higher among the study groups irrespective of the definition used. A high prevalence of elevated blood pressure was observed in one-quarter (25%) of the participants (obese: 17.5% and non-obese: 7.5%) by NCEP definition. A similar observation was reported by Adejumo *et al*. (2013) about the strong association between obesity (abdominal and generalized) and hypertension. In this present study reduced HDL- C was observed in one-fifth (20%) of the study population (obese: 12.5% and non-obese:7.5%) while elevated TG occurred in 17.6% (obese: 13.8% and non-obese:3.8%) of the participants. However, compared with the non –obese participants, reduced HDL-C and elevated TG were more prevalent among obese subjects in agreement with the studies of Adejumo *et al*. (2013) and Usha *et al*. (2014) that reported high percentage for hypertriglyceridaemia and low HDL-C among obese individuals. The dyslipidemia associated with obesity could be attributed to increased efflux of fatty acids from the adipocytes and consequent increase in the synthesis of triglycerides, low density lipoprotein-cholesterol and Apo B particles by the liver (Sniderman *et al*., 2007). The least observed metabolic syndrome component in the present study was elevated FPG (6.25%).

Furthermore, in this present study, insulin resistance had a positive correlation with body weight, waist circumference, BMI, SBP and DBP. The present study also observed that there was statistically significant relationship between insulin resistance and IDF definition for metabolic syndrome.

Insulin resistance is widely accepted as one of the plausible causes of metabolic syndrome. Juarez-Lopez *et al*. (2010) reported that insulin resistance is associated with components of metabolic syndrome. However, some studies have observed that a weak to moderate association exists between insulin resistance and metabolic syndrome (Mikhail, 2009).

Conclusion

The present study revealed the prevalence of metabolic syndrome and cardiovascular risk factors among young adults. In this study, elevated BP, reduced HDL-C and elevated TG are the most prevalent components of metabolic syndrome among obese young adults. This study highlights the need to screen both obese and non-obese young adults for metabolic risk factors. Furthermore, considering the large number of young adults who have at least one risk factor, the adoption of healthy life style at early stage of life should be emphasized.

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