Original Research Article

A STUDY OF CORRELATION OF ANTHROPOMETRIC DATA WITH ATHEROGENIC INDICES OF STUDENTS OF RIVERS STATE UNIVERSITY, PORT HARCOURT, NIGERIA

ABSTRACT

Aim: The aim of the study was to correlate anthropometric data with atherogenic indices of students in Rivers State University, Port Harcourt as a means of assessing their cardiovascular health.

Study design: A pilot study was carried out in Rivers State University, Port Harcourt in Rivers State, Nigeria. The study was conducted within a period of 4 months (June – September, 2018). A total of 82 students were selected from the recruitment process after consenting to participate in the study. Atherogenic indices (after determination of lipid parameters values) and anthropometric measurements were done at the Department of Medical Laboratory Science, Rivers State University, Port Harcourt, Nigeria.

Methodology: Five millitres (5mls) of fasting blood samples were collected into lithium heparin bottles and spun at 3500 rpm for 5 minutes to obtain plasma. Total cholesterol (TC) and Triglyceride (TG) were assayed based on enzymatic methods. High density lipoprotein (HDL) was assayed using precipitation and enzymatic method while low density lipoprotein (LDL) was calculated using Friedewald equation. After determination of lipid parameters, atherogenic indices were computed as ratios of these lipid parameters. Anthropometric measurements were collected using stadiometer, non-stretchable tape and weighing scale.

Results: Significant increases were seen in both atherogenic indices and anthropometric data of obese (OBS) and overweight (OVW) students compared to ideal weight (NOM) students. Correlation of anthropometric data with atherogenic indices in obese (OBS) students indicated significant positive correlation between WC with NHDL and CRI-2 as well as between WHR with NHDL, AC, CRI-1 and CRI-2.

Conclusion: Obesity is a strong factor among students that induces atherogenic hyperlipoproteinaemia and thus, CVD risks. Also, WHR and WC correlates strongly with atherogenic indices such as NHDL, AC, CRI-1 and CRI-2 and therefore, were seen as better and sensitive anthropometric parameters for predicting cardiovascular risks compared to WHtR and BMI.

Keywords: Anthropometric data, atherogenic indices, Rivers State, Students, Obese

1. INTRODUCTION

Dyslipidaemia, type 2 diabetes mellitus, cardiovascular disease (CVD) and other forms of metabolic disorders are global health problems associated with overweight and obesity that promote biochemical and neurohormonal processes which eventually culminate in a non-productive life of existence [1, 2, 3]. In developing countries like Nigeria and Tanzania, mortality due to CVD is expected to rise above 18 million by 2020 with deaths affecting age bracket of 15 – 59 [3]. According to reports, almost all unexpected deaths of medical origin in

Nigeria are due to CVD [2, 3]. As reported by *Ukpabi & Uwanurochi* [2], the prevalence of CVD in Northern Nigeria was 8% in 1970. Between 1993 and 2003, CVD prevalence was reported to be at an average of 17.6% in the Country and 20.1% in 2017 in South-East Nigeria [3]. More so, the assessment of lipoproteins and other risk factors for CVD in younger population such as student population has become necessary since metabolic changes such as atherosclerosis has been reported to begin in childhood and adolescent without sign of CVD risks [4, 5, 6]. Therefore, early detection of CVD risks could present a lot of time to slow down metabolic changes that results in obesity and dyslipidaemia. Several clinical measures are used in evaluating CVD risks and one of such measures involve the use of atherogenic and anthropometric indices which are non-invasive techniques [4, 5].

Atherogenic indices contribute significantly in predicting CVD risk especially when absolute values of lipid parameters are not markedly deranged [7, 8, 9]. Atherogenic indices considered in this study include TG/HDL ratio, Atherogenic index of plasma (AIP), Non-High-density lipoprotein cholesterol (NHDL-C), Atherogenic coefficient (AC), Castelli risk index 1 (CRI-1) and Castelli risk index 2 (CRI-2). TG/HDL ratio, is used to determine the presence and degree of coronary artery disease [9, 10, 11]. AIP is a very useful marker because it is relating to the size of HDL-C and LDL-C particles and could serve as an indicator of the lipoprotein atherogenic phenotype in the intravascular pool [12, 13, 14, 15, 16]. An AIP of <0.11, 0.11-0.21 and >0.21 indicate low, intermediate and high risk of CVD respectively [12, 14]. NHDL-C gives the cumulative fraction of the atherogenic lipoproteins that make up the total cholesterol [17]. NHDL-C of 3.4 - 4.0 mmol/L indicates no CVD risks, <3.4mmol/L indicates moderate risk of CVD, <2.6 indicates very high risk of CVD. More so, value of 4.9 - 5.6mmol/l indicates moderate risk of CVD while a value of 5.7 indicates high risk of CVD [17]. NHDL-C is derived by the removal the high density lipoprotein (HDL-C) fraction from total cholesterol (TC) [17]. AC is a measure of cholesterol in the low-density lipoprotein cholesterol (LDL-C), very-low-density lipoprotein cholesterol (VLDL-C) and intermediate density lipoprotein cholesterol (IDL-C) lipoprotein fractions in relation to high-density lipoprotein cholesterol (HDL-C) [18]. Thus, as AC value increases, the risk of developing CVD increases and vice versa [18, 19] and that note, AC is used as a marker for the assessment of the risk of CVD [18, 19] Brehm *et al.,* [19], defined atherogenic coefficient (AC) as the ratio of non-high-density lipoprotein (NHDL-C) to high-density lipoprotein cholesterol (HDL-C). Where NHDL-C is the difference between total cholesterol (TC) and high-density lipoprotein cholesterol (HDL-C). AC optimum value is 3.5 and value >3.5 indicates high risk of CVD [18]. Castelli risk index (CRI) is also used as a predictor of CVD risks and it is based on three vital lipid parameters namely: TG, LDL-C and HDL-C which are in turn independent risk factors for CVD [20]. CRI is made up of two ratios, which are Castelli Risk Index-1 (CR1-1) and Castelli Risk Index-2 (CRI-2) [20, 21]. CRI-1 and CRI-2 are more sensitive and specific indices of CVD risk than TC, LDL-C and particularly in individuals with hypertriglyceridemia of > 300mg/dl. CRI-1 is also known as cardiac risk ratio (CRR) [20, 21]. It is defined as the ratio of total cholesterol (TC) and high-density lipoprotein cholesterol (HDL-C) [20, 21]. CRI-2 is a molar ratio, defined as the ratio of low density lipoprotein (LDL-C) to high density lipoprotein (HDL-C) [20, 21]. As reported by Koleva *et al*., [21], CRI-1 and CRI-2 were observed to be high in individuals with metabolic syndrome when compared with healthy individuals, thus was reported to be indicative of risk to CVD. A CRI-1 value ≤ 3.5 is seen as normal while a value >3.5 indicates a high risk of CVD [20, 21]. A CRI-2 value ≤ 3.0 is normal while ≥3.0 is indicative of CVD risk [21].

Anthropometric indices have been reported to predict CVD risks and it is one of the most commonly used methods in the monitoring and assessment of the distribution of body fat [22, 23]. Anthropometric data considered in this study include Waist circumference (WC), body mass index (BMI), waist to hip ratio (WHR) and waist to height ratio (WHtR). The reason for selecting these anthropometric data is because these parameters are the most

common indices that are used in most Nigerian hospitals (especially BMI). Also, their measurement, can be carefully and easily done. More so, it is cost effective to get these measurements done. WC is a composite measure of all underlying adiposity and has been reported to correlate strongly with visceral and abdominal fat which are factors for CVD risk [21, 24]. BMI seems to correlate well with total body adiposity and thus used as an indicator of obesity [22, 25, 26]. According to Jimoh *et al*., [27], individuals are classified into groups depending on their BMI. Individuals with BMI of < 18.5kg/m^2 are classified as underweight, those with BMI of 18.5-25.5kg/m^2 are classified as ideal weight, while those with BMI of 25.5 – 30.0kg/m^2 are classified as overweight and finally, those with BMI of >30.0kg/m^2 are classified as obese. However, BMI cannot discriminate between adipose and non-adipose tissue in individuals and also cannot distinguish the different types of adipose tissue [4, 26]. WHR assess the regional adiposity especially at the legs [4]. Elevated WHR value = 0.88 for women and 0.95 for men [4]. WHtR has been reported to predict coronary artery risk factors alongside WC, WHR and BMI [4]. The cut-off value is 0.5 for both males and females [4, 26].

Metabolic disorders such as dyslipidaemia, atherosclerosis and other CVD risks have been reported to begin in younger population such as students without any sign of CVD risks [4]. Therefore, the aim of the study is to correlate anthropometric data with atherogenic indices of students in Rivers State University, Port Harcourt as a means of assessing their cardiovascular health.

2. MATERIAL AND METHODS

2.1 Materials and Reagents

Materials used in this study include a FIT non-stretchable tape (USA), Seca portable stadiometer (Germany), Vis spectrophotometer (Axiom Medical Limited, United Kingdom), MPW bucket centrifuge model 351 (Germany), Haier thermocool refrigerator (China), Hana weighing scale (China) and lipid profile reagents (TC, TG and HDL-C) which were purchased from Agappe Diagnostics, Switzerland.

2.2 Subjects

A total of 118 students were recruited in this study of which 82 students were selected based on the feedbacks gotten from the questionnaire administered. The recruitment process lasted for a period of a month and two weeks. The selected 82 students were between 18-30 years of age. Prior to the recruitment process, informed consent of all the students were obtained. More so, demographic information, medical history and pattern of lifestyle from the participants were obtained using a structured questionnaire. The students were recruited within Rivers State University, Port Harcourt and were divided into three major groups; ideal weight (NOM), overweight (OVW), and obese (OBS) based on their BMI. Those with BMI of 18.5-25.5kg/m^2, 25.5 – 30.0kg/m^2 and >30.0kg/m^2 were grouped as ideal weight, overweight and obese respectively as described by Jimoh *et al*., [27]. Students who did not return or fill their questionnaire, with BMI < 18.00kg/m^2, below 18 years, above 30 years or did not meet up with the selection criteria were not allowed to participant in the study. Of the 82 selected students, 11 were overweight, 31 were obese and 40 were of ideal weight. Atherogenic indices were calculated after the estimation of lipid parameters. BMI, WC, WHtR and WHR were also calculated after basic anthropometric measurements were done.

2.4 Study Area

The study was carried out in Rivers State University, Port Harcourt, Nigeria. Rivers State University, is a premier University in South-South Nigeria accommodating students from all parts of the country as well as foreign students. The University is located in the heart of Port Harcourt city which harbors multi-national and local oil and gas companies as well as increased levels of business activities. Due to the city's busy nature, Port Harcourt had witness enormous increase in the number of restaurants making high calorie foods easily accessed by students.

2.5 Experimental Design

A pilot study design was used to recruit a total of 118 students of which 82 were selected. The selected students were between 18 - 30 years of age. Anthropometric measurements were collected and atherogenic indices calculated (after lipid parameters were analysed) at the Department of Medical Laboratory Science, Rivers State University, Port Harcourt, Nigeria.

2.6 Inclusion and Exclusion Criteria

A structured questionnaire was given to all student participants to obtain demographic information, medical history and pattern of lifestyle. Students included in this study were apparently healthy subjects between 18-30 years of age, non-smokers, non-hypertensive, non-diabetic and without any history of chronic disease(s) such as diabetes mellitus. Omron digital blood pressure kit (Omron healthcare co., Ltd, Japan) was used to check the blood pressures of the students. Participants excluded were students below 18 or above 30 years, smokers. Students with history of liver disease, renal disease, hypertension or diabetes mellitus were excluded. Also, students on lipid lowering drugs or anti-hypertensive drugs or anti-diabetic drugs were also excluded.

2.7 Blood Specimen Collection, Preparation and Analysis

Five millitres (5mls) of fasting specimen was collected into heparinized bottle and was centrifuged at 3500 rpm for 5 minutes to obtain plasma. Plasma specimens obtained were transferred into plain bottles which were stored at -4^{0}C in a freezer. Plasma obtained was assayed for TG, TC and HDL-C. The method of assay for TC and TG were based on enzymatic methods as described by *Stavropoulous et al.,* [28] and *Flegg et al*., [29] respectively. HDL-C was assayed by precipitating out VLDL-C and LDL-C using phosphotungstic acid and magnesium ions, and enzymatic evaluation of HDL-C in the supernatant as described by *Flegg et al*., [29]. LDL-C was computed as described by *Friedwald et al.,* [30] using the Friedwald equation: LDL-C (mg/dl) = TC - (TG/5.0 + HDL-C).

2.8 Measurement of Anthropometric Data and Atherogenic indices

Heights (cm) and Weights (kg) were measured using a stadiometer and a weighing scale respectively with the participants wearing light Clothing, standing barefooted in an erected position, and head positioned straight as described by *Jimoh et al.,* [27]. WC and HC were measured in centimeters with a non-stretchable tape below the umbilical cord region as described by *Jimoh et al.,* [27]. The BMI was computed as body weight divided by squared height as described by *Jimoh et al.,* [27]. WHR was calculated by WC divided by HC as described by *Jimoh et al.,* [27] while WHtR was calculated as WC divided by Height as described by *Jimoh et al.,* [27]. Atherogenic indices such as AIP was calculated as Log (TG/HDL-C) as described by Dobiasova [12]. CRI-1 and CRI-2 were calculated as TC/HDL-C and LDL-C/ HDL-C respectively as described by Koleva *et al*., [21]. NHDL-C was calculated as TC – HDL-C as described by Devadawson *et al*., [17] while AC was calculated

as TC – HDL-C)/ HDL-C as described by Brehm *et al*., [19]. The essence of using four different anthropometric measures is to determine which measure predicts atherogenicity viz-a-viz cardiovascular risks better by correlating each anthropometric data with each atherogenic indices.

2.9 Statistical Analysis

Statistical analysis was done using GraphPad Prism version 5.03 (San Diego, California, USA). One-Way ANOVA with Turkey's multiple comparative analysis (post-analysis) was performed to compare anthropometric data and atherogenic indices in the subjects. Spearman's correlation of anthropometric data with each atherogenic indices was done and represented by the correlation coefficient (r). The essence of the correlation is to determine which anthropometric measures predicts atherogenicity better by correlating each anthropometric data with each atherogenic indices. Results obtained were presented as mean±standard deviation. The statistical significance was seen at P=.05.

3. RESULTS

3.1 Results of Lipid parameters

Values of lipid profile analysis used in calculating the atherogenic indices of are shown in table 1.

Table 1. Values of Lipid parameters

Parameter	GROUP NOM	GROUP OVM	GROUP OBS
HDL-C (mg/dl)	46.0 ± 11.37	41.88 ± 14.39	41.51 ± 16.07
TG (mg/dl)	93.95 ± 40.68	105.4 ± 61.42	142.5 ± 58.07
TC (mg/dl)	229.0 ± 99.20	408.1 ± 79.14	536.3 ± 181.2
LDL-C (mg/dl)	164.3 ± 98.73	345.1 ± 81.07	430.1 ± 138.1

3.2 Comparison of Anthropometric Data of Group NOM, OVW and OBS

When the BMI, WC WHR and WHtR values of group NOM were compared with values of group OVW and OBS, significantly higher values in BMI, WC and WHtR were observed in group OVM and OBS except WHR which indicated significant increase only in group OBS at P=.05 (table 2). Also, when group OVW were compared with group OBS, significantly higher values were seen in BMI and WHR of group OBS at P=.05 (table 2).

Table 2. Comparison of Anthropometric indices of Group NOM, OVW and OBS using one-Way ANOVA

Parameters	Group NOM	Group OVW	Group OBS	*P* value	F value	Remark
BMI (kg/m^2)	21.6±1.51^{a}	27.6±1.84^{bc}	33.1±1.93^{bd}	<0.0001	390.50	S
WC (cm)	69.9±5.59^{a}	82.4±9.8^{bc}	89.5±10.9^{bc}	<0.0001	47.10	S
WHR	0.8±0.1^{a}	0.8±0.2^{ac}	0.9±0.11^{bd}	0.0127	4.62	S

WHtR	0.4±0.03[a]	0.49±0.05[bc]	0.56±0.05[bc]	<0.0001	122.10	S

Values in the same row with different superscripts (a, b) differ significantly when comparing group NOM with other groups. Values in the same row with different superscripts (c, d) differ significantly when comparing group OVW with OBS. S = Significant.

3.3 Comparison of Atherogenic indices of NOM, OVW and OBS

When the TG/HDLc, AIP, NHDLc, AC, CRI-1 and CRI-2 values of group NOM were compared with values of group OVW and OBS, significantly higher values in TG/HDLc, AIP, NHDLc, AC, CRI-1 and CRI-2 were observed in group OVM and OBS at *P*=.05 (table 3). Also, when group OVW was compared with group OBS, significantly higher values in TG/HDL-C ratio and AIP were observed in group OBS at *P*=.05 (table 3).

Table 3. Comparison of Atherogenic indices of Group NOM, OVW and OBS Using one-Way ANOVA

Parameters	GROUP NOM	GROUP OVW	GROUP OBS	*P* value	F value	Remark
TG/HDL-C	2.19±1.19[a]	3.45±4.14[bc]	3.94±2.24[bd]	0.0048	5.715	S
AIP	0.28±0.22[a]	0.37±0.35[bc]	0.53±0.24[bd]	0.0004	8.726	S
NHDL (mg/dl)	183.0±97.26[a]	366.2±87.88[bc]	458.6±139.7[bc]	< 0.0001	52.61	S
AC	3.94±2.43[a]	9.84±9.23[bc]	12.64±6.76[bc]	< 0.0001	21.55	S
CRI-1	4.847±2.36[a]	11.84±8.68[bc]	13.65±6.77[bc]	< 0.0001	24.01	S
CRI-2	3.62±2.16[a]	94.24±.69[bc]	11.86±6.49[bc]	< 0.0001	22.16	S

Values in the row column with different superscripts (a, b) differ significantly when comparing group NOM with others. Values in the same row with different superscripts (c, d) differ significantly when comparing group OVW with OBS. S = Significant.

3.4 Correlation of Anthropometric Data with Atherogenic indices

A). Correlation of Anthropometric data with Atherogenic indices in Normal Weight Subjects

Results obtained showed no correlation between anthropometric data and atherogenic indices for Normal weight participants (group NOM) at *P*=.05 (table 4).

Table 4. Spearman's Correlation of BMI with Atherogenic Indices for Group NOM

Correlation	r	*P* value	Remark	Interpretation
BMI vs TG/HDL	0.1872	0.2475	NS	No correlation
BMI vs AIP	0.1534	0.3447	NS	No correlation
BMI vs NHDL	0.1255	0.4403	NS	No correlation
BMI vs AC	0.1964	0.2244	NS	No correlation
BMI vs CRI-1	0.2710	0.0908	NS	No correlation
BMI vs CRI-2	0.2277	0.1633	NS	No correlation
WC vs TG/HDL	0.04184	0.7977	NS	No correlation
WC vs AIP	0.06087	0.7091	NS	No correlation

WC vs NHDL	0.01050	0.9488	NS	No correlation
WC vs AC	0.2098	0.1939	NS	No correlation
WC vs CRI-1	0.1076	0.5088	NS	No correlation
WC vs CRI-2	0.2878	0.0756	NS	No correlation
WHR vs TG/HDL	-0.1423	0.3812	NS	No correlation
WHR vs AIP	-0.1287	0.4287	NS	No correlation
WHR vs NHDL	-0.2860	0.0736	NS	No correlation
WHR vs AC	-0.05451	0.7383	NS	No correlation
WHR vs CRI-1	-0.1516	0.3505	NS	No correlation
WHR vs CRI-2	0.05765	0.7274	NS	No correlation
WHtR vs TG/HDL	0.2839	0.0758	NS	No correlation
WHtR vs AIP	0.2480	0.1229	NS	No correlation
WHtR vs NHDL	-0.01336	0.9348	NS	No correlation
WHtR vs AC	0.03137	0.8476	NS	No correlation
WHtR vs CRI-1	0.2282	0.1567	NS	No correlation
WHtR vs CRI-2	-0.1700	0.3007	NS	No correlation

NS= No Significant Correlation.

B). Correlation of Anthropometric data with Atherogenic indices in Overweight Subjects

Results obtained showed no correlation between anthropometric data and atherogenic indices for overweight participants (group OVW) at *P*=.05 (table 5).

Table 5. Spearman's Correlation of Anthropometric Data with Atherogenic Indices for Group OVW

Correlation	r	*P* value	Remark	Interpretation
BMI vs TG/HDL	0.1091	0.7495	NS	No correlation
BMI vs AIP	0.09567	0.7796	NS	No correlation
BMI vs NHDL	0.909091	0.9788	NS	No correlation
BMI vs AC	-0.4000	0.2229	NS	No correlation
BMI vs CRI-1	0.07273	0.8317	NS	No correlation
BMI vs CRI-2	-0.07273	0.8317	NS	No correlation
WC vs TG/HDL	0.05023	0.8834	NS	No correlation
WC vs AIP	0.01373	0.9680	NS	No correlation
WC vs NHDL	0.2146	0.5263	NS	No correlation
WC vs AC	-0.4384	0.1775	NS	No correlation
WC vs CRI-1	-0.01827	0.9575	NS	No correlation
WC vs CRI-2	-0.2009	0.5536	NS	No correlation
WHR vs TG/HDL	0.4230	0.1949	NS	No correlation
WHR vs AIP	0.3940	0.2305	NS	No correlation
WHR vs NHDL	0.4966	0.1202	NS	No correlation
WHR vs AC	-0.1104	0.7467	NS	No correlation
WHR vs CRI-1	0.3908	0.2346	NS	No correlation
WHR vs CRI-2	0.2069	0.5416	NS	No correlation
WHtR vs TG/HDL	0.05977	0.7495	NS	No correlation

WHtR vs AIP	0.02074	0.7796	NS	No correlation
WHtR vs NHDL	-0.04138	0.9788	NS	No correlation
WHtR vs AC	-0.4966	0.2229	NS	No correlation
WHtR vs CRI-1	-0.1701	0.8317	NS	No correlation
WHtR vs CRI-2	-0.3081	0.8317	NS	No correlation

NS = No Significant Correlation

C). Correlation of Anthropometric Data with Atherogenic indices in Obese Subjects

The correlation results showed no association between BMI and WHtR against atherogenic indices in obese participants (table 6). However, significant positive correlations were seen between WC and NHDL, CRI-2. More so, significant positive correlations were seen between WHR and NHDL, AC, CRI-1 and CRI-2 at *P* =.05 (table 6).

Table 6. Spearman's Correlation of Anthropometric Data with Atherogenic Indices for Group OBS

Correlation	r	*P* value	Remark	Interpretation
BMI vs TG/HDL	0.01049	0.9554	NS	No correlation
BMI vs AIP	0.01301	0.9446	NS	No correlation
BMI vs NHDL	-0.1631	0.3806	NS	No correlation
BMI vs AC	0.05666	0.7621	NS	No correlation
BMI vs CRI-1	0.05605	0.7646	NS	No correlation
BMI vs CRI-2	0.04194	0.8227	NS	No correlation
WC vs TG/HDL	0.1065	0.5686	NS	No correlation
WC vs AIP	0.1076	0.5644	NS	No correlation
WC vs NHDL	0.3840	0.0330	S	Positive correlation
WC vs AC	0.3543	0.0508	NS	No correlation
WC vs CRI-1	0.3539	0.0508	NS	No correlation
WC vs CRI-2	0.3692	0.0410	S	Positive correlation
WHR vs TG/HDL	-0.01919	0.9184	NS	No correlation
WHR vs AIP	-0.01535	0.9347	NS	No correlation
WHR vs NHDL	0.4613	0.0090	S	Positive correlation
WHR vs AC	0.4488	0.0113	S	Positive correlation
WHR vs CRI-1	0.4475	0.0116	S	Positive correlation
WHR vs CRI-2	0.4855	0.0056	S	Positive correlation
WHtR vs TG/HDL	-0.01820	0.9226	NS	No correlation
WHtR vs AIP	-0.01659	0.9294	NS	No correlation
WHtR vs NHDL	0.1288	0.4897	NS	No correlation
WHtR vs AC	0.2196	0.2351	NS	No correlation
WHtR vs CRI-1	0.2196	0.2352	NS	No correlation
WHtR vs CRI-2	0.2259	0.2218	NS	No correlation

S= Significant Correlation, NS = No Significant Correlation.

DISCUSSION

Results obtained when the anthropometric data of ideal weight (NOM) subjects were compared with overweight (OVW) and Obese (OBS) students showed significant increase in BMI, WC and WHtR of overweight and obese subjects except in WHR where significant increase was only seen in OBS students. When OVM subjects were compared with OBS subjects, significant increases were also seen in BMI and WHR of obese subjects. However, WC and WHtR showed no significant differences. Our finding is consistent with the work of [1, 31, 32]. Syed [1], reported increased levels of anthropometric data such as WC, BMI and WHR in individuals with attributes of cardiovascular risks such as obesity and type 2 diabetics. Also, Arjmand *et al.*, [31], stated in their paper that WHR and WC were increased in obese individuals and were correlated positively with CRI-1 (TC/HDL-C) and CRI-2 (LDL-C/HDL-C). Kayode *et al.,* [32], also reported increase in WC and WHR in obese diabetic individuals as well as a good correlation in these obese diabetic patients. The significant increases observed could be as a result of accumulation of fat, increase in the adipocyte mass and decrease in insulin sensitivity associated with metabolic disorders such as dyslipidaemia and obesity. The non-significant increase seen in WC when OVW and OBS subjects were compared could be as a result of the inability of the WC to distinguish between the morphology of an enlarged abdomen with a very small sized hip circumference or short stature.

When atherogenic indices were considered, significant increases were observed in TG/HDL, AIP, NHDL, AC, CRI-1 and CRI-2 of OVW and OBS subjects when compared with NOM subjects. Our present result correlates with the study done by [16, 33, 34]. They reported increase in atherogenic indices in obese subjects. Niroumand *et al*., [16], reported significant increase in AIP of overweight and obese subjects with positive correlation between AIP and WC. Ademuyiwa *et al*., [33], also reported significant increase in atherogenic indices such as CRI-1 and CRI-2 among subjects with unfavorable cardiovascular risks profile like obesity. The increase seen could probably indicate the presence of hyperlipidaemia or dyslipidaemia as a result of increased abdominal adiposity or excessive collection of fat in other body tissues. Furthermore, the result obtained also indicated significant increase in TG/HDL and AIP when OVW subjects were compared with OBS subjects. This finding also correlates with the work done by [3, 9]. They also reported significant increase in atherogenic indices such as AIP and TG/HDL-C ratio among subjects with cardiovascular disease risks such as obesity. Ugwuja *et a*l., [3], reported increased values of AIP in their work among overweight and obese civil servants in Abakaliki, South Eastern Nigeria. More so, Myat *et al*., [9], reported that AIP was increased among obese staff of a University in Malaysia when evaluating cardiovascular risks using AIP. The increase in TG/HDL ratio and AIP (log of TG/HDL ratio) could be due to an increase in BMI which is usually accompanied by a greater accumulation of lipid and thus an increased atherogenic index of plasma. Our finding further suggest that TG/HDL ratio and AIP could differentiate the degree of atherogenicity better in overweight and obese individuals.

The correlation of anthropometric data with atherogenic indices of NOM subjects, showed no significant correlation. The result obtained (especially with BMI) is contrary to the finding of [6]. Pap *et al*., [6], reported in their work that students of the University of Novi Sad had high risk of cardiovascular disorder with increased anthropometric indices which they attributed to sedentary lifestyle of the students. However, in this study, sedentary statuses of the subjects were not determined and as such could be a contributing factor to the poor correlation.

Likewise, the relationship between anthropometric data and atherogenic indices for group overweight (OVW) also showed no significant correlation. This finding is supportive of the work done by [4, 35]. Ambakederemo *et al.,* [35], reported no correlation between anthropometric data with AIP while Furtado *et al.,* [4], reported no correlation between WHR and CRI-1 and CRI-2. However, our finding is contrary to the work done by [1, 22, 26, 36] in

which they stated that anthropometric data and atherogenic indices are proportional. Syed [1], stated in their work that anthropometric data such as WC, BMI and WHR correlated with AIP, with strong correlation seen between WC and AIP in type 2 diabetics in Jeddah, Saudi Arabia. In addition, Zhou *et al*., [22], also reported strong correlation between BMI, WC and WHR with AIP in non-obese hemodialysis patients. In a similar study, Sharanye [26], reported that WHtR and WC correlated strongly with AIP, CRI-1 and CRI-2, with stronger correlation seen between WHtR and AIP in non-obese male subjects. Finally, Ezeukwu and Agwubike [36], stated in their work that anthropometric data like BMI, WC, WHR and WHtR correlated positively with AIP in sedentary non-obese young Nigerian males.

The correlate of anthropometric data with atherogenic indices in OBS subjects, showed that BMI and WHtR have no significant correlation with atherogenic indices considered. Our finding is contrary to the work of [37] but in line with the reports of [35]. Lee *et al*., [37], reported that anthropometric indices such BMI was significantly related to incident of CVD such as hypertension in obese subjects. However, Ambakederemo *et al*., [35] reported no correlation between atherogenic indices like AIP and anthropometric data such as BMI, WC, WHR and WHtR in their study among patients attending Niger Delta University Teaching Hospital in Bayelsa State, Nigeria. However, significant positive correlation was seen between WC and NHDL and CRI-2. More so, WHR indicated significant positive correlation and NHDL, AC, CRI-1 and CRI-2. This finding is in concordance with the works of [5, 7, 24, 31]. Shabara and Shatida [5], reported positive correlation between WHR and CRI-1 as well as between WC and CRI-1 in obese Punjabi subjects. More so, Devi *et al.,* [7], also reported significant correlation between anthropometric data such as WC and lipid parameters associated with cardiovascular diseases in obese male adults of North India. In addition, Daif and Khaled [24], further reported that anthropometric data such as WC was associated with CRI-1. In the same vein, Arjmad *et al*., [31], stated in their work that WHR correlated positively with CRI-1 while WC correlated positively with CRI-2 when studying the association between anthropometric indices and coronary artery disease. The results obtained suggest that WC and WHR are sensitive and better markers of cardiovascular risks compared to BMI and WHtR. Furtado *et al*., [4], reported in their work that WHR correlates strongly with NHDL and therefore, the strongest predictor of CVD risks. The positive correlation of WC and WHR with NHDL, AC, CRI-1 and CRI-2 suggest WC and WHR are better and sensitive markers of atherogenic lipoproteins strongly associated with metabolic syndromes such as dyslipidaemia, obesity and cardiovascular diseases.

5. CONCLUSION

From the results obtained, it could be said that obesity is a strong factor among students that induces atherogenic hyperlipoproteinemia and thus, CVD risks. Also, WHR and WC correlates strongly with atherogenic indices such as NHDL, AC, CRI-1 and CRI-2 and therefore, were seen as better and sensitive anthropometric indices for predicting cardiovascular risks compared to WHtR and BMI.

6. RECOMMENDATION

The use of other anthropometric indices such as WHR and WC and not just BMI should be encouraged as simple tools in predicting CVD risks. In addition, the use of atherogenic indices in evaluating CVD risk should be included in routine analysis alongside lipid profile.

7. LIMITATION

The number of participants (students) for this study was small, blood pressures, alcoholism and sedentary lifestyle of the students were not considered in our analysis, and other risk

factors like family history and the presence of other diseases such as some cancers (e.g. breast and colon) and asthma were also not considered. Therefore, our findings are subject to further research and verification.

CONSENT AND ETHICAL CLEARANCE

Informed consent was obtained from the students prior to enrolment upon ethical clearance by the Ethics Committee of the institution.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

LIST OF ABBREVIATIONS

AC	=	ATHEROGENIC COEFFICENT
AIP	=	ATHEROGENIC INDEX OF PLASMA
BMI	=	BODY MASS INDEX
CRI-1	=	CASTELLI RISK INDEX 1
CRI-2	=	CASTELLI RISK INDEX 2
CVD	=	CARDIOVASCULAR DISEASE
HC	=	HIP CIRCUMFERENCE
HDL-C	=	HIGH DENSITY LIPOPROTEIN-CHOLESTEROL
IDL-C	=	INTERMEDIATE DENSITY LIPOPROTEIN-CHOLESTROL
LDL-C	=	LOW DENSITY LIPOPROTEIN-CHOLESTEROL
NHDL-C	=	NON HIGH DENSITY LIPOPROTEIN-CHOLESTEROL
NOM	=	IDEAL WEIGHT
OBS	=	OBESE
OVW	=	OVERWEIGHT
TC	=	TOTAL CHOLESTEROL
TG	=	TRIGLYCERIDES
WC	=	WAIST CIRCUMFERENCE
WHR	=	WAIST TO HIP RATIO
WHtR	=	WAIST TO HEIGHT RATIO

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