ORIGINAL ARTICLE

Association of body mass index and abdominal adiposity with atherogenic lipid profile in Nigerians with type 2 diabetes and/or hypertension

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ABSTRACT

Background: We explored the relationship between anthropometric indices (obesity and abdominal adiposity) and the presence of an atherogenic lipid profile in Nigerians with major cardiovascular risk factors (type 2 diabetes mellitus-T2DM, hypertension-HBP, and concomitant disease). **Materials and Methods:** Using a prospective design, 278 patients with T2DM, HBP, or concomitant disease, attending out-patient diabetes and hypertension clinics at a tertiary institution in Nigeria were evaluated. All patients were cholesterol-lowering oral medication naïve. Demographic and clinical data and anthropometric measurements were documented. Fasting lipid profiles were measured in all cases. The cut-off points for defining dyslipidaemia were: Elevated total cholesterol (TC) (mg/dL) ≥200, elevated low-density lipoprotein cholestrol (LDL-C) (mg/dL) ≥100, low high-density lipoprotein cholesterol (HDL-C) (mg/dL) <40 for men and <50 for women, and high triglycerides (TG) (mg/dL) ≥150 mg/dL. **Results:** We found a significantly higher mean BMI (kg/m^2) in the HBP group (30.5 ± 6.0) compared to T2DM (28.1 ± 5.9) and concomitant HBP and T2DM groups (29.4 ± 5.2) (*ANOVA*; P = 0.02). The most frequent dyslipidaemia was elevated LDL-C in 92 (96.8%) HBP, 73 (85.9%) T2DM and 79 (80.6%) concomitant disease. The frequency of low HDL-C was highest in T2DM (68.2%) compared to the other 2 groups (P = 0.03). **Conclusions:** Only TG levels were found to relate with any anthropometric index (waist circumference (WC) in this case) in Nigerians with major cardiovascular risk factors in this study. Routine anthropometric indices do not appear to be reliable surrogates for atherogenicity measured by abnormalities in TC, LDL-C and HDL-C.

Key words: Atherogenic profile, blacks, diabetes, hypertension, metabolic syndrome, Nigerians

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INTRODUCTION

Anthropometric and biochemical risk factors have been associated with an increased risk of adverse cardiovascular outcome.[1,2] Anthropometric indices (particularly body mass index-BMI and waist circumference-WC) are widely employed as predictors of future cardiovascular events such as heart disease and stroke.[3-6] Both measurements are relatively simple to use and have been employed in field surveys as surrogate markers of total body fat composition (BMI) and visceral fat composition (WC) and by extension, as measures of risk of cardiovascular disease (CVD). Apart from these anthropometric measures, the presence of certain patterns of lipid abnormalities (an atherogenic lipid profile) has also been consistently identified as a strong determinant of cardiovascular health.[7-9] Elevated total cholesterol, low HDL cholesterol, high LDL cholesterol, hypertriglyceridaemia and abnormal cholesterol ratios are associated with an increased risk of atherosclerosis.

These risk factors for CVD are particularly pertinent in persons with diseases such as type 2 diabetes mellitus (T2DM) and hypertension (HBP), either occurring alone or concomitantly. The Adult Treatment Panel (ATP) III cholesterol guidelines emphasise the importance of assessment and intervention in persons at increased CVD risk, focusing on the primary prevention in persons with multiple risk factors.[10] In resource-limited populations, it is important to ascertain methods of reducing resource utilisation by identifying credible alternatives or surrogates of CVD risk. Such recommendations, however, need to

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be supported by data that show the correlation between the alternative measures. Considering the relative ease of acquiring BMI and WC data, we sought to determine if either anthropometric index (BMI or WC) could be used to identify persons with pre-existing major cardiovascular risk factors (T2DM, HBP or concomitant disease) who have lipid abnormalities associated with atherogenicity.

MATERIALS AND METHODS

The study utilised a prospective design to evaluate patients with type 2 diabetes mellitus (T2DM), hypertension (HBP) and concomitant T2DM and HBP attending the diabetes and hypertension out-patient clinics at our tertiary hospital (the Lagos University Teaching Hospital, Idi-araba, Lagos State, Nigeria). Consecutively, attending out-patients who consented to participate in the study were recruited. Two hundred and seventy eight patients were recruited for the study. Approval of the study protocol was obtained from the Research and Ethics Committee of the hospital. All the patients were receiving routine treatment for their medical condition (oral hypoglycaemic agents and dietary management for all the T2DM, and antihypertensive agents for the HBP patients) and have had their medical condition for at least 5 years since diagnosis. Only patients who were treatment-naïve regarding statins and other lipid-lowering medications were included in the study.

The following data were collected in a standardized manner: Demographic data, clinical data and anthropometric measurements (weight, height, WC and hip circumference (HC)). Weight (kilogram) was measured in the fasting state (with only light clothing) using an electronic weighing scale, while height (metres) was measured without shoes using a stadiometer. WC was measured (to the nearest 0.1 centimetres) at the widest circumference of the abdomen[11] using a non-stretch linear tape. HC was measured (in centimetres) at the widest diameter of the hips over the greater trochanters.[12] Waist-to-hip ratio (WHR) was calculated as WC divided by HP. BMI was calculated as weight (kg) divided by height (m^2).[13] Obesity was defined according to the World Health Organization (WHO) guidelines, as a BMI ≥30 kg/m^2.[14] Elevated waist circumference (abdominal adiposity) was regarded as WC ≥102 cm for men and ≥88 cm for women,[10,15] while elevated WHR was defined as WHR ≥0.90 for men and ≥0.80 for women.[16]

Lipid profile was measured in the fasting state and all samples were analysed in the research laboratory of the Department of Medicine, College of Medicine, University of Lagos. Plasma triglycerides and total cholesterol levels were determined using standard enzymatic methods and an automated analyser, while high-density lipoprotein cholesterol (HDL-C) was measured by the dextran sulphate-magnesium precipitation procedure.[17] Low-density lipoprotein cholesterol (LDL-C) levels were calculated using the Friedewald formula.[18]

In order to characterise the lipid values as normal or abnormal, the Adult Treatment Panel (ATP) III criteria[10] were used. Total cholesterol (mg/dL) ≥200 was categorised as elevated total cholesterol. LDL values (mg/dL) ≥100 were categorized as elevated LDL. HDL cholesterol (mg/dL) was classified as low if <40 for men and <50 for women. Triglycerides (TG) (mg/dL) levels ≥150mg/dL were categorised as elevated TG.

Data were analysed using the Statistical Package for the Social Sciences (SPSS®) version 13.0 for Windows. Continuous variables (age, WC, BMI, WHR and lipid values) are presented as means ± standard deviations (SD) and compared using Analysis of variance (ANOVA) with posthoc Bonferonni analysis. Categorical variables (gender, presence or absence of obesity and abdominal adiposity, abnormal lipid classification e.g., hypercholesterolaemia, low HDL cholesterolaemia, high LDL-C) are presented as proportions and compared using Yates corrected X^2 test. Multiple linear regression analysis was used to explore the association between the lipid parameters and anthropometric indices (BMI and WC). Age (years) was also included as an independent variable in the regression model. Multiple regression analyses were conducted for the combined analyses of all the cases, and also in subgroup analyses based on the disease states (T2DM only, HBP only and concomitant disease only). Level of significance was set at a $P < 0.05$.

RESULTS

The baseline characteristics of the patients with T2DM, HBP and concomitant disease are shown in Table 1. The patients with concomitant disease were significantly older ($P < 0.001$) than the other two subgroups at the time of the study. In posthoc analysis, the significant difference was found to be due to the difference between the mean ages of T2DM and concomitant disease ($P = 0.000$) and HBP and concomitant disease groups ($P = 0.005$), with no significant difference between T2DM and HBP ($P = 0.61$). The mean BMI (kg/m^2) differed significantly across the three groups ($P = 0.02$), with posthoc analysis revealing the difference as being due to the disparity between the T2DM and HBP group ($P = 0.01$), compared to T2DM and concomitant ($P = 0.37$) and HBP and concomitant ($P = 0.49$). Differences in the WC (cm) and WHR across the three groups are also shown in Table 1. Most of the significant difference in WC was shown to be due to the difference between T2DM and HBP ($P = 0.009$) compared to T2DM and concomitant group ($P = 0.01$) or HBP and concomitant group ($P = 1.00$) in posthoc analysis. Also, the difference in WHR across the three

disease states was shown to be due to differences between T2DM and concomitant group (P = 0.005), in contrast to the T2DM and HBP (P = 0.13) and HBP and concomitant group (P = 0.70). All lipid comparisons yielded P > 0.05 in posthoc Bonferroni analysis. The fasting lipid profiles of the three groups were not significantly different.

Table 2 shows the frequency of lipid abnormalities in the 3 groups. Elevated LDL-C was the most frequent dyslipidaemia, while hypertriglyceridaemia was least frequent. The frequency of low HDL cholesterolaemia was highest in T2DM compared to the other groups. Metabolic syndrome, defined using the presence of at least three of the ATPIII criteria,[10] was present in 187 (67.3%) of the patients in this study. The frequency in T2DM, HBP and concomitant disease was 42 (49.4%), 47 (49.5%) and 98 (100%), respectively (P < 0.00001).

The results of multiple regression analysis exploring the relationship between lipid parameters (as dependent variables) and BMI, WC and age (as independent variables) are shown in Tables 3 and 4. In the combined analyses of all cases, the only significant relationship demonstrated was a weak positive association (P = 0.04) between TG and WC [Table 3]. The trend of the association is shown in Table 3. Multiple regression in subgroup analyses of each disease state did not reveal any significant relationship between the lipid parameters and anthropometric indices.

Table 1: Demographic, anthropometric and lipid profile characteristics of the study population

Characteristic	Hypertension only (n=95)	Diabetes only (n=85)	Concomitant diabetes and hypertension (n=98)	Statistics
Mean age±SD (years)	54.2±11.1	52.1±11.4	59.1±9.9	F=10.35; P=0.000*
Number of men (M to F ratio)	48 (1 to 1.02)	35 (0.7 to 1)	47 (0.92 to 1)	X^2=1.66; P=0.44
Body mass index (kg/m^2)	30.5±6.0	28.1±5.9	29.4±5.2	F=4.11; P=0.02*
Waist circumference (cm)	100.9±11.4	95.4±13.3	100.7±12.0	F=5.71; P=0.004*
Waist-to-hip ratio	0.94±0.08	0.92±0.08	0.95±0.07	F=5.18; P=0.006*
Total cholesterol (mg/dL)	208.2±42.3	218.8±51.4	215.3±62.4	F=0.94; P=0.39
Triglyceride (mg/dL)	135.2±65.9	121.0±73.1	126.1±63.5	F=1.04; P=0.36
HDL-cholesterol (mg/dL)	44.6±12.0	43.6±20.4	42.9±14.6	F=0.29; P=0.75
LDL-cholesterol	154.4±35.4	153.7±50.2	147.4±57.1	F=0.60; P=0.55

*Significant differences (P < 0.05), HDL – High-density lipoprotein; LDL – Low-density lipoprotein

Table 2: Frequency of lipid abnormalities categorised by subgroup of major cardiovascular disease

Parameter*	Hypertension only (n=95)	Diabetes only (n=85)	Concomitant diabetes and hypertension (n=98)	Statistics
Elevated total cholesterol	44 (46.3)	32 (37.6)	40 (40.8)	X^2=1.44; P=0.49
Elevated LDL cholesterol	92 (96.8)	73 (85.9)	79 (80.6)	X^2=12.24; P=0.002**
Low HDL cholesterol	46 (48.4)	58 (68.2)	55 (56.1)	X^2=7.26; P=0.03**
Elevated triglycerides	20 (21.1)	21 (24.7)	24 (24.5)	X^2=0.44; P=0.80

*The cut-off points for defining lipid abnormalities were: Elevated TC≥200 mg/dL, elevated LDL-C≥100 mg/dL, low HDL-C<40 mg/dL in men and <50 mg/dL in women and elevated TG≥150 mg/dL, **Statistics comparing all three groups, Comparison of frequency of low LDL-C in hypertension and diabetes (X^2=5.69; P=0.02), hypertension and concomitant disease (X^2=11.03; P=0.0009) and diabetes and concomitant disease (X^2=0.56; P=0.45), Comparison of frequencies for elevated TG between hypertension and diabetes (X^2=6.43; P=0.01), all other comparisons P>0.05, HDL – High-density lipoprotein; LDL – Low-density lipoprotein

Table 3: Multiple linear regression analyses exploring the determinants of the lipid parameters in all three disease states combined

Lipid parameter	Independent variables	Standardised coefficient (β)	t	P value
Total cholesterol (mg/dL)	BMI (kg/m^2)	–0.118	–1.40	0.16
	Waist circumference (cm)	0.107	1.27	0.20
	Age (years)	0.019	0.31	0.76
HDL cholesterol (mg/dL)	BMI (kg/m^2)	0.055	0.65	0.51
	Waist circumference (cm)	–0.015	–0.18	0.85
	Age (years)	–0.063	–1.–2	0.31
LDL cholesterol (mg/dL)	BMI (kg/m^2)	–0.054	–0.64	0.52
	Waist circumference (cm)	0.131	1.57	0.12
	Age (years)	–0.060	–0.99	0.32
Triglycerides (mg/dL)	BMI (kg/m^2)	–0.035	–0.43	0.67
	Waist circumference (cm)	0.171	2.06	0.04*
	Age (years)	–0.113	–1.87	0.06

*The only significant relationship demonstrated was a weak positive association between triglyceride values and waist circumference [Table 1], HDL – High-density lipoprotein; LDL – Low-density lipoprotein; BMI – Body mass index

Table 4: Multiple linear regression analyses exploring the determinants of the lipid parameters (as dependent variables) in the individual disease states

Parameters	Diabetes			Hypertension			Concomitant disease		
	Standardised coefficient (β)	*t*	*P* value	Standardised coefficient (β)	*t*	*P* value	Standardised coefficient (β)	*t*	*P* value
TC and BMI	–0.278	–1.38	0.17	–0.009	–0.07	0.94	–0.111	–0.75	0.46
TC and WC	0.234	1.16	0.25	–0.002	–0.02	0.98	0.176	1.18	0.24
TC and age	–0.123	–1.10	0.27	0.211	1.92	0.06	0.043	0.41	0.68
HDL-C and BMI	0.016	0.08	0.94	0.164	1.32	0.19	–0.037	–0.25	0.81
HDL-C and WC	–0.071	–0.34	0.73	–0.183	–1.49	0.14	0.221	1.52	0.13
HDL-C and age	0.034	0.30	0.76	–0.049	–0.45	0.66	–0.122	–1.20	0.23
LDL-C and BMI	–0.207	–1.02	0.31	0.092	0.73	0.47	–0.145	–0.99	0.33
LDL-C and WC	0.262	1.29	0.20	0.051	0.41	0.68	0.218	1.47	0.14
LDL-C and age	–0.095	–0.85	0.40	0.012	0.10	0.92	–0.001	–0.01	1.00
TG and BMI	–0.133	–0.66	0.51	0.022	0.18	0.86	–0.020	–0.14	0.89
TG and WC	0.203	1.00	0.32	0.086	0.69	0.49	0.193	1.35	0.18
TG and age	–0.076	–0.68	0.50	–0.028	–0.25	0.81	–0.233	–2.35	0.02*

*Subgroup analysis showed no significant relationship between lipid parameters and anthropometric indices in any of the three disease groups. There was a negative association between TG an age (*P*=0.02) only in patients with concomitant DM and HBP, HDL-C – High-density lipoprotein-cholesterol; LDL-C – Low-density lipoprotein-cholesterol; TC – Total cholesterol; BMI – Body mass index; WC – Waist circumference; TG – Triglycerides

DISCUSSION

This prospective study of 278 Nigerians with major cardiovascular risk factors (HBP, T2DM, and concomitant disease) explored the relationship between easily measurable anthropometric indices of obesity and abdominal adiposity and lipid parameters. The major findings of this study are that although dyslipidaemia (most frequently elevated LDL-C), abdominal adiposity, and obesity are all prevalent in our patients with HBP and T2DM, the only association of any lipid parameter with an anthropometric index was between TG and WC, and that occurred only in combined analyses of the three disease states. Our study buttresses the findings of Isezuo *et al*.,[19] in which the usefulness of HDL-C in predicting the presence of the metabolic syndrome in black Africans from Nigeria was evaluated. The study found that there was no association between HDL-C and BMI or HDL-C and WC. In a comparative study of body composition and its relationship to other markers of cardiovascular risk including lipids in black Haitians and whites, Désilets *et al.,* concluded that the metabolic syndrome may be ethnicity-specific in its phenotype and that standard anthropometric indices (including BMI and WC) may not be as effective measures of cardiovascular risk in populations of African descent compared with whites, unless appropriate cut-off values are defined.[20]

We find it interesting that despite the fact that the least common dyslipidaemia in our study population was hypertriglyceridaemia, TG levels were the only lipid parameter related to any anthropometric index in our patients. The low prevalence of hypertriglyceridaemia in people of African ancestry is not novel to our study, and has been reported previously.[21-24] The possibility of a genetic basis for certain lipid traits (including decreased total cholesterol, LDL-C and TG despite increased risk of insulin resistance) in persons of African ancestry exists.[25] Sumner *et al.,* explored the biochemical basis of normal TG levels despite the presence of insulin resistance in African Americans, and showed that lipoprotein lipase activity remains high in the presence of insulin resistance (unlike the reverse scenario in Caucasians). This enzymatic activity allows for the clearance of TG, a plausible explanation for the coexistence of insulin resistance and normotriglyceridaemia in African Americans.[21]

The association between abdominal adiposity measured by WC, and triglycerides in black men and women has been previously documented.[26,27]

Even at lower TG levels, the relationship of TG with insulin resistance and the inherent adverse effects are present in African Americans, implying that the ideal cut-off point for defining cardiovascular risk related to TG should be lowered in blacks. The results of our study draw attention to the lack of locally derived and applicable levels of adiposity based on anthropometric measurements. Presently, cut-off points for abdominal adiposity for Europid populations are applied to sub-Saharan black Africans in the absence of local cut-off points. This approach is potentially flawed as the cut-offs may not necessarily be representative of the status in all global populations or ethnicities. For instance, Asians have been found to develop adverse cardiovascular events even at values that would ordinarily be described as "normal anthropometric indices" in the Europids.[28] This disparity has been linked to the excess storage of visceral fat in the Asians for every comparable level of BMI.[28] Amongst black Africans, it is well-known that many females who have an excess cardiac morbidity over males have normal WHR even in the presence of varying degrees of obesity, possibly due to steatopygia, which masks the effect of abdominal fat when the WHR alone is used to assess adiposity.[29]

Studies specifically designed to determine appropriate cut-off points to define normalcy of anthropometric indices in black Africans are pertinent. Such studies could be conducted using a population-based study modelled according, for instance, to the methods described by the Study of Health Assessment and Risk in Ethnic Groups (SHARE) investigators,[30] in which principal components factor analysis was used to determine underlying latent factors associated with several clinical and biochemical markers in four ethnic groups (Europeans, Aboriginals, South Asians, and Chinese). In the interim before such data become available, we suggest that the International Diabetes Federation consensus of using the European recommendations be applied until such a time as specific data become available.[31]

An interesting finding in this study was that, on average, persons with HBP alone had a higher mean BMI than those with T2DM or concomitant disease. The exact reason is unclear, but this may be related to weight loss associated with the diabetes (either as a result of reduced calorie intake due to emphasis on dietary control, and/or the use of appetite suppressing oral hypoglycaemic agents, or the effect of poor glycaemic control). We also hypothesize that the higher frequency of elevated LDL-C in HBP (in contrast to the other two groups) may be connected to dietary modifications regarding cholesterol intake implemented in diabetes, but often less emphasised to persons with HBP, and not necessarily an amelioration of the effects of DM by HBP in persons with concomitant disease.

In conclusion, our study re-emphasises the dilemma of delineating the lipid parameters reflective of atherogenicity using routine anthropometric indices specifically in black Africans at high risk of adverse cardiovascular events. Studies aimed at determining the anthropometric cut-off points that correlate with atherogenic lipid profiles in our environment remain pertinent; as such data are useful for public health preventive approaches, counselling, research and non-drug therapy. Our study is limited in that other measures of adiposity such as bioimpedance assessment and abdominal computerised tomography were not utilised, and thus their degree of correlation with lipid profile was not determined. We, however, emphasise that although imaging techniques can be utilised to determine total body fat and its distribution reliably, these measures are neither available nor readily applicable in the routine clinical setting, in contrast to anthropometric indices. Our study is also not generalisable to the population without these cardiovascular risk factors as it did not include a control group of healthy individuals.

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