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Original Research Article

Obesity, Metabolic Abnormalities, Metabolic Syndrome and BMI-Metabolic-Risk Sub-Phenotypes among Young Adult Nigerians

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Abstract

Metabolic syndrome (MetS) is increasing globally. However, there is paucity of information on its association with obesity amongst young adults in Nigeria. This study was designed to investigate the prevalence of obesity, metabolic syndrome and the different BMI-metabolic risk sub-phenotypes in a young adult Nigerian population. A total of 200 young adult Nigerians (92 males; 108 females) took part in the study. Blood pressure and anthropometric readings were taken following standard protocols and body mass index was determined. Fasting blood sample was collected and biochemical assays were done using standard protocols. Obesity and metabolic syndrome were defined by the World Health Organization and modified National Cholesterol Education Program Adult Treatment Panel III criteria, respectively. BMI-metabolic-risk sub-phenotypes were defined by the presence or absence of the metabolic syndrome within the 3 BMI groups. Obesity was found in 10.88% (5.40% males; 15.80% females) of the study population. Metabolic syndrome was found in 23.80% (27.58% males; 20.58% females) of the population while hyperglycemia (41.26%) and hypertension (36.50%) were the most common metabolic abnormalities. Amongst the overweight and obese population, 80.00% and 60.00% respectively had healthy metabolic profiles while 23.68% of the normal weight participants were metabolically unhealthy. The different BMI-metabolic-risk sub-phenotypes occurred at rates of 20.00%–80.00% within the BMI groups. The prevalence of metabolic syndrome and BMI-metabolic-risk sub-phenotypes in this young adult Nigerian population is high. These findings underscore the need for an urgent public health action in order to forestall the possibility of a looming public health crisis.

Keywords: obesity, metabolic syndrome, BMI-metabolic-risk, sub-phenotypes, young adults.

INTRODUCTION

Metabolic syndrome (insulin resistance syndrome, syndrome X) has been described as a constellation of several interrelated metabolic risk factors that could lead to the development of atherosclerotic cardiovascular disease in overweight and obese individuals as well as type 2 diabetes mellitus patients [1-4]. The pathogenesis of metabolic syndrome is yet to be clearly defined. Nonetheless, it is characterized by several key components including insulin resistance or hyperinsulinemia, central obesity, hypertension, dyslipidemia (increase in plasma triglycerides (TG)), decrease in high density lipoprotein cholesterol (HDL-C), an LDL particle pattern shifted to small dense particles (type B pattern)), procoagulant state (increased plasma fibrinogen, increased plasminogen activator inhibitor-1 (PAI-1)), vascular abnormalities (increase in urinary albumin excretion, endothelial dysfunction), inflammatory markers and hyperuricemia [5-7, 3]. With obesity and dyslipidemia being its most prominent component, metabolic syndrome is becoming increasingly popular amongst young people in Africa as they are greatly affected by unhealthy weight gain [3].

The most commonly used definitions of metabolic syndrome are those by the World Health Organization (WHO), National Cholesterol Education Programme (NCEP) Adult Treatment Panel 3 (ATP III) and International Diabetes Federation (IDF). The definitions of NCEP ATP III and IDF are similar except for a slight variation in the waist parameter [8, 9]. The emphasis on waist circumference as the key component of IDF definition distinguishes it from the modified ATP III definition [10]. The NCEP ATP III definition offers the relative advantage of ease of utilization in

determining metabolic syndrome in the clinical setting coupled with the avoidance of emphasis on a single factor [11, 12]. The original NCEP ATP III criteria of a fasting glucose cut-off level of ≥110 mg/dL have been modified [13]. According to the modified NCEP ATP III criteria, metabolic syndrome is defined by the presence of any three or more of the following: abdominal obesity (waist circumference ≥ 102 cm in men and ≥ 88 cm in women); hypertriglyceridemia (triglyceride ≥ 150 mg/dL); low high-density lipoprotein-cholesterol (HDL-c) (HDL-c < 40 mg/dL in men and < 50 mg/dL in women); elevated blood pressure (systolic blood pressure ≥ 130 mmHg and/or ≥ 85 mmHg diastolic blood pressure) and elevated fasting glucose (fasting glucose ≥ 100 mg/dL) [11].

There is increasing worldwide prevalence of metabolic syndrome (Moreira *et al.*, 2014) and it is estimated that one quarter of the world population is affected by the metabolic syndrome [9]. Although metabolic syndrome began in the developed world, it has transformed into a global burden owing to increasing urbanization across the globe. Also, increasing prevalence of metabolic syndrome has been associated with increasing age [14, 2, 3]. This observation may be due to common biochemical changes associated with the aging process and metabolic syndrome [15, 9]. The urban centers of some developing nations also have a high prevalence possibly due to consumption of high-calorie-low-fiber fast food and low levels of physical activity [9]. This lifestyle pattern could also be responsible for the increasing prevalence of central and general obesity.

Obesity is a major global health concern which increases the risk of conditions such as type 2 diabetes mellitus, hypertension, cancer and cardiovascular diseases [16, 17]. There is a particular emphasis on central adiposity in the definition of metabolic syndrome [7]. Generally, obesity is a significant risk factor for metabolic syndrome [18]. However, obesity is not always occurring together with metabolic syndrome because normal-weight individuals could have cardiometabolic abnormalities while overweight and obese individuals could be metabolically healthy [19, 9]. This leads to the concept of metabolic-risk sub-phenotypes. These metabolic-risk sub-phenotypes have been investigated in Nigerian populations by previous authors [20, 21].

There is paucity of information on the prevalence of metabolic syndrome and its association with obesity amongst young adults in Nigeria. This study was therefore designed to investigate the prevalence of obesity, metabolic syndrome and the different BMI-metabolic risk sub-phenotypes in a young adult Nigerian population.

MATERIALS AND METHODS

Participants

This study was carried out amongst young adults (aged 15-35 years) residing in Asaba. A total of 200 participants (92 males; 108 females) selected by convenience sampling, took part in the study. After the research protocol had been thoroughly explained to the intending participants who were apparently healthy, they were made to sign the informed consent form prior to participation. The participants were grouped into four age groups; 15-20 years, 21-25 years, 26-30 years and 31-35 years.

Ethical Approval

Ethical approval for this study was obtained from the Ministry of Health Research Ethics Committee (MOHREC) of Delta State, Nigeria (HM/596/T/55).

Measurements

Participants' weight was measured using a standard weighing scale (Hana model, China), with participant dressed in light clothing. Participants' height was measured using a stadiometer. Body mass index (BMI) was calculated by dividing the participants' weight (in Kilograms) by the square of the participants' height (in metres). Measurement of participants' waist circumference and hip circumference (in centimetres) was carried out with the participant in an erect posture. Blood pressure measurement was done by trained personnel, with participants remaining in a sitting position, having rested for about ten minutes. The systolic blood pressure (SBP) and diastolic blood pressure (DBP) were taken at the 1st and 5th Korotkoff sounds, respectively. Two separate readings were taken per participant after an interval of two minutes and the average reading was eventually recorded.

Biochemical Analysis

Blood sample collection was preceded by an overnight fast of 10-12 hours. The concentration of fasting blood glucose was determined by the glucose oxidase method [22]. Whole blood (5 mL) was collected in EDTA (ethylenediamine tetraacetic acid) containing bottle and the plasma was separated by centrifugation. The concentration of total cholesterol, HDL-cholesterol and triglycerides were determined by enzymatic colorimetric methods [23, 24, 25] while LDL-cholesterol was determined by the Friedewald equation [26].

Definition of Metabolic Syndrome

BMI was defined according to the WHO classification: normal weight (BMI value > 18.5 but < 25), overweight (BMI value of 25-29.9) and obese (BMI value ≥ 30) [27]. Metabolic syndrome was defined according to the modified NCEP ATP III criteria [11]. Participants having the metabolic syndrome were classified as metabolically obese if they have the metabolic syndrome while participants were classified as metabolically healthy if they were without

the metabolic syndrome. Using the three (3) BMI groups, six BMI-metabolic risk phenotypes were defined as: Metabolically Healthy Normal Weight (MHNW), Metabolically Healthy Overweight (MHOW), Metabolically Healthy Obese (MHO), Metabolically Obese Normal Weight (MONW), Metabolically Obese Overweight (MOOW) and Metabolically Obese Obese (MOO).

STATISTICAL ANALYSES

Data was analyzed on the basis of age group, sex, BMI, metabolic risk and where appropriate, data was reported as mean ± standard deviations. The prevalence of metabolic disorders was determined as a ratio of the number of participants presenting with the disorder and the total number of participants in the category multiplied by 100. Descriptive data analysis was done using *Statistical Package for the Social Sciences* (SPSS) version 23.0 (SPSS Inc Chicago IL) while charts were generated with Microsoft Excel 2003 (Microsoft Corporation US).

RESULTS

The clinical and anthropometric parameters of the participants are presented in table 1. The females in the study population had higher fasting blood glucose relative to males across all age groups while males had a higher systolic blood pressure and diastolic blood pressure when compared with the females across all age groups.

A total of 59.06% of the participants (65.20% males, 54.50% females) had normal weight, 29.53% of the participants (29.40% males, 29.70% females) were overweight while 10.88% of the participants (5.40% males, 15.80% females) were obese (Figure 1).

Hyperglycemia and hypertension were the most common metabolic abnormalities among the participants, occurring in 41.26% and 36.50% respectively in the study population. Whereas the prevalence of hypertension was higher in males (58.62%) relative to females (17.64%), the prevalence of hyperglycemia was higher in females (52.90%) relative to males (27.60%) (Figure 2).

The prevalence of metabolic syndrome in the study population was 23.80%. More males (27.58%) had metabolic syndrome relative to females (20.58%) in the study population (Figure 3).

Amongst the participants who had a normal weight, 23.68% (23.52% males and 23.80 females) were metabolically unhealthy and thus considered as metabolically obese. On the other hand, 60.00% of the participants (66.66% males and 50.00% females) who were actually obese based on their BMI figures had a healthy metabolic profile. Both sexes had mixed metabolic profiles in the study population (Figure 4).

Table-1: Clinical and anthropometric characteristics of participants in the study population

Participants	FBG	BMI	CHOL	TRIG	HDL-C	LDL-C	SBP	DBP	WC
15-20									
Male	93.00 ± 0.00	22.32 ± 0.47	268.39 ± 0.00	69.96 ± 0.00	40.93 ± 0.00	213.46 ± 0.00	140.00 ± 0.00	100.00 ± 0.00	81.83 ± 3.16
Female	101.12 ± 2.18	21.92 ± 0.64	285.09 ± 20.53	107.47 ± 10.66	93.87 ± 6.82	169.72 ± 24.71	119.00 ± 4.20	75.25 ± 3.13	77.52 ± 3.07
Total	100.22 ± 2.12	22.08 ± 0.42	283.24 ± 18.20	103.30 ± 10.28	87.99 ± 8.41	174.58 ± 22.33	121.33 ± 4.38	78.00 ± 3.89	79.19 ± 2.24
21-25									
Male	101.00 ± 2.08	24.11 ± 0.68	268.39 ± 26.12	120.59 ± 15.30	103.96 ± 10.91	140.31 ± 29.30	130.83 ± 2.99	78.16 ± 4.07	82.45 ± 1.18
Female	103.53 ± 2.23	24.85 ± 0.73	247.05 ± 8.35	116.12 ± 12.01	85.28 ± 4.82	138.54 ± 8.27	117.00 ± 3.87	74.76 ± 2.47	83.19 ± 1.57
Total	102.73 ± 1.78	24.59 ± 0.53	253.79 ± 9.85	117.53 ± 9.31	91.18 ± 5.02	139.10 ± 10.32	121.36 ± 3.15	75.84 ± 2.09	82.93 ± 1.09
26-30									
Male	95.71 ± 3.19	24.83 ± 0.59	219.62 ± 6.92	99.02 ± 7.68	98.95 ± 11.88	100.85 ± 9.11	130.71 ± 3.25	79.50 ± 2.88	85.37 ± 1.73
Female	104.00 ± 4.24	25.38 ± 1.00	251.67 ± 19.42	115.98 ± 12.02	112.01 ± 6.57	116.45 ± 22.38	116.66 ± 3.94	75.33 ± 1.93	82.53 ± 2.97
Total	98.95 ± 2.63	25.08 ± 0.55	232.16 ± 9.05	105.66 ± 6.70	104.06 ± 7.66	106.96 ± 10.19	125.21 ± 2.85	77.86 ± 1.92	84.10 ± 1.63
31-35									
Male	97.75 ± 2.65	24.72 ± 0.68	254.21 ± 16.29	145.67 ± 22.68	89.53 ± 9.01	135.54 ± 21.60	142.00 ± 8.02	83.00 ±3.69	86.80 ± 1.86
Female	102.00 ± 7.67	29.66 ± 1.51	264.74 ± 27.73	85.60 ± 9.03	91.20 ± 6.76	156.41 ± 22.81	110.75 ± 6.57	72.75 ± 5.85	94.73 ± 3.19
Total	99.16 ± 2.94	26.53 ± 0.78	257.72 ± 13.59	125.65 ± 17.27	90.09 ± 6.22	142.49 ± 15.94	131.58 ± 7.14	79.58 ± 3.32	89.70 ± 1.74

FBG – Fasting Blood Glucose; BMI – Body Mass Index; CHOL – Cholesterol; TRIG – Triglycerides; HDL-C – High Density Lipoprotein-Cholesterol; LDL-C – Low Density Lipoprotein-Cholesterol; SBP – Systolic Blood Pressure; DBP – Diastolic Blood Pressure; WC – Waist Circumference.

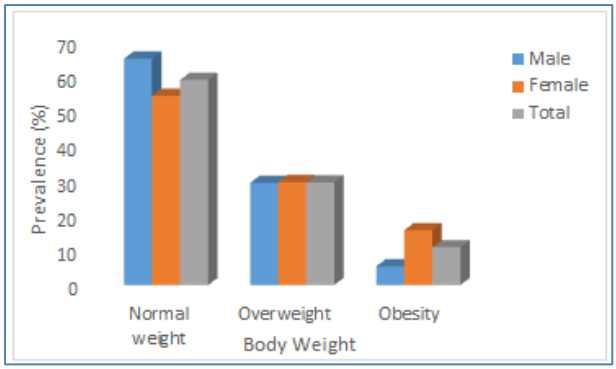

Fig-1: BMI distribution in the population

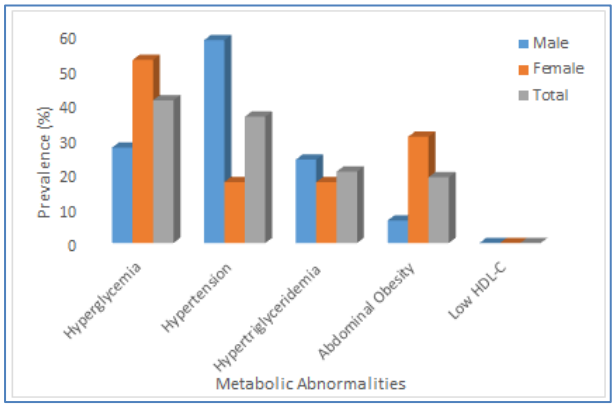

Fig-2: Prevalence of metabolic abnormalities in the population

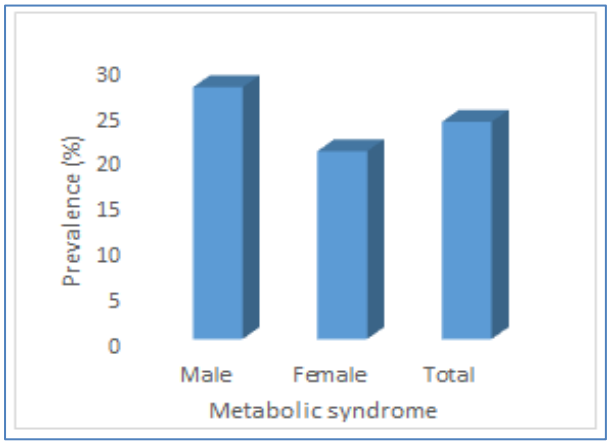

Fig-3: Prevalence of metabolic syndrome in the population

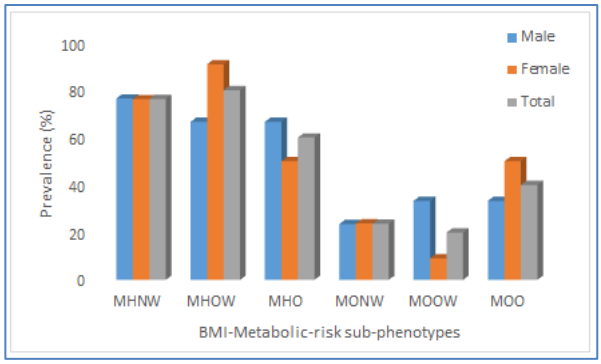

Fig-4: Prevalence of BMI-metabolic-risk sub-phenotypes in the population

DISCUSSION

Metabolic syndrome is characterized by a cluster of metabolic risk factors that are linked to an increased risk for atherosclerotic cardiovascular disease and type 2 diabetes mellitus [7, 28]. The World Health Organization (WHO), the International Diabetes Federation (IDF), the American Heart Association (AHA) and the National Heart, Lung, and Blood Institute (NHLBI) are among several other major organizations that independently developed different diagnostic criteria for the appropriate characterization of metabolic syndrome [29]. These efforts culminated in a 2009 joint interim statement that proposed a harmonized set of diagnostic criteria for metabolic syndrome [8, 7].

The concept of metabolic syndrome is not entirely new in Nigerian populations although the few available studies have focused on entire adult populations [20, 21]. This present study was therefore designed to assess the prevalence of the metabolic syndrome, its relationship with BMI and thus, characterize the different BMI-metabolic risk sub-phenotypes amongst young Nigerian adults.

This study reported that more than half of the study population (59.06%) had normal weight based on their BMI figures while over 40% were either overweight or obese based on their BMI. This finding is in tandem with a previous study [21] that reported a 45% prevalence of undesirable BMI in the studied population. Specifically, obesity was found in 10.88% of the total population in this study with a higher prevalence of obesity in females (15.80%) relative to males (5.40%). Although this figure is slightly lower than the 11.8% previously reported [20], it is within the range of 8.1%-22.2% prevalence rate of obesity reported in another study [30]. Other similar studies are in agreement with the higher prevalence pattern found among the females [31, 32, 33]. In a recent study, this higher prevalence of overweight and obesity in females has been attributed to factors such as lack of physical exercise, involvement in less strenuous and physically tasking activities as well as poor participation in sports due to cultural and societal considerations [34]. The prevalence pattern of overweight and obesity across gender is further corroborated by the mean values of BMI across the different age groups. Apart from the 15-20 age groups, females had higher BMI values across all other age groups in the study population (see Table 1). General obesity and central obesity in particular, are recognized risk factors for metabolic syndrome. The spate of obesity and overweight is likely to worsen with increasing urbanization especially in developing nations like Nigeria.

Metabolic syndrome is a public health burden because it increases the risk of suffering a heart attack or stroke and developing type 2 diabetes mellitus by two to three folds and five folds respectively [35]. The

prevalence of metabolic syndrome reported in this study was 23.80%. More males (27.58%) had the metabolic syndrome when compared to the females (20.58%) in the study population. There are several diagnostic criteria for metabolic syndrome [29, 13, 11, 10, 8]. Although there are clear similarities amongst the different criteria, the availability of these different definitions of metabolic syndrome poses an obvious challenge to relative comparison of figures obtained from various studies across different ethnicities. Thus, the diagnostic criteria are a significant factor in determining the prevalence of metabolic syndrome. For instance, the prevalence of metabolic syndrome was reported as 34.6% and 36.8% using the NCEP ATP III and IDF criteria respectively in the same study population [36]. This current study defined metabolic syndrome based on the modified NCEP ATP III criteria [11]. The NCEP ATP III definition is easy to use and the measurement of insulin resistance is unnecessary [3]. The findings of this study compares relatively with a reported 27.9% mean overall prevalence of metabolic syndrome in Nigerian studies that adopted the ATP III criteria [37]. The prevalence of metabolic syndrome in this study is lower than the 14.3% prevalence rate reported in a similar study amongst Nigerian adolescents and young adults [38]. Methodological differences may account for the difference in prevalence rates because the said study defined metabolic syndrome using the IDF criteria. Although the findings of this study is lower than the 30.7% reported in a previous study [21] and higher than the 12.1% reported in another study [39], the higher prevalence of metabolic syndrome observed amongst males in this study is common to both studies [39, 21]. The studies cited above used the NCEP ATP III criteria, thus making comparison easy. While one may not be so certain, it is highly probable that the high prevalence of metabolic syndrome in this study may have resulted from a shift to a westernized lifestyle and low levels of physical activity [3, 9]. The high burden of metabolic syndrome amongst participants in this study implies a high risk of developing atherosclerotic cardiovascular diseases and type 2 diabetes mellitus in the nearest future [35, 7, 28].

It is well established that metabolic syndrome results from a cluster of metabolic risk factors [2, 7, 3, 4, 28]. This study identified these metabolic abnormalities and reported their prevalence in the study population (see figure 3). This study reported hyperglycemia (41.26%) as the most common metabolic abnormality in the population with more females (52.90%) relative to males (27.60%) being hyperglycemic in the study population. Correspondingly, the females in the study population had higher mean values of fasting blood glucose across all age groups (see Table 1). Previous studies have reported a female preponderance of impaired fasting glucose which consequently resulted in the prediabetes state [40, 41, 42]. It has been suggested that this prevalence pattern may be due to the possible effects of differences in steroid hormones on metabolism and the proportionally larger visceral adipose tissues of females [40]. Hyperglycemia leads to prediabetes which precedes diabetes mellitus. Clearly, prediabetes is an at-risk state for diabetes [43, 41]. Therefore, the high prevalence of hyperglycemia amongst the young adults in this present study suggests that in the absence of urgent interventions, a future diabetes epidemic may occur.

Hypertension is the most critical risk factor for cardiovascular diseases and thus, contributes greatly to the global cardiovascular crisis [44, 34]. This study reported a high prevalence of hypertension (36.50%) in the study population with a higher prevalence in males (58.62%) relative to females (17.64%). A previous study had similarly reported hypertension as the most common metabolic abnormality occurring in 86.6% of subjects with metabolic syndrome [2]. The higher prevalence of hypertension amongst males is in tandem with previous reports [3, 45, 34]. Also, this prevalence pattern corresponds to the mean values of systolic blood pressure and diastolic blood pressure in this study. Males had higher values across all age groups in the study population (see Table 1). The high prevalence of hypertension particularly amongst the males is worrying because of the increasing risk of cardiovascular diseases which it portends.

The prevalence of abdominal obesity was higher in females (30.69%) when compared to males (6.52%) in the study population although higher mean values of waist circumference were reported in a mixed pattern across the different age groups (see Table 1). This prevalence pattern is common in previous studies where the prevalence of obesity [3] and abdominal obesity [39, 42] were reportedly higher in females. Waist circumference can be used to determine abdominal fat mass. Excess abdominal fat is clinically relevant and linked with the risk of cardiometabolic diseases [46, 34].

In Nigeria, the prevalence of different BMI-metabolic-risk sub-phenotypes is high [21]. This present study reported that 60.00% of the obese population had a healthy metabolic profile which falls within the prevalence range of 6%-75% for the metabolically healthy obese (MHO) phenotype that has been reported in other populations [47]. However, it is higher than the 10.1% prevalence of the MHO phenotype in Cameroonian populations [48]. The higher prevalence in this present study may be due to differences in the defining criteria because the Cameroonian study defined a healthy metabolic profile by the presence of zero or one cardiometabolic abnormality. The striking difference between the figure reported in this present study and other previous studies that reported 33% of MHO phenotype [20, 21] may be explained by the design of this present study. The

young adults recruited in this present study beyond being supposedly healthy may not have actually suffered any chronic ailment or disability either in the past or presently. This cannot be said of the general population that usually has a preponderance of middle-aged and elderly adults as reported in other studies. Besides, it is possible that the metabolic consequences of their weight gain are not yet evident thus eliminating the presence of co-morbidities in these young adult population [49]. Also, this study shows that 80.00% of those overweight on the basis of BMI do not have the metabolic syndrome. Furthermore, the data from this study shows that 23.68% of the normal weight individuals were metabolically obese (MONW). This is lower than the 37.6% prevalence [21] but higher than the 8.6% prevalence [20] and 1.4% prevalence [48] of MONW phenotype in previous studies. The earlier cited methodological differences pose a serious challenge in comparing these figures. It however agrees with the previous study that reported a higher prevalence of MONW among females [21]. Taken together, the findings of this study is significant for this young adult population. It clearly shows that 23.68% of the participants who are having a normal weight on the basis of their BMI and thus, would have been deemed to have a low risk of developing cardiovascular diseases are ironically at high risk due to their unhealthy metabolic profile. In similar ironic circumstances, 80.00% and 60.00% of participants who are termed overweight and obese respectively on the basis of their BMI may not be at high risk of developing cardiovascular diseases since they are metabolically healthy. Thus, it is not unlikely that there are disparities between BMI definitions and metabolic health status in this study population.

Care should be taken in the generalization of the data from this study since it is urban-based. This study is limited by the small sample size which may equally limit its statistical reliability. The small sample size is due to a cultural challenge. In most Nigerian populations, there is a sense of sacredness attached to blood. Hence, most individuals are unwilling to participate in studies involving collection of their blood samples. However, the detailed research design, the investigation of previously unverified metabolic disturbances in the study population and the sampling of supposedly healthy young adults without any chronic health complications are major strengths of this study.

CONCLUSION

This study reported an obesity prevalence rate of 10.88% in the population. Arising from the 23.80% prevalence rate of metabolic syndrome, it is clear that there is a high burden of metabolic syndrome in this young adult Nigerian population. The most common metabolic abnormalities in the study population were hyperglycemia and hypertension. The different BMI-metabolic-risk sub-phenotypes in this study had prevalence rates of 20.00%-80.00% suggesting a high prevalence of these BMI-metabolic-risk sub-phenotypes within the BMI groups in the population. Juxtaposing these figures with their health implications clearly underscore the need for an urgent public health action in order to forestall the possibility of a looming public health crisis in the study population.

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