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School Type, Lifestyle Factors and the Risk of Metabolic Syndrome in Nigerian Adolescents

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Results: Prevalence of MetS was 5.6% (public= 5.1%, private= 0.5%). After controlling for all variables in the model, school type (R^2=17.3%) and fatness (R^2=2.7%) were significantly associated with MRS, respectively with the school type recording a stronger unique contribution (β = 0.494, p<0.0005) than fatness (β = 0.149, p=0.023). The likelihood of an adolescent in public school developing MetS risk is 3.0 (95% CI=1.21-7.62, p=0.018) times that of his/her peer in private school. The odd of an adolescent developing MetS risk is 1.4 (95% CI=1.20-1.72, p<0.0005) times with a unit increase in age.

Conclusion: School type was a strong predictor of MetS risk. Adolescents in public school were at higher risk of metabolic syndrome compared to their peers in private school. These results suggest that stakeholders in education and health promotion should pay particular attention to school type when planning preventive strategies for reducing cardiometabolic disease risk in adolescents.

Keywords: metabolic syndrome, school health, adolescents, socioeconomic status, health promotion.

I. Introduction

Metabolic syndrome (MetS) is the aggregation of adverse cardiovascular disease (CVD) and metabolic risk factors that include abdominal adiposity, hypertension, hyperglycemia, hypertriglyceridemia and hypoalphalipoproteinemia.[1] The coexistence of any three or more of these CVD risk factors in the same person constitutes MetS which in recent times has become a major health challenge worldwide, increasing the risk of CVD, Type 2 diabetes mellitus (T2DM) and some forms of cancer in adults.[2,3] Metabolic syndrome was first described by Gerald Reaven in 1988 and since then, numerous definitions and diagnostic criteria have been presented[4]. However, the International Diabetic Federation (IDF)[5] proposed a definition in 2007 in which the presence of central obesity and any other two risk factors constitute MetS. Despite these different definitions of MetS, the common denominator of this syndrome is insulin resistance.[1]

Like many other regions, MetS is becoming common in Africa. In a review of the literature, Okafor[6] reported prevalence rates of MetS in some African countries including Nigeria as ranging from15.9% to 36%. Onyenekwu and Colleagues[7]also reported MetS prevalence rate of 14.3% in adolescents and young adults from Ogun State, Nigeria.

Determination of MetS epidemiology in adolescents is important as it does not only reveal the magnitude of the problem but enables stakeholders in health promotion to identify the targets for timely intervention. Since most studies in Nigeria take place in school settings which most of the time did not stratify samples on the basis of school type, it is difficult to identify the type of school (public or private) with higher vulnerability to cardiometabolic disease (CMD) risk. There are significant socioeconomic disparities between students from public and private schools. In Nigeria, students attending private schools are mainly from parents of high socioeconomic status (SES), who are perceived to be more likely to engage in sedentary activities such as excessive screen times, little or no physical activity and consumption of energy-laden fast food which could lead to overweight (OW) and obesity (OB). In comparison, their peers in public schools, most of who are from low/medium SES are perceived to be more active as they often walk and bike to school.

In a study of 1,338 Brazilian children aged nine to eleven years, Ferreira and Co-workers[8]reported the prevalence of obesity in private and public schools to be 19.9% Vs 9.0% and hypertension in private and public schools to be 21.2% Vs11.4%, respectively. In all cases, the rates were higher in private schools compared to public schools. They concluded that children from private schools have higher SES, BMI and HTN[8] compared to those from public schools. Overweight and OB prevalence rates of 11.8% Vs 11.7%have been reported in Nigerian students attending private schools

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compared to rates of 3.3% Vs 0.9% among their peers in public schools, respectively.[9] In contrast, students from private schools displayed a significantly (p=0.032) more favorable mean systolic blood pressure (SBP) than their counterparts in public schools (95.5% Vs 96.8%). In a study of CVD risk in 37,504 Brazilian adolescents (ERICA), MetS prevalence rates of 2.8% and 1.9% were observed in public and private school student, respectively.[10]Similarly, in the gender-specific analysis, both boys and girls in public schools displayed higher prevalence rates than their counterparts in private schools. In a population-based study of young adolescents from Eastern France[11], prevalence of overweight was 22.7%, higher in low SES zones and in public schools than in private schools.

Two modifiable lifestyle risk factors known to be associated with MetS or CVD in youth are cardiorespiratory fitness (CRF) and body fatness[12]. Studies investigating the relationship among CRF, fatness and MetS have reported the existence of independent association among these variables.[13,14] However, a few others have either documented independent association of fatness but not fitness with CVD risk[15] or fitness, but not fatness with CVD risk.[16] The consideration of fitness and fatness in the study of cardiometabolic disease is therefore important.

There is paucity of data on the epidemiology of MetS in Nigerian youth, especially on the basis of sociodemographic factors. Many of the available studies focused on the prevalence of the individual components of MetS.[9,17] The available study on prevalence of MetS in youth did not make comparison on the basis of school type.[7] Thus, the purpose of this study was primarily to examine the relationship of school type with clustered metabolic risk score (MRS). The study also determined the contribution of fitness and fatness in predicting MRS. A secondary purpose of the study was to characterize the MetS risk profile of Nigerian adolescents based upon school type. It was hypothesized that the type of school attended by adolescents could predict their MetS risk. If school type can be shown to influence children's MetS risk, this could suggest a consideration of additional strategy by stakeholders in health promotion and education for reducing risk of MetS among the youth.

II. Materials and Methods

a) *Participants*

Participants consisted of a total of 218 apparently healthy secondary school children (115 girls and 110 boys) ranging in age from 11 to 18 years from two schools. This is a cross-sectional school-based study conducted between September and November, 2019 prior to the scourge of Covid-19 pandemic. Participants were selected using probability sampling procedure in which they were systematically drawn from the class registers in each school. Details of the sampling procedure, inclusion and exclusion criteria have been previously described[16]. Written informed consent of parents and assent of children were obtained before participation. All tests were conducted between 9:00am and noon, and the research protocol was conducted in accordance with the principles of the Declaration of Helsinki and approved by the Ethics Review Board of Kogi State University, Nigeria before data collection commenced. Throughout the duration of the project, all tests were performed in the same order by the same members of the testing team to ensure consistency.

b) *Study Setting*

The present study was conducted at two schools, a public school (Public) in Dekina Local Government Area (LGA) and the other, a private (Private) school in Ofu LGA, all in Kogi East Senatorial District, Kogi State of Nigeria. The public school represented a typical Nigerian public school which is non-residential where students commute to school daily by walking or bicycling. Typically, the schools close by 2:00 pm, after which students go home and hardly return to school for any other activity. The private school, a residential catholic school, belongs to a group of schools with a population of 16 schools spread throughout the country. The school operates a stringent daily schedule: Students start lesson by 8:00 am after completing some cleaning work in their dormitories. They close by 2:00 pm, go for lunch and siesta. Participation in games is between 5:00 to 6:30 pm daily. All activities are compulsory.

Public schools are government owned, attended mostly by children from low and middle socioeconomic class (SEC), while private schools are expensive, of high academic quality and attended mostly by children from the upper SEC. Generally, there is more discipline in privately-owned missionary schools than public schools in the country.

c) *Anthropometric measurements*

Participants' anthropometric characteristics were measured according to standard procedure.[18] Body mass and stature were assessed indoors in each school with the aid of an electronic weighing scale (Seca digital floor scale, Sec-880; Seca, Birmingham, UK) and a wall-mounted stadiometer (Model Sec-206; Seca, UK). Height was measured to the nearest 0.1cm and body mass was evaluated with participants in minimal clothing to the nearest 0.1kg. Participants' body mass indices (BMI) in ($kg.m^{-2}$) were computed, and used to estimate body fatness. Details of the sex and age-specific classification of BMI into healthy weight (HW) and overweight (OW) are presented in the FITNESSGRAM revised data.[19]

Both the triceps and medial calf skinfold thickness were measured on the right side of participants' bodies with the aid of the Harpenden skinfold calipers (Creative Health Products, MI, USA). All measurements were taken twice and the average of two readings recorded. The revised regression equations of Slaughter et al, as cited[20] for black children, were used to estimate % fat from the sum of triceps and medial calf skinfolds.

The waist circumference (WC) was measured to the nearest 0.1cm with a retractable metal tape (Creative Health Products, MI, USA) at the level of umbilicus midway between the lower rib margin and the iliac crest at the end of a quiet expiration. Two measurements were made and the average recorded. The WC was used to estimate abdominal fat.[21]

d) *Fitness testing*

Participants' CRF was assessed using the 20 meter multistage shuttle run test (20-MST) protocol. The 20-MST is a widely used, valid, and reliable test of aerobic fitness which has been shown to enhance motivation among children and adolescents.[22] The number of laps completed by each participant was used to estimate his/her CRF.[23] In order to assess the relationship between CRF and cardiometabolic risk factors, the total sample was divided into two groups (fit and unfit) based on their performances according to FITNESSGRAM sex and age revised health-related cut-points.[19] Details of the administrative procedure of the test are described elsewhere.[14]

e) *Biochemical measurement*

Fasting plasma glucose (GLU), high density lipoprotein cholesterol (HDL), and triglycerides (TG) were obtained through finger stick blood samples and analyzed with a CardioCheck Plus Analyzer (CCPA) (PTS Diagnostics, Indianapolis, IN, USA). The reliability and validity of CCPA have been reported.[24] Details of the specific procedure have been published elsewhere.[16]

f) *Blood pressure measurement*

Blood pressure measurements were taken while participants occupied a sitting position after 10 minutes of quiet rest with an automated digital BP monitor (HEM-705 CP; Omron, Tokyo, Japan).The resting SBP, diastolic blood pressure (DBP) and pulse rate were monitored on each participant's right arm using appropriate cuff sizes. This instrument has been shown to be accurate.[25] Measurements were taken twice at 2-minute intervals, and the average of the two readings recorded.

g) *Continuous metabolic risk score*

A continuous metabolic risk score was computed from the following variables: plasma GLU, SBP, WC, HDL, and TG. Each of these variables was standardized by subtracting the mean value for each sex group from the individual's value and then dividing by the value of standard deviation [z = (value – mean)/SD]. The standardized HDL was multiplied by -1 because it is inversely related to the MetS risk. The z-scores of the individual risk factor were summed to create a clustered metabolic risk score (MRS) with a lower score indicating a more favorable metabolic risk profile. Since there is no unanimous definition of MetS in youth, authorities (ADA and EASD)[26] have recommended the use of a continuous value of MetS score. This approach has been used in pediatric populations previously.[27,28]

h) *Reference values for risk abnormalities*

Participants were classified as having MetS if they had three out of the following: TG concentration of $\geq$1.7mmol; HDL concentration of $\leq$1.04mmol; glucose concentration of $\geq$5.6mmol; SBP level $\geq$130 mmHg; and WC in the 90th percentile for age and sex as recommended by the International Diabetic Federation (IDF)[5]. However, participants with one or two risk factors were considered at risk of MetS. The metabolic risk profile (MRP) of participants was determined by grouping them into two: those without risk factors as "no risk" and those with one or more risk factors as "risk".

i) *Data Analysis*

Descriptive statistics (mean ± SD) of measured and derived variables were used to characterize the sample. Data were checked for normality of distribution before analysis and transformation made where necessary. All categorical variables were dummy-coded before statistical analyses. The independent samples t-test was used to examine differences in physical characteristics, performance, and features of metabolic syndrome between public and private schools. The Chi-square contingency test was used to evaluate the association between school type and different number of metabolic risks. Hierarchical multiple regression analyses were conducted to determine the independent association between school type, gender, fitness, fatness and composite metabolic risk scores. The independent association of school type, gender, fitness, fatness and MRP was examined using binary logistic regression model. Odd ratios of being at risk of metabolic syndrome were calculated between school types. The model was adjusted for age as a confounding variable. All statistical analyses were performed using the Statistical Package for the Social Sciences (Windows Version 20; SPSS Inc, Chicago IL, USA) at an alpha level of 0.05 or less.

III. Results

Demographic, anthropometric, biochemical and performance characteristics of participants are presented in Table 1. There were more participants (53.8%) from private school compared to those from public school (46.2%). When school type was stratified by risk status, we found metabolic risk prevalence to be 13.7% in private school and 33.5% in public school.

When school type was stratified by gender, MetS risk prevalence was 24.4% in males and 22.8% in females. Regarding physical characteristics, private school children were on the average younger ($p<0.0005$) and taller ($p=0.025$) compared to their peers from the public school. Data analyzed on the basis of MRP indicated that participants from the private school displayed lower values of WC ($p<0.0005$), SBP ($p<0.0005$), GLU ($p<0.0005$), TG ($p=0.035$) and MRS ($p<0.0005$), but better aerobic fitness ($p=0.0005$) than their counterparts from public school.

Table 1: General characteristics of participants stratified by school type and risk profile (n = 197)

Variable	Public (N = 91)			Private (N = 106)		
	Risk (66)	No Risk (25)	Combined (91)	Risk (27)	No Risk (79)	Combined (106)
Male	36 (78.3)	10 (21.7)	46 (100)	12 (23.5)	39 (76.5)	51 (100)
Female	30 (66.7)	15 (33.3)	45 (100)	15 (27.3)	40 (72.7)	55 (100)
Age (y)	16.0±1.9	15.4±2.1	15.9 ± 1.9	15.1±1.6	13.1±1.6	13.6 ± 1.8†
Stature (cm)	160.0±8.9	154.6±8.9	158.3 ± 9.2	165.0±8.4	160.2±10.5	161.4 ± 10.6*
Body mass(kg)	53.9±12.8	50.4±10.8	52.9 ± 12.3	60.1±11.0	50.4±12.5	52.9 ± 12.8
Body fat (%)	15.2±7.7	17.0±7.0	15.7 ± 7.5	17.5±9.3	14.7±5.5	15.4 ± 6.7
BMI (kg.m^{-2})	20.9±3.7	20.8±3.0	20.9 ± 3.5	22.0±3.2	19.5±3.5	20.1 ± 3.4
WC (cm)	73.4±8.2	71.5±5.4	72.9 ± 7.5	61.3±5.3	58.8±2.5	59.5 ± 3.4†
SBP (mmHg)	114.8±13.2	109.4±14.8	113.3 ± 137	105.2±17.0	95.9±14.6	98.3 ± 15.7†
GLU (mmol)	5.5±0.7	5.0±0.5	5.4 ± 0.7	5.1±1.0	4.7±0.5	4.8 ± 0.7†
HDL (mmol)	1.2±0.3	1.5±0.3	1.3 ± 0.3	1.1±0.3	1.5±0.4	1.4 ± 0.4
TG (mmol)	1.2±1.0	1.0±0.3	1.1 ± 0.9	1.2±1.1	0.8±0.3	0.9 ± 0.8*
MRS	-5.9±1.1	-7.4±1.1	-6.3 ± 1.9	-7.9±2.1	-9.4±1.0	-9.0 ± 1.5†
20-MST (lap)	22.3±12.4	19.1±7.3	21.4 ± 11.3	36.7±16.1	42.0±14.8	40.6 ± 15.3†

$p<0.05$, $p<0.01$; †$p<0.0005$

Figure 1 presents the number and proportions of participants in each type of school considered to be at risk of individual features of MetS. There were higher proportions of adolescents at risk of MetS in the public school compared to the private school across all risk factors. The risk of hypoalphalipoproteinemia (23%), hyperglycemia (21%) and abdominal obesity (15%) were most prevalent among the participants, with majority from public school.

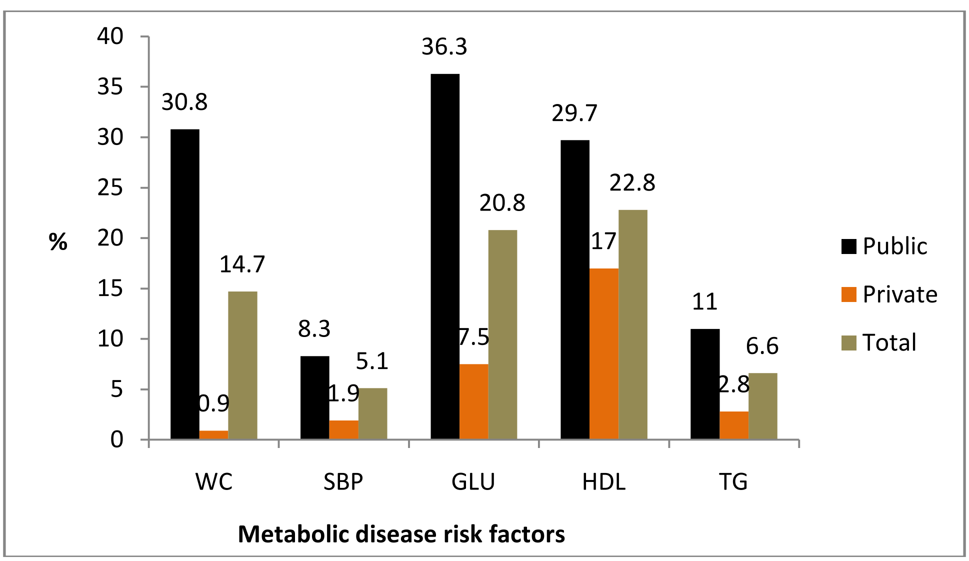

Figure 1: Prevalence of metabolic risk abnormalities by school type

Figure 2 shows the observed number of adolescents with metabolic risk factors based on school type. In order to determine if school type was associated with different numbers of metabolic risk, the Chi-square test of independence was computed and the results showed a statistically significant ($\chi^2_{(3,197)}=47.71$, $p<0.0005$; Cramer's V=0.49.2) association, with adolescents from private school displaying disproportionately fewer metabolic risks. Further analysis indicated that school type accounted for 49.2% of metabolic risk profile.

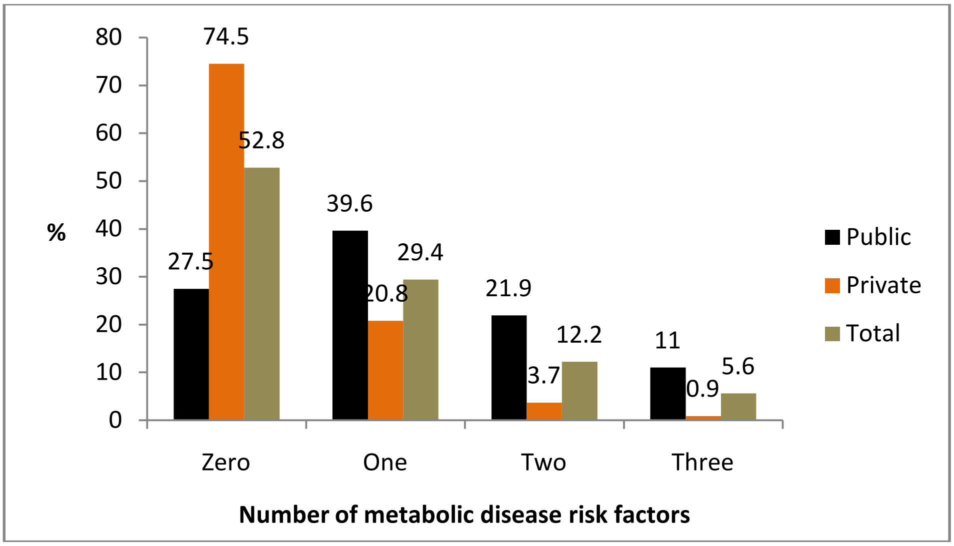

Figure 2: Metabolic syndrome risk factor distribution by school type

Results of the hierarchical multiple regression models assessing the ability of school type, fitness and fatness to predict MRS after controlling for age and gender are presented in Table 2. Age and gender were entered in step 1, explaining 20.1% of the variance in MRS. Addition of school type, fitness and fatness in step 2 increased the total variance explained to 45.1 %, ($F_{(5,190)}=31.41$, $p<0.0005$) after controlling for all the variables in the model. In the final model, School type and fatness were the only significant predictors, with school type recording a higher beta value ($\beta=0.494$, $p<0.0005$) than fatness ($\beta=0.149$, $p=0.023$).

Table 2: Predictors of metabolic syndrome risk

Predictors	Model 1			Model 2		
	R^2	β	P	R^2	β	P
Age	0.209	0.438	0.0005	0.451	0.069	0.335
Gender		0.125	0.051	-	0.042	0.523
School type	-	-	-	-	0.494	0.0005
20-MST	-	-	-	-	-0.132	0.092
BMI	-	-	-	-	0.149	0.023

Results of the logistic regression model assessing the impact of school type, fitness, fatness and age on metabolic risk profile was significant (χ^2 4 N=197=67.1, $p<0.0005$]. Only age (OR=1.4, 95% CI=1.20-1.72,$p<0.0005$) and school type (OR=3.0, 95% CI=1.21-7.62, $p=0.018$) had significant effect. These results indicate that the model was able to differentiate adolescents with from those without MetS risk. Age made a significant contribution with an odd ratio of 1.44 suggesting that the odd of developing MetS risk increases by a factor of 1.4 with a unit increase in age. As for the school type, the results showed likelihood of a public school student developing MetS risk being 3 times that of his peer in private school.

IV. Discussion

Metabolic syndrome is characterized by both cardiovascular and metabolic system derangements resulting from abdominal fat accumulation and insulin resistance, with CVD and T2DM as its major sequelae.[29] Although the pathophysiology of MetS is not well understood, Brotman and Girod[30] have proposed that MetS is a state of insulin counter-regulatory overdrive in which there is a chronic duel between insulin and counter-regulatory hormones, such as glucagon, glucocorticoids and catecholamines along with free-fatty acids (FFA). In the biochemical tug-of-war, insulin attempts to store fuel while counter-regulatory hormones and FFA try to prevent fuel storage. This unending battle is thought to cause the complex abnormalities of MetS.

Since childhood MetS often leads to adult condition, its early detection and management are germane in the prevention and management of CVD and T2DM during adult life. Adolescents constitute a major part of the general population and future workforce in any society. Their health status is therefore of paramount importance, especially in a resource-limited and low average life expectancy country like Nigeria.

In the present study, the prevalence of MetS among participants was 5.6% with participants from public school displaying a higher rate (5.1%). This result is comparable with the 4.7% (Public=2.8%; Private=1.9%) reported for Brazilian adolescents,[10] 5% noted for Iranian children and adolescents[31] and 5.9% observed in South African adolescents[32] but higher than the global[33] adolescent prevalence of 3.3%. The result is also lower than the prevalence of 14% found for Nigerian adolescents and young adults[7]. Our findings are in agreement with those of the Brazilian study.[10]Potential reasons for the strikingly high prevalence rate in the Nigerian sample[7]may be due to the older age (18 years) and higher weight status which comprised overweight and obese participants. Sampling variations and measurement protocols may be additional reasons.

We observed that the proportion of adolescents with central obesity having MetS was higher than any other component irrespective of school type or gender (data not shown). Indeed, of the 11 adolescents with MetS, 10 had central obesity. This result is at variance with findings from the ERICA study[10] in which elevated TG and BP were most common among the sample with MetS. Our result is also inconsistent with those of adolescents and young adults from South-West Nigeria[7] where hypoalphalipoproteinemia was most prevalent among those with MetS.

In this study, hypoalphalipoproteinemia was the most prevalent metabolic risk abnormality. This was followed by central obesity and hyperglycemia. In all cases, greater proportions of participants from public school were more at risk of these abnormalities. In the ERICA study,[10] the most prevalent individual component of MetS was low HDL. This agrees with our results. The high hypoalphalipoproteinemia in our study is a cause for concern, as HDL is considered the most potent independent CVD risk factor because of its protective role against coronary atherosclerosis.[34] If abnormality of HDL becomes an issue at this early age, it calls for urgent intervention to prevent CVD burden in adult life.

Our results indicate that school type was independently associated with MRS after adjustment for age and gender. This is not surprising, as several previous studies[8-11] investigating the association of school type with MetS and its individual components have documented similar findings. However, most of these studies[8,9,35] found students from private schools displaying more unfavorable metabolic risks and other health indicators compared to their peers from public schools while a few studies (including the present one)[10,11] reported otherwise. Plausible reasons for our results include: differences in age, fitness levels, socioeconomic background and residential status of study participants. We observed that adolescents from private school were younger and fitter (Table 1). These variables are generally known to positively influence health status. As earlier noted, Nigerian students attending private schools come mainly from family backgrounds with high SES, while those attending public schools are mainly from low/middle SES. Unlike in the past when parents were less educated with low economic power, contemporary Nigerian parents are more informed and able to take better public health decisions affecting family members, particularly in the areas of good nutrition, physical exercise and other personal health issues, than their counterparts in the past. Parents of low SES lack the capacity to address such health issues. Furthermore, students from public schools being older and exposed to harsh environmental stressors occasioned by their poor socioeconomic settings are relatively more likely to be disadvantaged with regard to optimal health and quality of life generally. In addition, the residential status of students attending private school in our study conferred additional advantage. Unlike those attending public school, they live in boarding facility with good daily schedule that include compulsory evening games and general enforcement of discipline.

The present study has certain limitations. The cross-sectional design used for data collection precludes determination of causality. Only two schools were involved in this study which may not be representative of similar schools in the study area. Future studies need to involve more schools to strengthen extrapolation. However, the strength of this study lies in its use of health-related cut-points to measure fitness and weight status.

V. Conclusion

The prevalence of MetS in this study is moderate and higher among students from public school. Adolescents from private school generally displayed better metabolic profile than those from public school. Hypoalphalipoproteinemia was the most prevalent component of MetS among the participants irrespective of school type. However, school type was the strongest determinant of metabolic profile of the Nigerian adolescents. From public health perspective, findings from this study highlight the need to implement measures that promote healthy lifestyles within the school environment, particularly in public schools. Early identification of youth with cardiometabolic disease risk is critical for prevention of MetS later in life.

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Authors' contribution

D.I.M. participated in the conceptualization, study design, data collection, analyses and writing of the original draft; M.N.A contributed to the design of study, formal analysis, and interpretation of results; N.O.A. contributed to data collection and analysis. All authors have read and approved the final version of the manuscript.

Conflict of interest

The authors declare no conflict of interests

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