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Research Article

Variability in the Prevalence of Metabolic Syndrome among People of African Ancestry; using Different Diagnostic Criteria

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Abstract

Introduction: Over the years, metabolic syndrome was thought to be rare in Africa, but current trends are showing increase prevalence in both developed and developing countries. The prevalence of metabolic syndrome is believed to be on the increase in African populations due to westernization which results in the increase in the prevalence of obesity. Obesity plays major role in the pathogenesis of metabolic syndrome; it has interwoven mechanism with other components of metabolic syndrome. Based on the variation in the assessment of obesity combined with other relative factors, there may be discrepancy in assessment of metabolic syndrome in Africans. Hence, the aim of this study was to assess the prevalence of metabolic syndrome and to evaluate its determinants using different diagnostic criteria.

Methods: One thousand, five hundred and sixteen (1518) participants were recruited, the cross-sectional study was conducted in 678 participants from African ancestry, with a minimum age of 18 years and no upper age limit. Obesity was assessed using body mass index (BMI), waist circumference (WC) and waist hip ratio (WHR), while conventional blood pressure was assessed using electronic blood pressure monitoring device (Omron, Kyoto, Japan), blood sample was taken for laboratory parameters such as lipid profile [Triglyceride (TG), High lipid lipoprotein (HDL)], fasting blood sugar. Seven diagnostic groups (Modified NCEP-ATPIII, NCEP-ATPIII, IDF, WHO, EGIR, AHA/NHLBI and AACE diagnostic criteria) were used for assessment of prevalence and determinants of metabolic syndrome among the study group. Descriptive and inferential statistics were conducted using SPSS version 22.0.

Results: Prevalence of metabolic syndrome in Modified NCEP-ATPIII, AACE, IDF, WHO, AHA/NHLBI, NCEP-ATPIII and EGIR diagnostic criteria were 24.2%, 22.4%, 21.4%, 20.4%, 18.7%, 16.6% and 14% respectively. Among the 668 selected participants, 36.8% were obese while 23.4% were overweight. All the indices for crude assessment of obesity increased prevalence of metabolic syndrome. Participants with increased waist circumference (WC) were 39.7%, those with BMI greater or equal to 30 kg/m2 were 36.8%, while those with abnormal WHR were 36.2%. In this study, 24.7% had blood pressure of 130/85 mmHg while 15.2% had blood pressure greater than 140/90 mmHg. Prevalence of MS was higher in females compared to males in all the diagnostic groups except EGIR. The prevalence increases with age among all the groups.

Conclusion: Prevalence of metabolic syndrome varies and depends on the criteria used in different diagnostic categories. WC (is an appropriate measure for crude assessment of central obesity among African with high prevalence of obesity. Hypertension and other relative factors also affected the prevalence of MS. This study concluded that modified NCEP III criterion is more suitable to determine the proportion of metabolic syndrome in Africans. This study also suggested that age and sex should be considered as criteria for diagnosing metabolic syndrome.

Keywords: Metabolic Syndrome; African Ancestry; Diagnostic Criteria

Introduction

Metabolic syndrome (MS) is the accumulation of several disorders, which together raise the risk of an individual developing atherosclerotic cardiovascular disease, insulin resistance, and diabetes mellitus and neurological complications [1,2]. Irrespective of the discrepancies in various definitions, there is shocking figure of a vast proportion of the population being at high risk of development of cardiovascular complications of metabolic syndrome [3]. The prevalence of metabolic syndrome is believed to be on the increase in African populations due to westernization and genetic factor [4,5].

Globally, obesity is a major health problem in urban areas in diverse regions [6]. Overweight/obesity levels are rising in more developed and developing parts of Africa. Several studies have suggested that central obesity has a key role in the elevated cardiovascular risk associated with MS, however, the BMI is not a robust marker of central obesity [7,8]. Hypertension and diabetes have been attributed to increased body [6,8]. Risk of comorbidities tends to rise with body mass index (BMI). Adiposity contributes significantly to cardiovascular disease (CVD) in both Africans and non-Africans. Obese people, especially African women have two to four times greater risk of CVD morbidity and mortality than non-African women. Clear evidences show that specific ethnic groups are particularly vulnerable to obesity [9,10]. However, considerable variation exists across ethnic groups in the proportion of fat and lean tissue at equivalent BMIs and other environmental-genetic interactions, there is still unexplained variation in the association between comorbidities and higher BMIs differs among various ethnic groups.

However, a number of expert groups developed clinical criteria for the metabolic syndrome. The groups include, National Cholesterol Education Program Adult Treatment Panel III (NCEPATPIII), American Association of Clinical Endocrinology (AACE), International Diabetes.

Federation (IDF), American Heart Association/National Heart, Lung, and Blood Institute (AHA/NHLBI) and European Group for the study of Insulin Resistance (EGIR). Three or more of the five components to constitute MS [9,10]. All the groups agreed on the major components of the metabolic syndrome these are, obesity, insulin resistance, dyslipidaemia and hypertension. Yet, there is still no universally accepted definition or criteria. The prevalence of MS may be inappropriately assessed due to multiple definitions for the metabolic syndrome. The existing guidelines were either difficult to use or gave conflicting results when attempting to assess individuals from different ethnicity. Therefore, it is difficult to compare data from different studies where different definitions and/or population have been used to define or categorize metabolic syndrome.

In the past, most widely accepted definition were produced by World Health Organization (WHO), the European Group for the Study of Insulin Resistance (EGIR), and the National Cholesterol Education Program-Third Adult Treatment Panel (NCEP ATP III). Meanwhile, IDF group suggested that there must a universally acceptable diagnostic tool that should be accessible clinically. Therefore, the International Diabetes Federation (IDF) released different guidelines and criteria based on gender, race and ethnicity [10-12]. However, till date, European cut off points are still recommended in most African populations where specific data on diagnostic criteria are not yet available.

Recently among some Africans, metabolic syndrome is being diagnosed according to the Modified National Cholesterol Education Program Adult Treatment Panel III (ATP III) criteria, i.e. at least three of the following had to be present: blood pressure ≥ 130/85 mmHg; waist circumference ≥ 102 cm (men) or ≥ 88 cm (women); triglycerides ≥ 1.69 mmol/l or on drug treatment for elevated triglycerides; HDL cholesterol < 1.03 mmol/l (men) or < 1.29 mmol/l (women) or on drug treatment for reduced HDL cholesterol; fasting glucose ≥ 5.55 mmol/l or on drug treatment for elevated glucose. In other diagnostic groups, history or treatment of hypertension were not counted as criteria for metabolic syndrome as they applied to all other study populations [1,2,10,13,14]. Central or abdominal obesity is first major criterion attributed to metabolic syndrome [14]. Crude assessment of anthropometric measures of central/abdominal obesity such as BMI, waist circumference (WC), and waist-hip ratio (WHR) are strong and consistent predictors for obesity related diseases such as type 2 diabetes mellitus, hypertension, metabolic syndrome, stroke e. t. c. [14]. Body mass index (BMI) is the most commonly used parameter to determine central obesity, this is assessed as weight in kilogram divided by square of height in meters, body mass index (BMI) greater than 30 kg/m^2 is classified as obesity. However, World Health Organization (WHO) guidelines state that alternative measures that reflect abdominal obesity such as WC, WHR and waist-to-height ratio (WHtR) have been found to be superior to BMI. For WHR, optimal cut off values of 0.89 for men and 0.82 for men and women respectively was initially suggested as better anthropometric measure for estimating the risk of type 2 diabetes mellitus [16]. For instance, a study among Chinese population revealed that BMI and WC were found to be the important indices of obesity. Among Asians and Indians, the prevalence of abdominal obesity when WC was considered was found to be 46% and 68% respectively, while the prevalence recorded when WHR was considered were 12% and 64% respectively [17]. However, majority believed WC is the best measurement of obesity, whereas some agreed that WHR could also be used as an alternative indicator for obesity [18].

Study has revealed that hypertensive patients had a significantly higher WHR (>0.9) as well as a significantly higher BMI (>25 kg/m^2) when compared to the apparently normal individuals. Hypertension is also a core component of metabolic syndrome associated with obesity, sex and age. Coincidentally, prevalence of MS is increasing across the globe, and it tends to increase with age and varies with sex and race [14,17,19,20].

Generally, it has been observed that the predictive values of MS are particularly relevant when using traditional metabolic risk factors rather than non-traditional biomarkers [21]. Therefore, this study evaluated the prevalence and determinants of metabolic syndrome among the population with high prevalence of obesity using established diagnostic criteria.

Methods

Study design and population

This cross- sectional study was conducted among 753 male and 763 female participants (Total population was 1516) with a minimum age of 18 years and no upper age limit. The population size for the study is less than 10,000; therefore, the sample size was calculated using Leslie - Fischer's formula

$$N = (Z_{1-\alpha})^{2*}(P(1-P)/D^2$$

Where Z is the confidence level, P is the expected proportion of individuals with cardio-metabolic risk factors, and D is the margin of error. P was set at 0.40 and D at 0.05. The calculation was performed at the 95% confidence level. The required sample size for the study was calculated to be 450 participants. However, a total of 1516 participants were recruited in this study. Using matching random technique, one thousand, two hundred and sixteen (1216) apparently healthy participants were from Soweto, South Africa, and three hundred from the ongoing study at Human Nutrition Research Laboratory (HNRL), Johannesburg, South Africa.

Ethical clearance/approval

Ethical approval was obtained from the University of Witwatersrand, Human Research Ethics Committee [Medical (Reference number: M190472)]. Participants were provided with information sheets detailing the purpose and process of the study. Each participant gave written, informed consent for his/her voluntary participation in the study.

Clinical and demographic data

Six hundred and seventy-eight (678) participants with a minimum age of 18 years and no upper age limit were selected in the study. Acutely ill, psychotic, debilitated, pregnant or individuals with physical disability were excluded from the study. All participants were given informed consent form and comprehensive questionnaire. Detailed information about each participant's demographic data, family history, smoking habits, alcohol consumption, use of medication and other relevant history was obtained.

Measurements and analysis

Anthropometric measurement

Anthropometric measurement was used to assess the size, shape and body composition of adipose tissue. They were measured according to the international standards for anthropometric assessments [22]. Weight measurements were recorded using an electronic scale (Healthometer Professional) to the nearest 0.1 kg. During all the measurements, the participants were asked to take their shoes off, and minimal clothing was worn which allowed access to areas of measurements. Participants were asked to step on the scale and stand still without supporting themselves on any object and weight was recorded when the scale had stopped fluctuating. Height was measured using a stadiometer (Seca portable stadiometer) to the nearest 0.1 cm. When the measurement was taken the head of the participant was placed in the Frankfort plane with the body standing upright and a sliding headboard was lowered to the vertex of the head. Body mass index was calculated as weight in kilograms divided by the square of height in meters (kg/m^2). Participants were considered to be underweight if BMI is <18.5 kg/m^2, normal if BMI is between 18.5 and 24.9 kg/m^2, overweight if their BMI is greater than or equal to 25kg/m^2 and obese if their BMI is greater than or equal to 30kg/m^2. Waist circumferences was determined using a tape measure with participants wearing minimal clothing on the abdominal region. Waist circumference was determined at the narrowest width midway between the iliac crest and the lowest rib to the nearest 0.1 cm at the end of a gentle expiration. Normal waist circumference was taken as ≤ 102 cm in men and ≤ 88 cm in women. Hip circumference was measured at the level of the greatest posterior protuberance, perpendicular to the long axis of the trunk [22]. Normal waist- hip ratio was taken as >0.9 in men and > 0.85 in women.

Conventional (clinic) blood pressure assessment

Conventional blood pressure was measured using automated sphygmomanometer (Omron, Kyoto, Japan) after 10 min of rest in the seated position. Regular adult cuff of 9.5-12.5 inches (12 cm wide and 23cm long) was used for arm circumference less than 33 cm while large adult cuff of 13.516.5 inches was used for arm circumference that is greater than 33 cm, brachial blood pressure was recorded to the nearest 2 mmHg. Korotkov phases I and V were identified as systolic blood pressure (SBP) and diastolic blood pressure (DBP) respectively. Five consecutive BP readings were obtained. The average of the five readings were taken as the BP. Participants were classified as hypertensive if they were on antihy-

Diagnostic criteria	Modified NCEP-ATP III	NCEP-ATP III	IDF	AHA	WHO	EGIR	AACE
WC (cm)	M≥102 F ≥88	M≥102 F ≥88	M≥102 F ≥88	M≥102 F ≥88	-	M≥102 F ≥88	-
BMI (kg/m^2)	-	-	-	-	>30	-	≥25
WHR	-	-	-	-	M >0.9 F>0.85	-	-
BP (mmHg)]	≥130/85	≥130/85	≥130/85	≥130/85	≥140/90	≥140/90	≥130/85
TG (mmol/L)	> 1.7	> 1.7	> 1.7	> 1.7	>1.7	> 1.7	> 1.7
HDL (mmol/L)	M<1.03 F<1.3	M<1.03 F<1.3	M<1.03 F<1.3	M<1.03 F<1.3	M<0.9 F<1.0	M<1.03 F<1.3	M< 1 F<1
Fasting Glucose, DM, IGT, or IFG (mmol/L))	≥ 5.6	> 6.l ± DM	≥ 5.6 +DM	≥ 5.6	DM	≥ 5.6 or IGT/IFG	IGT/IFG
Anti-hypertensive	Yes	No	No	No	No	No	No
Microalbuminuria	-	-	-	-	Yes	-	-

Table 1: Assessment of metabolic syndrome using different diagnostic indices.

NCEP-ATPIII: National Cholesterol Education Program Adult Treatment Panel III; WHO: World Health Organization; IDF: International Diabetes Federation; AHA/NHLBI: American Heart Association/National Heart Lung and Blood Institute: EGIR: European Group for the study of Insulin Resistance: AACE:American Association of Clinical Endocrinology, BMI: Body Mass Index; TG: Triglyceride; HDL: High Density Lipid Lipoprotein, IGT- Insulin Glucose Tolerance; IFG- DM- Diabetes Mellitus

pertensive therapy and/or if the mean value of blood pressure was higher than 130/85 mmHg or 140/90 mmHg, depending on the diagnostic group in Table 2.

Biochemical analysis

After an overnight fasting, 5ml of venous blood sample was collected from the cubital fossa using aseptic procedure, and the following parameters: lipid profile [Triglyceride (TG), high lipid lipoprotein (HDL)], fasting blood glucose were analysed at the Contact Laboratory Services (CLS).

Diagnosis of metabolic syndrome

Metabolic syndrome was defined according to seven different diagnostic groups: modified NCEPATPIII, AACE, IDF, WHO, AHA/NHLBI and EGIR diagnostic criteria (Table 2).

Statistical analysis

Statistical analyses were performed with IBM Corp. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp, (2013). Metabolic syndrome was determined as defined by different diagnostic groups using any three or more major criteria stated in Table 2. Frequencies were calculated for categorical variables and ranges were calculated for continuous variables. Chisquare tests were performed to compare categorical variables.

	Obese	Underweight	Normal BMI	Overweight
Number	63	517	341	543
Age (years)	25.7 ± 11.0	30.4 ± 15.8	41.4 ± 18.8	48.7 ± 15.4
Female (%)	42.9	47.2	53.7	76.2
Alcohol intake (%)	35.5	30.8	24.9	17.8
Smokers (%)	27	23.2	20.7	9.5
Hypertensive (%)	4.8	16.4	33.7	39.8
Diabetic (%)	0	3	6.6	11

Table 2: General characteristics of the study population according to BMI status.

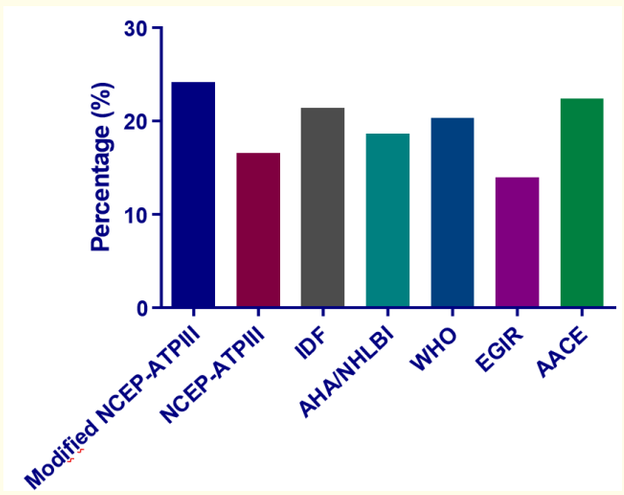
BMI, body mass index; Normal BMI ≥ 18.5 and < 25 kg/m^2; overweight BMI ≥25 and < 30 kg/m^2; Obese BMI ≥30 kg/m^2; values expressed as a percentage or mean ±standard deviation; P value < 0.05 considered.

Results

Figure 1 shows prevalence of metabolic syndrome (MS) in the study population using different diagnostic criteria. Variation in measure of criteria result to discrepancies in the prevalence of metabolic syndrome among same population (study population). In this study the prevalence of MS using modified NCEP-ATP III

was the highest (24.2%). Prevalence when NCEP-ATPIII, IDF, AHA/NHLBI, WHO, EGIR and AACE were considered revealed 16.6%, 21.4%, 18.7%, 20.4%, 14% and 22.4% respectively.

When waist circumference (WC) was considered using modified NCEP-ATPIII, NCEP-ATPIII, IDF, WHO, AHA and EGIR, prevalence of metabolic syndrome in the study population were 24.2%, 16.6%, 21.4%, 18.7%, 18.7% and 14% respectively (Table 2 and figure 2). When BMI was considered in WHO and AACE prevalence of MS was 20.4% and 22.4% respectively, while prevalence of MS when WHR was considered was 20.4% (Table 2 and figure 2). WHO considered both BMI and WHR, but highest prevalence was recorded when modified NCEP-ATPIII was considered in people from African ancestry. However, EGIR recorded 14% prevalence despite consideration of WC while WHO recorded 20.4%. Notably, modified NCEP-ATPIII with highest prevalence considered those on anti-hypertensive therapy and fasting glucose of 5.6mmol (instead of fasting blood sugar of >6.1 mmol) which was considered in NCEP-ATPIII. This study revealed that the prevalence of MS using modified NCEP-ATP III was higher (24.2%) than NCEP-ATPIII (16.6%). Moreover, the study further revealed lowest MS prevalence in EGIR criteria (14%), despite considering WC and blood pressure of 140/90 mmHg compared to AHA (18.7%) criteria where the only adjustment was reduction of 10 mmHg in systolic pressure and 5mmHg in diastolic pressure.



(Metabolic syndrome diagnostic groups)

Figure 1: Prevalence of metabolic syndrome in the study population using different diagnostic criteria.

NCEP-ATPIII- National Cholesterol Education Program Adult Treatment Panel III, WHO- World Health Organization, IDF- International Diabetes Federation, AHA/NHLBI- American Heart Association/National Heart, Lung, and Blood Institute, EGIR - European Group for the study of Insulin Resistance, AACE- American Association of Clinical Endocrinology.

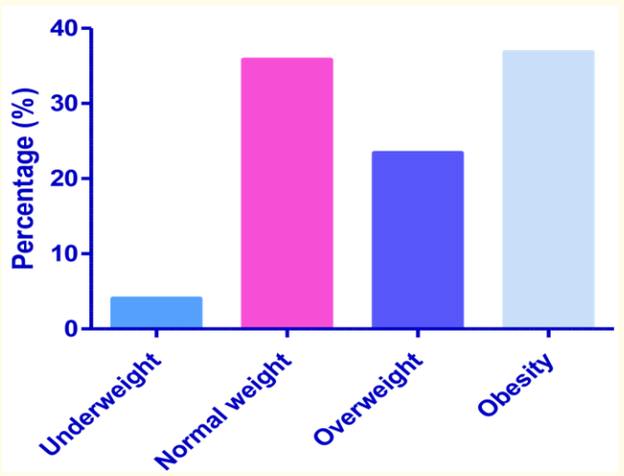


Figure 2: Percentage of underweight, normal weight, overweight and obese individuals in the study population.

In figure 2, less than 5% were underweight, 35.8% had normal weight, and 23.4% and 36.8% were overweight and obese respectively.

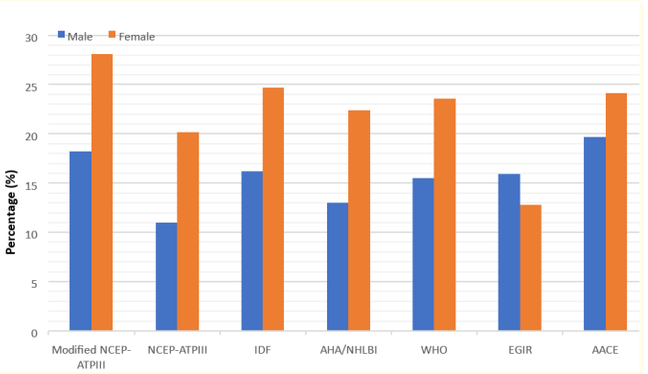


Figure 3: Gender variation in different diagnostic categories.

The prevalence of metabolic syndrome is higher in females than males in all the diagnostic groups except EGIR group where males had higher prevalence than male. NCEP-ATPIII- National Cholesterol Education Program Adult Treatment Panel III, WHO- World Health Organization, IDF- International Diabetes Federation, AHA/NHLBI- American Heart Association/National Heart, Lung, and Blood Institute, EGIR - European Group for the study of Insulin Resistance, AACE- American Association of Clinical Endocrinology

Among the study population, 34.5% had HDL while 11.4 while 13.2% and 20.9% had fasting blood glucose >6.1mmol and >5.6mmol respectively. Notably, less than 10% of the study population had diabetes mellitus (MS). However, 33.4% and 20.6% had SBP >130 mmHg and >140 mmHg respectively while 24.7% and 34% had DBP of > 90 and >85 mmHg respectively.

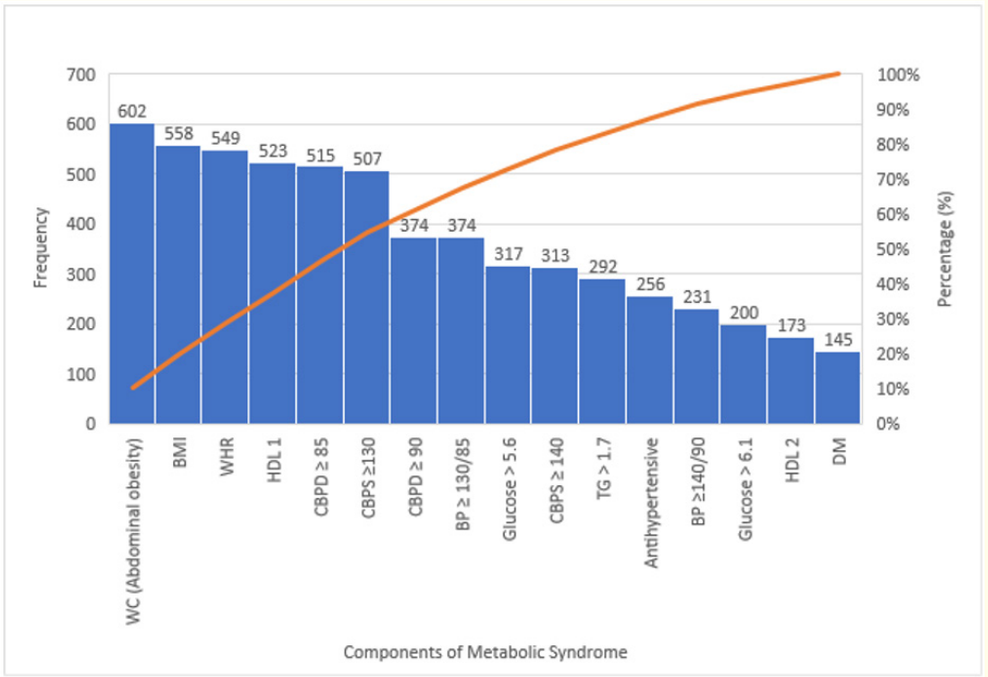


Figure 4: Frequency and percentage of components of metabolic syndrome among the study population.

While 15.2% had BP >140/90 mmHg, 24.7% of the population had BP > 130/85 mmHg while 16.9% were on antihypertensive therapy [Figure 4]. WC- waist circumference, WHR- waist Hip Ratio, HDL1- High Lipid Lipoprotein <1.03 mmol/l in male and female < 1.3 mmol/l, TG- Triglyceride, BP- blood pressure, CBPS- Conventional Blood pressure (Systolic), CBPD- Conventional Blood pressure (diastolic), HDL2- WHO High Lipid Lipoprotein value, < 0.9 mol/l in male, <1.0 mmol/l in female, DM- Type 2 diabetes mellitus.

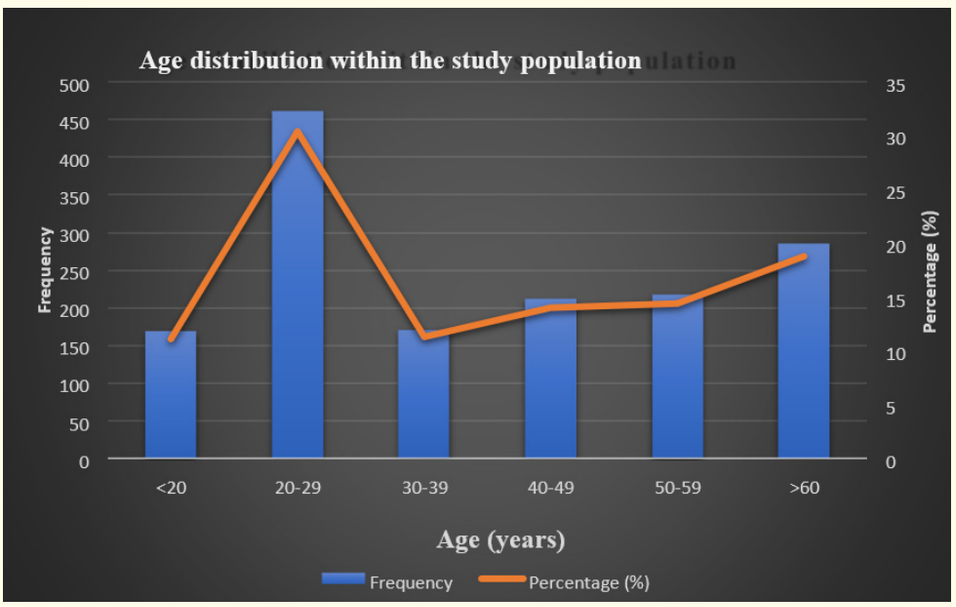


Figure 5: Age distribution within the study population.

Figure 5 shows age distribution of study participants and revealed that those between 20 and 29 years had highest percentage (30.4%) while age group below 20 years had lowest percentage (11.1%). However, age group of 40 years and above constituted about 50% of the study population, that is, 40-49, 50-59 and 60 and above respectively.

Age group	Modified NCEP- IDF	AHA/NHLBI WHO	EGIR	AACE	NCEP-	ATPIII	ATPIII
< 20 years	3%	1.2%	1.8%	1.8%	0.6%	1.2%	4.1%
20 - 29 years	4.6%	2.4%	4.8%	3.9%	3.3%	2.6%	6.1%
30 - 39 years	13.5%	9.4%	12.3%	11.7%	14%	5.8%	15.2%
40 - 49 years	25.9%	21.7%	24.5%	23.6%	24.5%	16%	25.9%
50 - 59 years'	50.5%	35.3%	44%	37.6%	43.1%	31.7%	43.6%
60 years and above	53.7%	34.7%	45.6%	38.9%	43.5%	29.8%	44.9%

Table 3: Percentage of Age Distribution among Different Diagnostic Criteria of Metabolic Syndrome.

Table 3 shows variation between the age distributions among those with metabolic syndrome following different diagnostic criteria. Among all the groups there is increase in prevalence of metabolic syndrome with age. There is highest prevalence of 25.9%, 50.5% and 53.7% among individuals between age 40 - 49 years, 50-59 years, 60 years and above respectively in modified NCEP-ATP III. However, there was lowest prevalence (0.6%) among those less than 20 years when WHO diagnostic criteria were considered. NCEP-ATPIII- National Cholesterol Education Program Adult Treatment Panel III, WHO- World Health Organization, IDF- International Diabetes Federation, AHA/NHLBI- American Heart Association/ National Heart, Lung, and Blood Institute, EGIR - European Group for the study of Insulin Resistance, AACE- American Association of Clinical Endocrinology.

Influence of Smoking and Alcohol on Prevalence of Metabolic Syndrome.

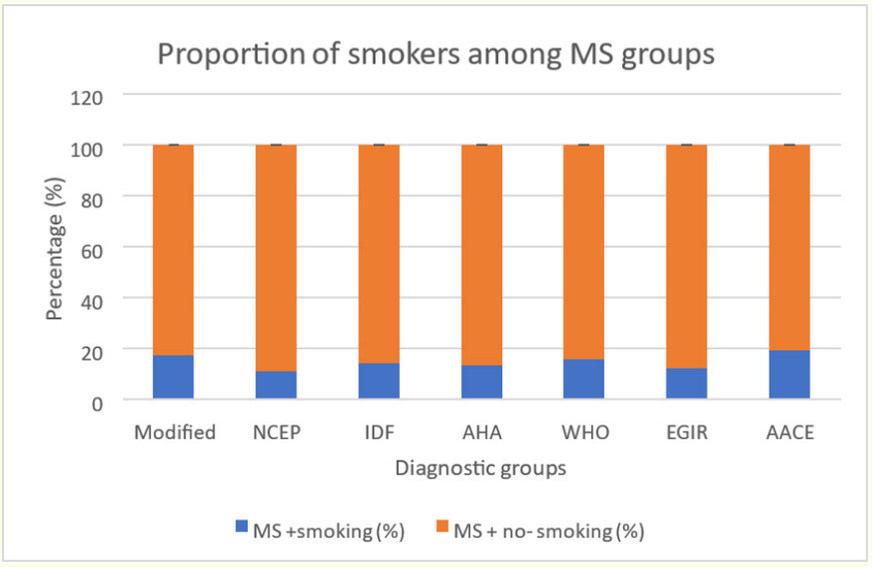


Figure 6: Percentage of smokers among each diagnostic group.

Figure 6 sbows increase in the rate of smoking and alcohol intake among those with metabolic syndrome. This study revealed that rate of smoking was high in AACE (19%) and modified NCEPATP III (17.2%) while lowest rate was recorded in EGIR (12.2%) and NCEP-ATPIII (11.1%).

Figure 7 shows that the rate of alcohol intake was high in AACE (21.6%), modified NCEP-ATP III (20.5%) while lower rate was recorded in EGIR (14.1%) and NCEP-ATPIII (13.9%). NCEP-ATPIII- National Cholesterol Education Program Adult Treatment Panel III, WHO- World Health Organization, IDF- International Diabetes Federation, AHA/NHLBI- American Heart Association/National

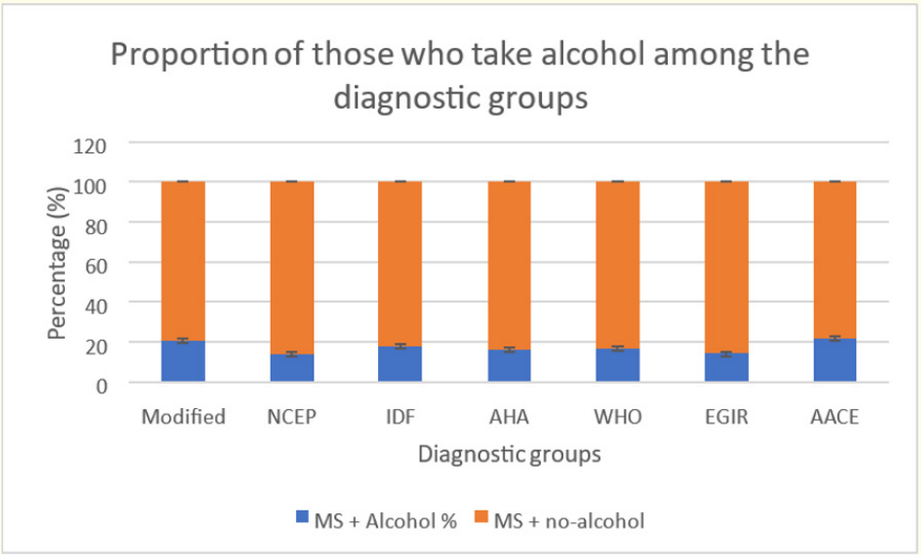


Figure 7: Percentage of those who take alcohol among the diagnostic groups.

Heart, Lung, and Blood Institute, EGIR - European Group for the study of Insulin Resistance, AACE- American Association of Clinical Endocrinology.

Discussion

This study is the first documentation where seven (7) diagnostic criteria were used to assess prevalence of metabolic syndrome in a community sample of African ancestry. In this population, there was high prevalence of obesity and overweight individuals (Table 2 and figure 2). Our study is in support of Maseko., *et al*. (2018) which reported that 71% of Africans in South Africa were either overweight or obese, with women having a higher prevalence of obesity (75%) compared to men (47%) [22]. Similarly, this study also revealed (Table 2) higher percentage of obesity among female (76.2%). Our findings (Table 1) also showed significant increase in number of hypertensive and diabetic individuals among those who are overweight and obese. Meanwhile, there was significant increase in alcohol intake and smoking among underweight individuals; which may be due to the effect of alcohol and smoking on nutritional status. Another explanation for this trend could that overweight/obese individuals have reduced their smoking and alcohol intake because they are aware of their poor health status. Some studies have reported controversial assessment of obesity in the diagnosis of metabolic syndrome, this study revealed that all the measures of obesity influenced the prevalence of the syndrome, this implies that obesity is important in the development of metabolic syndrome. However, irrespective of various criteria there was high prevalence of MS in the study group. Highest prevalence of MS (24.2%) was recorded when modified NCEP-ATP III diagnostic criteria was considered, in this group, antihypertensive therapy was recognized as major criteria (Figure 1). This indicates that hypertension is another important determinant of metabolic syndrome in this population. Additionally, our results show that there was higher prevalence when blood pressure of 130/85 mmHg (e. g AACE, IDF) was considered than groups where 140/90 mmHg was considered (e. g WHO, EGIR). The significant difference in prevalence is likely due to the change in systolic and diastolic blood pressure of 10 mmHg and 5 mmHg respectively. Studies among Korean, Chinese and Malaysians showed that most frequently observed component of MS was hypertension [3,20,21]. Therefore, to achieve early diagnosis and management of cardiovascular diseases, this study is in agreement with recent annual screening (USPSTF) recommendation; defining hypertension as blood pressure equal or higher than 130/80 mmHg in people with African ancestry [23]. However, pathological role of insulin resistance in the diagnosis of metabolic syndrome among Africans cannot be underestimated.

Gender is an important factor in metabolic syndrome [24]. Currently, there is no specific gender prevalence in all documented data, but most studies reported a higher prevalence of the metabolic syndrome in women compared with men [25]. In this study population, metabolic syndrome is common in women compared to men except in EGIR group (Figure 3). The higher prevalence of MS in women may be due to the higher indices of obesity in women in this population. This is confirmed by the findings of this study which show that there is a higher percentage of overweight and obese women in women compared to men (Table 1). Furthermore, in this population, indices of obesity play a major role in the in the pathogenesis of MS, followed by hypertension. This indicates that the indices of obesity and BP should be used as classical determinants MS in this population. Hence, diagnostic criteria (Figure 4) that focused on indices of obesity and blood pressure are more relevant for diagnosis of metabolic

syndrome in people of African ancestry. However, studies by both Lee., *et al*. (2016) and Yang., *et al*. (2018) indicate that lipid changes contribute to increase in prevalence of metabolic syndrome in women [17,21]. Interestingly, majority of the participants in our study had increased waist circumference followed by indices of blood pressure assessment (Figure 4); This implies that abdominal obesity and body mass index are important contributors to metabolic syndrome; they are likely responsible for cardiovascular disease among Africans.

Apart from the indices of obesity and hypertension, age contributes significantly to MS. After the age of 60 years, the prevalence of MS increases slightly or it decreases (Table 3). This trend has also been shown with BMI. A number of studies have shown that BMI increases with increasing age until the age of 60 years [24,25]. After the age of 60 years, BMI either decreases or remains constant. Our results also show that the prevalence of MS increases with increasing age until the age of 60 years. Interestingly, participants from age 18 to 39 years had the lowest prevalence of MS according to the WHO criterion.

Smoking and alcohol intake are modifiable risk factors associated with cardiovascular problem such as atherosclerosis, heart failure, myocardium infarction etc. [27]. The development of MS is influenced by smoking and alcohol consumption [28]. Highest proportion of smokers and those who take alcohol was recorded in AACE group with MS prevalence of while lowest proportion of those who take alcohol and those who smoke was recorded in EGIR group and NCEP-ATPIII group respectively (Figure 6 and Figure 7); this implies that, smoking and alcohol categorically influenced the prevalence of metabolic syndrome (Figure 1). Our study corroborated the study by Slagter and colleagues, their study emphasized reduction of alcohol intake and cessation of smoking to reduce the prevalence of MS.

Conclusion

Our results indicate that obesity is the main determinant of MS, better assessed by waist circumference. Although, WHO is the only criterion that incorporates two indices of obesity (BMI and WHR) and the stringent threshold of BP ≥ 130/85 mmHg has not been adopted in South Africa, our findings revealed that modified NCEP-ATPIII criterion is the more suitable for diagnosis of MS in people with African ancestry than the other six criteria because of the high prevalence of obesity and hypertension in this population. In addition, age, sex and influence of smoking and alcohol should be considered in the assessment of MS in Africans.

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Conflict of Interest

No conflict of interest.

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