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Original Research Article

Evaluation of Metabolic Syndrome Using Lipid Accumulation Products, Visceral Adiposity Index and Body Mass Index in Apparently Healthy Students of University of Maiduguri

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Abstract: ***Introduction*:** Metabolic Syndrome (MetS) is a group of conditions that together raise your risk of cardiovascular disease, diabetes mellitus, dyslipidemia and hypertension. The diagnosis of MetS was established according to the revised criteria of the NCEP/ATP III (MS-NCEP/ ATP III). Although BMI is the most common screening measures to identify people who are at relatively high risk of MetS, this tool is not particularly the most effective tool. Thus, we seek to find single parameter with the strongest diagnostic accuracy for MetS in a sample of healthy, unrelated adults. ***Materials & Methods*:** The study was conducted on 200 apparently healthy male and female students of university of Maiduguri. Random sampling techniques were used to recruit the subjects aged 18–41 years with mean age of 25.65±5.56 years for males and 24.11±4.60 years for females. Examination of subjects consisted of physical examination with measurement of anthropometric and clinical parameters, filling out a questionnaire, and evaluation of serum lipid levels. ***Result*:** The result shows the mean±SD for the components of MetS includes BP (SBP=105.67±9.82; DBP=70.43±6.16); TG=1.69±0.72; HDL=1.10±0.37; FBG=3.88±0.72; WC=87.76±8.41 for males and BP (SBP=104.69±9.93; DBP=69.93±6.44), TG=1.82±0.69; HDL=1.13±0.39; FBG=3.64±0.79; WC=86.93±9.89 for females. The result shows prevalence of MetS in males was 8.1% and 21.5% in females. The result also shows that LAP has the highest diagnostic accuracy among the study population (AUC=0.856) than VAI (AUC=0.820) and BMI (AUC=0.523). LAP was also found to have highest diagnostic accuracy in males (AUC=0.908) than VAI (AUC=0.850) and BMI (AUC=0.498) while in females VAI was found to have highest diagnostic accuracy with AUC (0.865) than LAP (AUC=0.721) and BMI (AUC=0.436). ***Conclusion*:** This study therefore shows LAP has the highest diagnostic accuracy and particularly the most effective tool in identifying males who are at the risk of MetS. While VAI has the highest diagnostic accuracy and particularly the most effective tool in identifying females who are at the risk of MetS.

Keywords: Metabolic syndrome, Lipid, Visceral, Healthy, Apparently.

1. INTRODUCTION

Metabolic Syndrome (MetS) is a group of conditions that together raise your risk of cardiovascular disease, diabetes mellitus, dyslipidemia and hypertension [1]. MetS has been one of the major public health as well as clinical challenges both in developed and developing countries, [2, 3]. The global prevalence of adults with MetS is estimated to be 20–25% and is rising [4, 5]. The etiology of MetS is not fully understood, but aging, inflammation, obesity, sedentary lifestyle, and genetics are implicated as predisposing factors [6]. MetS has been diagnosed or defined using the revised diagnostic criteria of National Cholesterol Education Program/Adult Treatment Panel III (NCEP/ATP III)[6].According to the program MetS is defined when at least three of the following five risk

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determinants are present: waist circumference ≥ 90 cm in men and ≥ 80 cm in women; blood pressure > 130/85 mmHg or patient is taking antihypertensive medications; high-density lipoprotein cholesterol (HDL-C) < 0.9 mmol/L in men and < 1.03 mmol/L in women; fasting plasma glucose ≥ 5.6 mmol/L or patient is undergoing regular treatment for diabetes mellitus; and triglyceride level ≥ 1.70 mmol/L. Nevertheless, it would be useful if a simpler index is available for easy diagnosis of individuals at risk of MetS in clinical settings [8].

Accumulation of body fat as visceral adipose tissue (VAT) rather than subcutaneous adipose tissue (SAT) was more closely correlated with CVD [9]. Thus, evaluation of obesity may play an important role in management of CVD. Computed tomography (CT) and magnetic resonance imaging (MRI) are the gold standard for measuring visceral fat, but they are inconvenient and expensive [9-11].

Hypertension is the most common cause of cardiovascular disease. The major causes of hypertension are Age (more common after 50 years of age), family history, genetic composition, Environment (unhealthy diets, stress), excessive salt intake, the consumption of tobacco and alcohol, physical inactivity and obesity [12]. Studies have indicated that hypertension is associated with metabolic disturbances and may be considered a metabolic disorder [10].

Anthropometric measures of central adiposity, such as BMI or abdominal circumference have been used routinely to evaluate MetS but neither could distinguish accumulation of VAT from SAT [9, 12]. Thus, both biochemical and anthropometric measurements have been used to calculate lipid accumulation product (LAP), a novel index of central lipid accumulation based on a combination of waist circumference (WC) and serum triglycerides (TG). Several studies have shown that LAP is a simple, accurate and inexpensive index and is thus widely used as a marker of metabolic disorders and a predictor of MetS [8, 13, 14].

Furthermore, in order to predict VAT-associated cardio metabolic risk, a mathematical model, Visceral Adiposity Index (VAI) was developed that uses both anthropometric measurements like Body Mass Index (BMI) expressed in kg/m2 and Waist Circumference (WC) expressed in cm and functional (triglycerides [TG] and high-density lipoprotein [HDL] cholesterol [17, 18]. The use of VAI as a routine indicator for the evaluation of visceral adipose function has been reported to be useful for cardiometabolic risk assessment because of its higher sensitivity and specificity than classical parameters (WC, BMI, and lipids) [17]. Body Mass Index (BMI) has been the most commonly used anthropometric index to define and classify adults into obese, overweight, or normal weight in clinical practices. It is the weight in kilograms divided by the square of height in meters. It is also used in interpreting the individual's fatness and risk factors for the development or the prevalence of many non-communicable diseases [18]. Thus, early and accurate identification of high-risk individuals for MetS could be important to predict and prevent CVD and type 2 diabetes. However, there are paucity of epidemiological data on the clinical significance of LAP and VAI in the evaluation of MetS among apparently healthy individuals <40 years in Maiduguri, Borno state, Nigeria.

2. MATERIALS AND METHODS

The study was conducted on 200 apparently healthy male and female students of university of Maiduguri. Random sampling techniques were used to recruit the subjects aged 18–41 years. Examination of subjects consisted of physical examination with measurement of anthropometric and clinical parameters, filling out a questionnaire, and evaluation of serum lipid levels. Individuals presenting the following conditions were excluded from the study: severe obesity (BMI>40 kg/m2), previous liver failure diagnosis, chronic kidney disease requiring renal replacement therapy, corticosteroid and immunosuppressant use, hypertension and cognitive impairments.

2.1 Measurements

Anthropometric measurements were made by well-trained examiners using standardized instruments. Body weight was measured on a digital scale with participants wearing light clothing and no shoes. Height was determined without shoes using a standard stadiometer. Body mass index was calculated as weight (kg) divided by height squared (m2). WC (cm) was measured using non-elastic tape at the midway point between the last rib and the iliac crest after normal expiration. Blood pressure was measured on the right arm using an automated device (DINAMAP-R (Criticon, Tampa, Florida)) after the participant rested for 10 min in a seated position. Blood pressure was measured 3 times with a 3-min interval between each measurement, and the average of the three measurements was recorded for Systolic (SBP) and diastolic blood pressures (DBP).

2.2 Biochemical Analyses

Blood samples were collected from venous vessels after 12-h fasting. Plasma glucose was determined in duplicate by a glucose oxidase method, TG and high-density lipoprotein cholesterol (HDL-C) levels were measured by an enzymatic method using Hitachi chemistry autoanalyzer Cobas C311.

2.3 Assessment of Visceral Adiposity Index

VAI score was calculated using the following sex-specific equations, when Triglycerides (TG) levels expressed in mmol/l and HDL is HDL-Cholesterol levels expressed in mmol/l:

- **Males:** VAI = (WC /39.68 + (1.88 × BMI)) × (TG /1.03) × (1.31 /HDL),
- **Females:** VAI = (WC/36.58 + (1.89 × BMI)) × (TG/ 0.81) × (1.52 /HDL) [16].

The diagnosis of MetS was established according to the revised criteria of the NCEP/ATP III (MS-NCEP/ ATP III): any three or more of the following criteria:

i. WC>102 cm (men) or >88 cm (women),
ii. Fasting TG≥150 mg/dl,
iii. SBP≥130 and/or DBP≥85 mmHg,
iv. Fasting HDL-C<40 mg/dl (men) or <50 mg/dl (women), and
v. Fasting plasma glucose (FPG)>5.6 mmol/L [7, 19]. WC was measured at the midpoint between the lower rib and the iliac crest.

2.4 Assessment of Lipid Accumulation Product

The total-body lipid accumulation is described as:

- LAP for men=(waist circumference [cm] - 65)x (triglyceride concentration [mmol/l]);
- LAP for women=(waist circumference [cm] - 58)x(triglyceride concentration [mmol/l]) [13, 15, 19].

3. STATISTICAL ANALYSIS

Data were analyzed using spss vs 20.0 and the results were presented as mean ± S.D. Prevalence rates were expressed as percentages. The areas under the curves (AUCs) for ROC curves were determined for each continuous variable to identify the predictors of MSNCEP/ATP III and MS-IDF. AUCs are provided with S.E.M. and 95% confidence intervals (95% CI). ROC curves, a plot of the sensitivity (SEN) (true positive) versus 1-specificity (SP) (false positive) for each potential predictor tested, determine the ability of a screening measure for correctly identifying individuals based on their classification by a reference test.

4. RESULTS

In the present study, 200 participants of both sexes who fulfilled the inclusion criteria were enrolled into the study. There were 135 males and 65 female participants with mean age of 25.65±5.56 years for males and 24.11±4.60 years for females. The anthropometric and clinical characteristics of the participants are shown in table 1. The values for the components of MetS includes BP (SBP=105.67±9.82; DBP=70.43±6.16); TG=1.69±0.72; HDL=1.10±0.37; FBG=3.88±0.72; WC=87.76±8.41 for males and BP (SBP=104.69±9.93; DBP=69.93±6.44), TG=1.82±0.69; HDL=1.13±0.39; FBG=3.64±0.79; WC=86.93±9.89 for females (table1). Prevalence of MetS according to the IDF definition was 8.1% in males and 21.5% in females as shown in table2. Performance of the three markers for identifying persons with MetS according to the IDF criteria was assessed as shown in table3. In males, the performance of LAP to detect MetS-IDF was better in comparison with VAI and BMI. The LAP cut-off value in male was 50.00 with sensitivity (0.909), specificity (0.200) and AUC (0.908) exhibiting high performance as compared with VAI (sensitivity (0.906), specificity (0.240) and AUC (0.850)) and BMI (sensitivity (0.545), specificity (0.444) and AUC (0.498)) as shown in table3 and figure 1. In females, the performance of LAP to detect MetS-IDF was better compared with VAI and BMI. LAP cut-off value was 41.50 with sensitivity (0.929), specificity (0.400) and AUC (0.721) as compared with VAI (sensitivity (0.786), specificity (0.373) and AUC (0.865)) and BMI (sensitivity (0.429), specificity (0.490) and AUC (0.436)) as shown in table3 and figure 2. Figure 3 shows the performance of LAP, VAI and BMI of the study subjects.

Table 1: Clinical characteristics of the study population

Variables	Whole subjects Mean ± SD	Males Mean ± SD	Females Mean ± SD
Age	25.15±5.31	25.65±5.56	24.11±4.60
SBP	105.4±9.84	105.67±9.82	104.69±9.93
DBP	70.17±6.25	70.43±6.16	69.93±6.44
WC	87.49±8.90	87.76±8.41	86.93±9.89
BMI	22.52±3.36	22.59±2.86	22.36±4.23
VAI	2.29±1.11	2.21±1.11	2.49±1.12
LAP	43.68±25.63	39.06±23.69	53.26±26.99
TC	3.62±0.74	3.60±0.71	3.66±0.79
TG	1.73±0.71	1.69±0.72	1.82±0.69
HDL	1.11±0.37	1.10±0.37	1.13±0.39
LDL	1.78±0.44	1.80±0.42	1.76±0.46
FBG	3.80±0.75	3.88±0.72	3.64±0.79

Table 2: Prevalence of Metabolic syndrome among the study subjects (n=200)

Metabolic Syndrome			
Sex	**Yes (%)**	**No (%)**	**Total**
Male	11(8.1)	124(91.9%)	135
Female	14(21.5%)	51(78.5%)	65
Total	**25(12.5%)**	**175(87.5%)**	**200**

Table 3: Performance of Markers for identifying persons with Metabolic Syndrome according to sex

Makers	Population	Cut-off	Sensitivity	Specificity	AUC(95%CI)	p-values
LAP	Male	50.00	0.909	0.200	0.908(0.857-0.960)	0.000
	Female	41.50	0.929	0.100	0.721(0.600-0.842)	0.012
VAI	Male	2.54	0.906	0.240	0.850(0.724-0.976)	0.000
	Female	2.52	0.786	0.373	0.865(0.765-0.842)	0.000
BMI	Male	22.75	0.545	0.444	0.498(0.307-0.689)	0.981
	Female	21.60	0.429	0.490	0.436(0.276-0.605)	0.468

Table 4: Performance of Markers for identifying persons with Metabolic Syndrome among the study subjects

Markers	AUC	P-Values
LAP	0.856	0.000
VAI	0.820	0.000
BMI	0.523	0.795

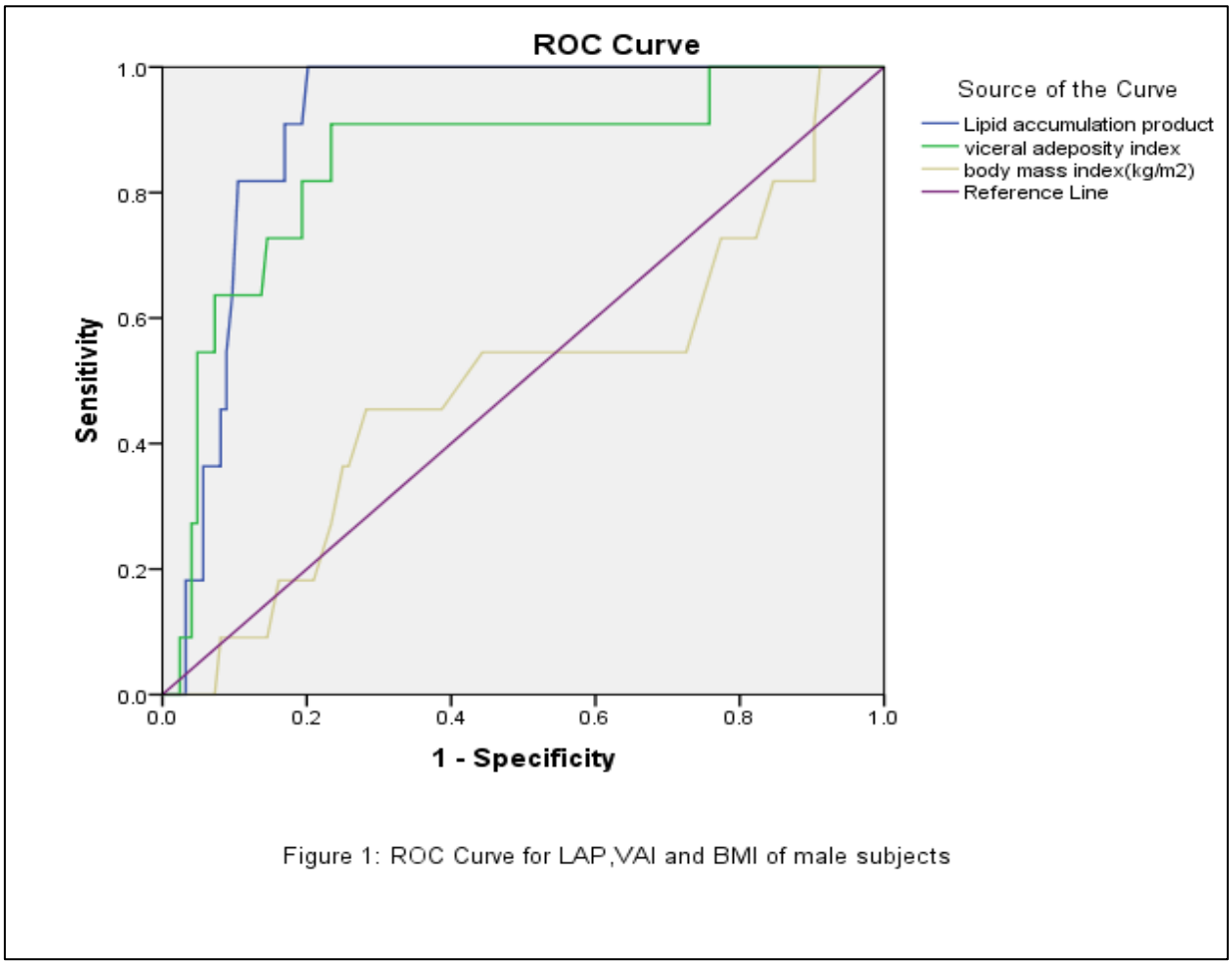

Figure 1: ROC Curve for LAP,VAI and BMI of male subjects

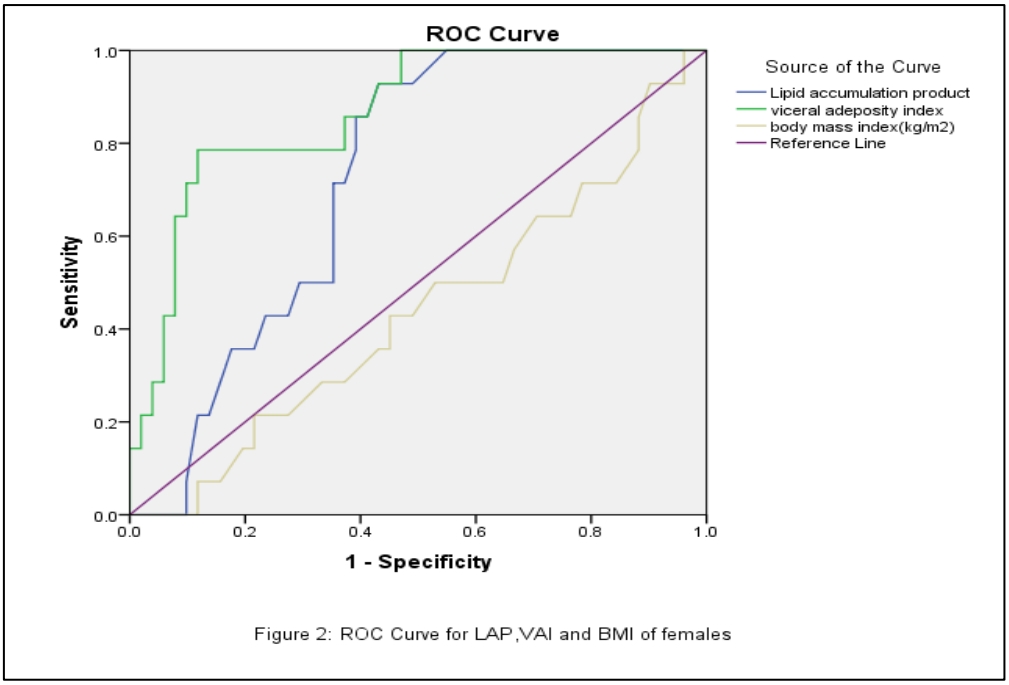

Figure 2: ROC Curve for LAP,VAI and BMI of females

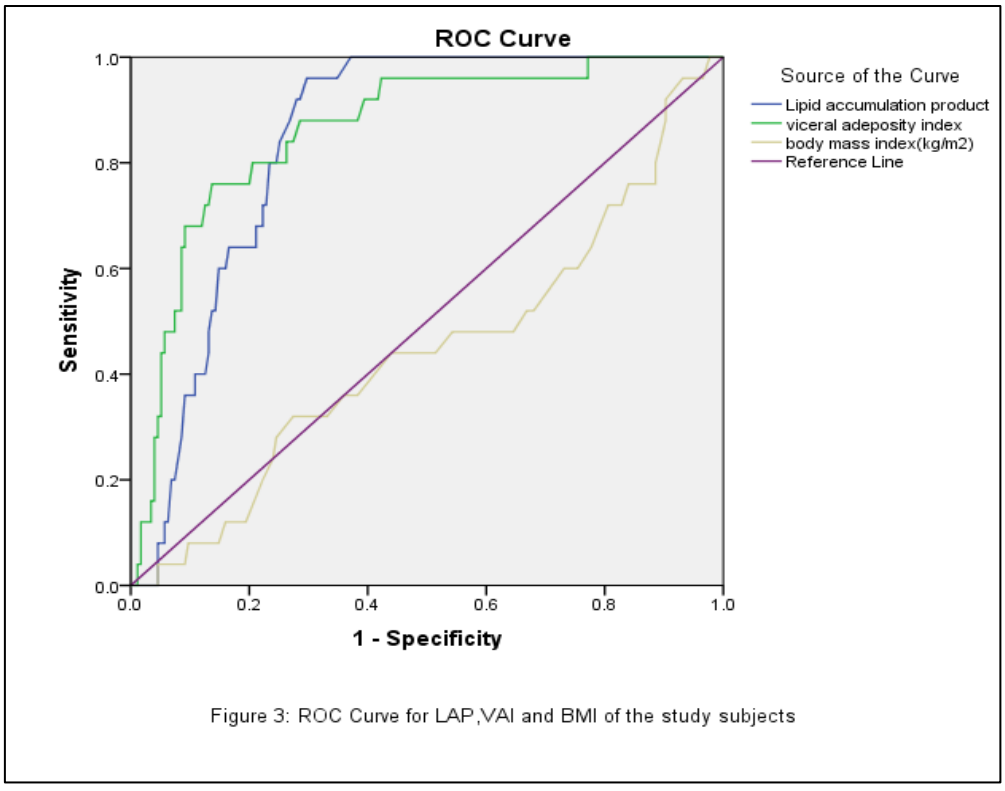

Figure 3: ROC Curve for LAP,VAI and BMI of the study subjects

5. DISCUSSION

This study is the first to identify the most efficient MetS risk assessment systems LAP, VAI or BMI, in healthy individuals in Maiduguri. Although BMI is the most common screening measures used to identify people who are at relatively high risk of MetS, it is not particularly the most effective tool [20] as it does not give a clear idea about central obesity [18] and it is also not gender-specific entity. Consequent to this limitation, we conducted a cross-sectional population-based survey on metabolic syndrome in Maiduguri, Borno state on healthy individuals in order to identify single parameter/ index as surrogates with high efficiency in predicting metabolic syndrome. Obesity, notably abdominal obesity (Visceral adiposity), is the most important cardiovascular and MetS risks factor. Visceral adipose tissues have been found to be correlated with plasma triglyceride (TG). TG is also a reliable predictor for these cardiometabolic syndromes [21]. WC has also been reported as a robust predictor

for cardiometabolic risk and a simple measure of truncal fat. It reflects both abdominal subcutaneous adipose tissue and visceral adipose tissue, and therefore represents the main component of MetS [22]. However, waist circumference is unable to distinguish between visceral adipose tissue and subcutaneous adipose tissue. Therefore, it is important to identify a routinely applicable indicator for evaluation of visceral adiposity. Furthermore, the use of triglyceride levels in combination with waist circumference, termed hypertriglyceridemic waist, has been shown to be able to identify individuals with the greatest amount of visceral fat and is found to be associated with increased risk of MetS [8]. The prevalence of MetS within our study subjects was found to be 12.5% and gender wise it is 21.5% in females and 8.1% in males. This prevalence is low compared to the one reported in Turkey where the prevalence was reported to be 33.9% within the adult population and gender wise was 54.5% in women and 45.1% in men [2, 28]. This difference may be due to inclusion of overweight and obese subjects among the previous study. This difference may also be due to influence of ethnic food and cultural ties which are associated with feeding lifestyle of the people. Our finding was also not in agreement with report of Roomi where overall prevalence was 21.7%, male 21.9% and females 14.1% [29]. Similarly Aisha reported higher prevalence of MetS it overall prevalence of 25.78%, 22.41% in males and 32.26% in females in northwestern Nigeria [30]. The differences observed compared to our population of study could also be due to individual lifestyle such as smoking and alcohol use which are potential risk factors of obesity and MetS.

Receiver operating characteristic (ROC) curves were plotted to assess the performance of MetS predictors by gender and among study subjects. The power of MetS prediction was quantified by the area under the curve (AUC) with 95% confidence intervals, i.e. a larger AUC reflecting better predictive accuracy.

In this study, we found that LAP has the strongest diagnostic accuracy (AUC = 0.856) for MetS among the healthy, unrelated adults than VAI (AUC=0.820) and BMI (AUC=0.523). This report is similar to findings of [8] and also to reports of [23]. Our finding is also in agreement with report of [24]. Our AUC results for the MetS predictors also shows that LAP has the highest diagnostic accuracy for MetS (AUC=908) than VAI and BMI in males than females. Our results were similar to those previously reported by [23] in cross-sectional study of healthy Argentinian men and report of [25] who found that LAP had the highest diagnostic accuracy for metabolic syndrome, with an AUC of 0.91 and 0.90 in males and females. Our result was also similar to those reported by [26] and [27].

6. CONCLUSIONS

This study therefore shows LAP has the highest diagnostic accuracy and particularly the most effective tool in identifying males who are at the risk of MetS. While VAI has the highest diagnostic accuracy and particularly the most effective tool in identifying females who are at the risk of MetS. These simple clinical tools may help, in a primary care setting, to identify subjects at risk of metabolic syndrome and who require further biochemical evaluation.

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