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Determinants and Prevalence of Metabolic Syndrome in Subjects Attending the General Outpatient Department of the Federal Medical Centre Katsina State, North West Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Metabolic Syndrome (MS) is a term that describe the presence of conditions that increase an individual risk for heart disease and other disorders such as diabetes and stroke, and its occurrence is in the rise in residents of North-Western Nigeria, The aim of this study was to investigate the

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prevalence and determinants of metabolic syndrome in respondents from Katsina senatorial zone attending the Out-patient Department of the Federal Medical Center Katsina, Katsina State, Nigeria. A total of 211 (male 109; female 102) respondents aged 10 to 80 years were recruited for the study. Anthropometric parameters and blood pressure of respondents were determined using standard methods; serum lipid profile was determined using enzymatic methods. From the results, 11.8% of the male respondents were under weight, 51.6% were within the normal range, 25.4% of the study male population was found to be overweight and 12.8% were obese. 13.5% of the female respondents were under weight, 51.9% were within the normal range, 22.8% of the study female population was found to be overweight and 13.1% were obese. All serum lipids measurements with the exception of serum LDL-C concentration correlated positively with age. There were no statistically significant differences between the frequencies of total cholesterol, HDL, LDL and TRIG between the male and female respondents. The most common form of Dyslipidemia in the male and female respondents is low HDL-C. BMI, SBP, LDL-C, HDLC and TRIG were associated metabolic syndrome with the association being significant for SBP and HDL-C (0.05; 0.03) in the male respondent, in the female respondents BMI, SBP, DBP, LDL-C and TRIG were associated metabolic syndrome with the association being significant for SBP, DBP, and TRIG (0.04; 0.04; 0.04) respectively. The prevalence of metabolic syndrome was highest in male (31.75%) than in the female respondents (28.33).The prevalence of metabolic syndrome is common in the population under study with the male respondents having the highest prevalence. A robust and well design intervention program by concerned authorities is desirable to address complications of the risk factors for metabolic syndrome in the population.

Keywords: Obesity; metabolic; hypertension; lipid; Katsina.

ABBREVIATIONS

MS : Metabolic Syndrome
HREC : Health Research Ethics Committee
ANOVA : Analysis of Variance
WC : Waist Circumference
SBP : Systolic Blood Pressure
DBP : Diastolic Blood Pressure
BMI : Body Mass Index
TC : Total Cholesterol
LDL-C : Low Density Lipoprotein Cholesterol
HDL-C : High Density Lipoprotein Cholesterol
TRIG : Triglyceride

1. INTRODUCTION

Worldwide there is an increase in reported cases of Metabolic Syndrome (MS) prevalence in populations [1] Metabolic syndrome (MS) symbolizes the co-occurrence of risk factors that increase one's risk for heart disease and other disorders such as diabetes and stroke. MS is a clustering of metabolic disturbances such as abdominal obesity, high blood pressure (BP), increased blood glucose level, and dyslipidemia, all of which increases the risk of cardiovascular disease (CVD) and type 2 diabetes mellitus [2]. The worldwide increase in the prevalence of MS cannot be fully explained by lifestyle factors such as sedentary behavior and caloric intake alone. Exposures to environmental toxicants, such as heavy metals, have been implicated [3]. It has been reported that metabolic syndrome is common in residents of North-Western Nigeria, commoner in the females than males [4].

The study was aimed at determining the prevalence of metabolic syndrome and dyslipidemia and their components among selected male and female subjects from Katsina Senatorial zone attending the general out-patient Department of the Federal Medical Center Katsina, Katsina State, Nigeria. Results from the study will provide novel approaches to preventing and managing non-communicable diseases.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted during 2016-2017 in Katsina State, Nigeria located between latitude $12^0$15'N and longitude $7^0$30'E in the North West Zone of Nigeria, with an area of 24,192km^2 (9,341 sq meters) and a population of 7.6 million with the growth rate of 3.0% per annum. With more than 50% of the population between the ages of 15-64 years and 80% of the population engaged in subsistence farming and livestock rearing [5]. The State has a rainy season that begins in April and ends in October, while the dry season starts in November and last till March. The average annual rainfall, temperature, and relative humidity of Katsina State are 1,312 mm, 27.3ºC and 50.2%, respectively.

2.2 Sampling Technique

In this cross sectional study the Federal Medical Center Katsina a tertiary referral hospital was chosen. The method of Yusuf *et al*. [6] was adopted in selection of subjects that participate in the study, where with the use of stratified sampling technique; proportionate allocation was given to each age group to make up the required sample size depending on the population of the subjects in each age group.

All out patients within the study age groups were taken into. However, in each age group, systematic sampling method was employed in which the subjects in each age group were given numbers serially according to their age grouping, thereby giving each subject an equal chance. The first subject was selected by the use of a random number Table and thereafter the rest of the subjects were picked at regular interval (sample interval) so as to meet the sample size requirement in each group. The sample interval was determined by dividing the total number of subjects in the age groups by the sample size (number of patients from the zone presenting to the GOPD in the preceding year before the study):

2500/250 =10.

A total of 250 out patients were selected for the study, out of which 211 have complete data.

Only those with complete data taken were included in the study analysis. The residential township of each subject was accessed from the database of the Health Evaluation Centre of the Federal Medical Centre. Of the 211 individuals who were enrolled in the final analysis, 109 were male and 102 were female. All data were anonymised, and the ethical approval of the study protocol was given by the Ethical Committee Katsina State Ministry of Health.

2.3 Anthropometric and Blood Pressure Measurements

The weight of each subject was measured, being bare footed and in light clothing, using WEYLUX weighing scale, model 424J; Sliding Beam Column Scale, (Short Pillar with height of 560mm). Measurements were recorded to the nearest one (1) kilogram (Kg). Height of the subjects was measured using ACCUSTAT Ross Stadiometer, 44817 (Genentech Incorporated). The measurements were recorded to the nearest 1cm. Waist measurements were taken with the use of a non-stretch metallic tape with a narrow blade and a blank lead-in. Waist circumference was measured on bare skin in the narrowest part of the abdomen between the ribs and iliac crest. Ideal waist circumference was taken as > 102 cm for male and > 88 cm for female [4]. The BMI (for age groups 10-80 years) was then computed using the standard formula [BMI=weight (kg)/height (m^2)] [6]. Based on the recommendation of World Health Organisation for BMI classification [7] the subjects were grouped as underweight (< 18.5 kg/m^2; normal (18.5–24.9 kg/m^2), Overweight (25.0–29.9 kg/m^2); Obese (≥ 30.0 kg/m^2). Blood pressure of the subjects was measured using the method of Wesseling [8]. Aneroid Sphygmomanometer model OGO2, Kenzmedico Company Limited, Saitama Japan was used, with each of the participant seated in a quiet place on a chair with a back support. Blood pressure was taken as normal when Systolic blood pressure is less than 120 mm Hg and diastolic blood pressure is less than 80 mm Hg; as elevated when systolic blood pressure is 120-129 mm Hg and diastolic blood pressure is less than 80 mm Hg; High blood pressure (stage 1) when systolic blood pressure is 130-139 mm Hg or diastolic blood pressure is 80-89 mm Hg; High blood pressure (stage 2) when systolic blood pressure is 140 Hg or higher or diastolic blood pressure is 90 mm Hg or higher [9].

2.4 Biochemical Measurements

Blood samples were taken from each subject by veni puncture after which the samples were allowed to clot at room temperature before being centrifuged in order to separate the serum and then frozen before the analysis.

2.4.1 Lipid profile

The Serum TC concentration was measured by the end point colorimetric method of Allain *et al.* [10] with the use of T60 spectrophotometer and test kits obtainable from Spectrum diagnostics. In this method, the cholesterol was determined after enzymatic hydrolysis and oxidation. The indicator quinoneimine was formed from the reaction between hydrogen peroxide and 4-aminoantipyrine in the presence of phenol and peroxidase.

The serum HDL-Cholesterol of the male and female subjects was measured with a T60 spectrophotometer with test kits obtained from Spectrum diagnostics. In this method, low density lipoprotein and chylomicron fractions are precipitated quantitatively by addition of phosphotungstic acid in the presence of Mg_2^+ ions. After centrifugation, the cholesterol concentration in the HDL fraction which remained in the supernatant was then determined [11].

The serum LDL-Cholesterol concentration of the male and female subjects was measured with a T60 spectrophotometer with test kits obtainable from Spectrum diagnostics. In this method, low density lipoproteins are precipitated by heparin at their iso-electric point (pH=5.04). After centrifugation, the HDLCholesterol and VLDL remained in the supernatant. The cholesterol concentration in the LDL fraction was determined by enzymatic method [12].

The serum Triacyl glycerol concentration of the male and female subjects was measured with a T60 spectrophotometer with test kits obtainable from Spectrum diagnostics. In this method, the triglycerides are determined after enzymatic hydrolysis with lipases. The indicator is a quinoneimine formed from hydrogen peroxide, 4-amino phenazone and 4-chlorophenol under the catalytic influence of peroxidase [13].

International Diabetic Federation (IDF) criteria, was used to classify participants for presence of metabolic syndrome (IDF criteria: abdominal obesity: waist circumference (WC) > 94 cm and at least two of the following: hypertriglyceridaemia, low HDL-C and high blood pressure (blood pressure > 130/85 mmHg). TC, LDL-C and TRIG were considered high if they were ≥5.2 mmol/L, 3.4 mmol/L and 1.7 mmol/L, respectively, and HDL-C was considered low if it was <1.0 mmol/L. [14;15;16]. Dyslipidemia was considered when at least one lipid disorder (hypertriglyceridaemia, hypercholesterolemia and or low HDL-C) was present.

2.5 Statistical Analysis

The results were presented as mean ± standard deviation. Relationship and association between parameters were explored using ANOVA and student's t-test. Multivariate logistic analysis stratified by gender was performed to explore the association between measured parameters and metabolic syndrome.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Anthropometric parameters, blood pressure and serum lipid profile in male and female subjects

Being the same for both sexes and for all ages of adults, the BMI is the most useful population-level measure of overweight and obesity [17] More than 1.9 billion adults, 18 years and older, were overweight in the year 2016. Out of which over 650 million were obese [17]. The BMI of the male subjects are presented in Table 1. From the results, 11.8% of the male subjects were under weight, 51.6% were within the normal range, 25.4% of the study male population was found to be overweight and 12.8% were obese. The BMI of the female subjects are presented in Table 2. From the results, 13.5% of the female subjects from the three senatorial zones were under weight, 51.9% were within the normal range, 22.8% of the study female population was found to be overweight and 13.1% were obese. Tables 1 and 2 also represent the mean serum lipid levels in male and female subjects. Mean TC level is highest in female subjects (3.73 mmol/l) compared to the male subjects (3.72 mmol/l), LDL- cholesterol is higher in male subjects (2.05 mmol/l) compared to the females (2.03 mmol/l), HDL-cholesterol is highest in female subjects (1.09 mmol/l) compared to the male subjects (0.91 mmol/l) and Triglycerides is highest in the male subjects (1.24 mmol/l) compared to the female subjects (1.16 mmol/l). But all the differences failed to achieve significance. The pattern of mean serum lipids concentration is similar for the male and female subjects. Mean TC levels are significantly higher ($p<0.05$) in the age groups 71-80years, 61-70years and 51-60years than in the age groups 10-20 years, 21-30 years and 41-50 years. The male subjects in the age groups 61-70, 31-40, 51-60 and 71-80 have a significantly higher ($P<0.05$) LDL-C values than the age groups 41-50, 21-30 and 10-20. The HDL-C values are significantly higher ($p<0.05$) in the age groups 41-50, 71-80, 61-70 and 31-40 than the age groups 10-20, 21-30 and 51-60. The age groups 31-40, 71-80, 61-70 and 51-60 have a significantly higher ($p<0.05$) mean TRIG values compared to the age groups 10-20, 41-50 and 21-30. There were no statistically significant differences between the frequencies of total cholesterol, HDL, LDL and TG between the male and female subjects in the study.

Table 1. Mean BMI, waist circumference (cm), systolic and diastolic blood pressure (mm Hg), and serum lipid profile (mmol/l) in Katsina senatorial zone male subjects

Age(years)	BMI	WC	Systolic blood pressure	Diastolic blood pressure	TC	LDL-C	HDL-C	TRIG
10-20 (n=19)	18.6± 2.2	73.8±8.4	114.7± 10.0	75.0 ± 10.6	3.0±0.3	1.2± 0.2	1.0± 0.1	1.1± 0.2
21-30 (n=16)	22.1± 1.1	75.2±6.3	127.2 ± 11.7	80.6± 2.5	3.5±0.6	1.4± 0.3	1.0± 0.1	1.2± 0.1
31-40 (n=15)	24.2± 1.1	84.4±10.6	134.7± 9.8	82.0± 2.9	3.5±0.9	2.3± 0.6	1.0± 0.1	1.3± 0.2
41-50 (n=16)	25.6± 0.8	88.5 ±5.3	132.4± 10.6	81.4± 3.6	3.7±1.2	1.9± 0.7	1.1± 0.2	1.2± 0.1
51-60 (n=15)	26.4± 0.5	88.8±9.63	136.8 ± 7.9	84.3± 4.7	3.9±0.8	2.3±0.6	1.0± 0.1	1.3± 0.1
61-70 (n=17)	25.7± 0.2	85.9±10.6	141.1 ± 7.3	82.1± 3.4	4.2±1.3	2.6± 0.9	1.1± 0.2	1.3± 0.1
71-80 (n=11)	24.9± 0.4	83.6 ±3.6	142.9± 5.0	86.3± 5.7	4.3±1.3	2.1± 0.3	1.1± 0.2	1.3± 0.1

Values are given as Mean ± Standard Deviation. KEY: BMI= Body Mass Index, WC= Waist Circumference, TC =Total Cholesterol, LDL-C= Low Density Lipoprotein Cholesterol, HDL-C=High Density Lipoprotein Cholesterol, TRIG= Triglyceride

Table 2. Mean BMI, waist circumference (cm), systolic and diastolic blood pressure (mm Hg), and serum lipid profile (mmol/l) in Katsina senatorial zone female subjects

Age(years)	BMI	WC	Systolic blood pressure	Diastolic blood pressure	TC	LDL-C	HDL-C	TRIG
10-20 (n=21)	17.8± 2.6	69.7±3.6	107.6± 8.3	74.9± 7.3	3.2±0.2	1.3±0.5	1.0±0.1	1.1±0.2
21-30 (n=14)	22.3± 0.6	71.4±7.3	117.8± 4.5	78.8± 5.3	3.5±0.7	1.8±0.3	1.1±0.3	1.1±0.04
3140 (n=16)	25.2± 1.8	73.8±5.3	120.3± 3.4	79.5± 3.9	3.8±1.0	1.7±0.4	1.2±0.3	1.1±0.2
41-50 (n=14)	26.3± 0.7	85.3±4.3	134.5± 10.1	80.4± 2.0	3.5±0.8	1.8±0.6	1.1±0.2	1.1±0.1
51-60 (n=15)	26.9± 0.3	83.7±6.2	141.8± 10.4	82.4± 3.1	3.8±0.7	2.2±0.5	1.1±0.8	1.3±0.1
61-70 (n=12)	26.6± 0.4	83.2±6.0	143.2± 9.3	82.6± 3.2	4.2±0.9	2.8±0.3	1.1±0.6	1.2±0.9
71-80 (n=10)	26.1± 0.7	79.3±4.6	141.9± 18.5	88.0± 4.7	4.0±0.8	2.6±1.0	1.0±0.1	1.2±0.1

Values are given as Mean ± Standard Deviation. KEY: BMI= Body Mass Index, WC= Waist Circumference, TC =Total Cholesterol, LDL-C= Low Density Lipoprotein Cholesterol, HDL-C=High Density Lipoprotein Cholesterol, TRIG= Triglyceride

3.1.2 Determinants of metabolic syndrome

The determinants of metabolic syndrome in the male and female subjects are shown in Table 3 with decreased HDL-C being the most common component of metabolic syndrome in both the male and female subjects, while elevated TRIG were the least. The sequence for the determinants of metabolic syndrome occurs in the order: ↓HDL > Hypertension > ↑WC > ↑TRIG. From the Table as was observed for the subjects the highest hypertensive subjects (40.37%) were observed in the male subjects and the least (37.25%) was observed for the female subjects. For the subjects with an elevated waist circumference the male subjects have the highest (31.19%) while the female has the least (28.43%). The male subjects recorded the highest number of subjects with elevated triglycerides (16.51%) and the female subjects have the least (15.69%). The highest decreased HDL-C was in the male subjects (41.28%) while the least was in the female subjects (37.26%). The prevalence of metabolic syndrome was highest in male (31.75%) than in the female subjects (28.33%).

Table 3. Determinants of metabolic syndrome (%) in male and female subjects

Determinant	Number (%)	Number (%)
	Male (n=109)	Female (n=102)
Hypertension	44(40.37)	38(37.25)
↑WC	34(31.19)	29(28.43)
↑TRIG	18(16.51)	16(15.69)
↓HDL-C	45(41.28)	38(37.26)

3.1.3 Dyslipidemia

The most common form of Dyslipidemia in the male and female subjects is low HDL-C (Table 4), with the male subjects exhibiting highest percentage decrease (41.28%) and the female subjects the least (37.26%). The male subjects from Katsina have the highest percentage elevated triglyceride (16.51%), while the female subjects have the least (15.69%). The percentage elevated LDL-C is highest in female subjects (10.78%) and lowest in male subjects (7.34%). Elevated TC was highest in female subjects (18.63%) and lowest in the male subjects (12.84%).

Table 5 represents the results of multivariate logistic regression analysis for metabolic syndrome risk Factors in the subjects stratified by gender. From the Table BMI, SBP, LDL-C, HDLC and TRIG were associated metabolic syndrome with the association being significant for SBP and HDL-C (0.05; 0.03) in the male subjects. From the Table, BMI, SBP, DBP, LDL-C and TRIG were associated metabolic syndrome. With the association being significant for SBP, DBP and TRIG (0.04; 0.04; 0.04) respectively in the female subjects.

Table 4. Dyslipidemia (%) in male and female subjects

Dyslipidemia	Number (%)	Number (%)
	Male (n=109)	Female (n=102)
↑TC	14(12.84)	19(18.63)
↑LDL-C	8(7.34)	11(10.78)
↑TRIG	18(16.51)	16(15.69)
↓HDL-C	45(41.28)	38(37.26)

3.2 Discussion

The results of the prevalence of anthropometry (Underweight, normal weight, overweight and obesity) in the male and female subjects differs from the prevalence reported for traders from Bodija Ibadan, Nigeria [17] with the subjects in the present study having a comparatively lower overweight and obese but a higher normal weight values. The reason for the difference may be due to the sedentary nature of the subjects from Bodija as compared to the subjects in our study as traders normally open their shops in the morning and close at night with them performing most of their activities while sitting, which may likely explain the disparity seen. The prevalence of obesity in the present study is similar to the world prevalence values for adults as reported by Planchart *et al.* [3]. The values are also lower than the overweight and obesity prevalence for men (70.8%) and women (77.7%) African-Americans [19], obesity prevalence (81% men; 93% women) in Ghanaian and Nigerian born African-Americans [20], the prevalence in Sokoto reported by Sabir et al. [4], and obesity prevalence (17.2%) in rural workers from Idemili South Local Government Area, Southeast Nigeria [21]. The difference may be due to age range differences in subjects studied as our study comprises a younger starter age range (10 years +) compared to the other studies.

Table 5. Multivariate logistic regression analysis for metabolic syndrome risk factors in subjects stratified by gender

Risk factor	Male			Female		
	OR	95% CI	Pvalue	OR	95% CI	Pvalue
BMI	1.05	23.50-24.40	0.54	1.05	23.80-25.10	0.56
WC	0.65	86.60-90.50	0.27	0.82	77.40-78.70	0.77
SBP	1.21	132.00-133.00	0.05	1.13	129.00-130.00	0.04
DBP	0.83	81.20-82.20	0.48	1.24	80.30-81.60	0.04
LDL-C	1.11	1.58-2.52	0.15	1.11	1.28-2.94	0.86
HDL-C	1.13	0.44-1.39	0.03	0.85	0.47-1.70	0.14
TRIG	1.38	0.77-1.72	0.56	1.19	0.54-1.80	0.04

Key: OR=Odd Ratio, BMI= Body Mass Index, WC= Waist Circumference, SBP= Systolic Blood Pressure, DBP= Diastolic Blood Pressure, LDL-C= Low Density Lipoprotein Cholesterol, HDL-C= High Density Lipoprotein Cholesterol, TRIG= Triglyceride

The waist circumference mean values reported in the present study (Men range= 73.84-88.52 cm; Women range= 69.64-85.26 cm) is higher than the mean value reported (Men= 74.78 cm; Women= 71.72 cm) in a study conducted in Vietnam [22] and lower than the mean values (108.3, 102.1, 115.7) reported for post menopausal women with diabetes in Sydney Australia [23], it is also falls within the range of the mean value (86.2) reported for men and women subjects in a study conducted in Sokoto city, Nigeria [4]. Reports have indicated that Vietnamese have the world lowest prevalence of anthropometry, while Australians have a higher prevalence compared to West Africans [24]. This may explain the difference and similarity in the observable disparity.

The prevalence of high blood pressure in the male (40.37%) and female (37.25%) subjects in this study is lower when compared to the prevalence reported (46.1%) for subjects from Sokoto metropolis, Sokoto state, Nigeria [4], but the prevalence is higher than the prevalence of elevated blood pressure (19.3%) reported by Okaka and Eiya [25] in a rural community in Southern Nigeria, the prevalence (16%) reported for Ghanaian and Nigerian born African-Americans [20] and the prevalence (23.1%) reported by Oguoma et al. [26] in a Nigerian population with impaired fasting blood glucose level and diabetes mellitus.

The mean serum lipid levels in the male and female subject's falls within the values considered acceptable for African Americans [27]. The levels of serum lipid values were low when compared to the general US population [27]. The values are also lower when compared to serum lipid values reported by Okaka and Eiya [25] in a rural population from southern Nigeria, the results of Akintunde and Salawu [28] on serum lipids concentration of Staff of Ladoke Akintola University Ogbomosho, Nigeria, Tehran lipid and glucose study [29], results of lipid profile of Ghanaian and Nigerian-born African-Americans [19] and the lipid profile reported by Bently and Rotimi [19] for African-Americans. As it has been established that BMI has positive correlation with lipid levels [30], the lower mean BMI in the study subjects compared to the above reported studies may explain these differences. The trend of relative low serum lipid profile observed in this study is similar to what was reported in lipids profile studies conducted in Northern Nigeria [31;32;33;34;35] and the results of a study conducted a rural population from south-western Uganda [36]. All serum lipids measurements with the exception of serum LDL-C concentration correlated positively with age. This finding is in line with the Bogalusa heart study [30] and the Framingham Offspring Study [37] that shows positive correlation between lipid profile and age and the study of Sairam et al. [38] conducted in India, but differs from the Honolulu Heart Program study [40], and the findings of Marhoum et al. [41], whose study brought into light the hypothesis that there is an increase in the levels of cholesterol with age until the sixties but the level start to decrease beyond that age.

The prevalence of low HDL-C exhibited by the male female subjects is similar to what was reported in staff of Ladoke Akintola University of Technology, Ogbomosho [26] and from Sokoto, Nigeria [4] and in a Nigerian population with impaired fasting blood glucose level and diabetes mellitus [26], but lower than the prevalence (71.3%) reported in a rural population in South-western Uganda [36]. But the prevalence is higher than the prevalence of low HDL-C (16.6%) reported for African-Americans [19], the lower prevalence seen in African-Americans may be attributed to increase in the use of lipid-lowering medications and improvements in their effectiveness [27].

Prevalence of elevated TRIG in the male (16.51%) and female (15.69%) subjects in the present study is lower compared to the prevalence of 38.0% reported for rural workers from Idemili South Local Government Area, Southeast Nigeria [21].

The Low high-density lipoprotein-cholesterol level as the most prevalent dyslipidemia in the present study is similar to what was reported among Northern Mexican adolescents [42], but the result is in contrast to the reported abdominal obesity, raised diastolic blood pressure and hyper triglyceridemia as determinants of metabolic syndrome in rural workers from Idemili South Local Government Area, Southeast Nigeria [21].

The low values of lipid profile in the study population has been reported in studies conducted in Africa [42;43;44].

The male and female subjects may be predisposed to atrial fibrillation (AF), as the low cholesterol levels and high cholesterol variability shown by the subjects were earlier associated with a higher risk of AF development [45].

4. CONCLUSION

The prevalence of metabolic syndrome is common in the population under study with the male subjects having the highest prevalence. A robust and well design intervention program by concerned authorities is desirable to address complications of the risk factors for metabolic syndrome.

CONSENT AND ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee (Katsina HREC assigned number: MOH/ADM/SUB/1174/1/190) and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki. All the participants signed an informed consent letter, together with the guardians of the minors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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