



Dyslipidaemia and Blood Pressure Patterns Among Patients with Type 2 Diabetes Mellitus in Calabar, Nigeria: A Comparative Cross-Sectional Study

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Abstract

Context: Type 2 diabetes mellitus (T2DM) is frequently accompanied by dyslipidaemia and hypertension. Although these cardiometabolic abnormalities are well documented, there is limited local evidence describing their pattern among patients with T2DM in Calabar, Nigeria. This study compared lipid profile parameters and blood pressure patterns between adults with T2DM and healthy non-diabetic controls.

Materials and Methods: A hospital-based comparative cross-sectional study was conducted among 80 adults comprising 40 T2DM patients and 40 apparently healthy non-diabetic controls recruited from the University of Calabar Teaching Hospital, Nigeria. Fasting venous blood samples were collected for the determination of serum total cholesterol (TC), triglycerides (TG), high-density lipoprotein (HDL-C), low-density lipoprotein (LDL-C) and very low-density lipoprotein (VLDL-C). Blood pressure and anthropometric measurements were obtained using standardized procedures.

Results: Diabetic participants exhibited significantly higher LDL-C (4.64 ± 2.40 vs. 3.27 ± 1.78 mmol/L; $p = 0.005$) and TC (6.79 ± 2.45 vs. 5.56 ± 1.88 mmol/L; $p = 0.004$) than non-diabetic controls. No significant differences were observed in HDL-C, TG, or VLDL-C ($p > 0.05$). Anthropometric parameters were

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comparable between groups. However, blood pressure patterns differed significantly ($p = 0.008$), with elevated blood pressure occurring more frequently among diabetic participants. HbA1c also differed significantly as 70.0% of diabetic participants had HbA1c values within the diabetic range compared with none of the controls ($p < 0.001$).

Conclusion: T2DM was associated with significantly elevated atherogenic lipid fractions, abnormal blood pressure patterns, and poor long-term glycaemic control, highlighting an increased cardiovascular risk among affected individuals.

Keywords: Type 2 diabetes mellitus; Dyslipidaemia; Blood pressure; Glycated haemoglobin; Comparative cross-sectional study.

1.0 Introduction

Diabetes mellitus (DM) is one of the fastest-growing non-communicable diseases globally and represents a major public health challenge because of its increasing prevalence and associated cardiovascular complications. According to the International Diabetes Federation (IDF), approximately 537 million adults were living with diabetes in 2021, with projections indicating an increase to 643 million by 2030 and 783 million by 2045. Sub-Saharan Africa is expected to experience one of the greatest increases in disease burden, while Nigeria accounts for a substantial proportion of diabetes cases within the region owing to rapid urbanization, lifestyle changes, population ageing, and increasing obesity rates.^{1,2}

Type 2 diabetes mellitus (T2DM), which accounts for more than 90% of diabetes cases worldwide, is characterized by chronic hyperglycaemia resulting from insulin resistance and progressive pancreatic β -cell dysfunction.^{1,3} Persistent hyperglycaemia promotes oxidative stress, chronic low-grade inflammation, endothelial dysfunction, and metabolic derangements that contribute to both microvascular and macrovascular complications. These pathological processes substantially increase the risks of cardiovascular disease, stroke, nephropathy, neuropathy, and premature mortality among affected individuals.^{4,5,6,7}

One of the major metabolic abnormalities associated with T2DM is diabetic dyslipidaemia, which is characterized by elevated low-density lipoprotein cholesterol (LDL-C), increased triglyceride concentrations, elevated very-low-density lipoprotein cholesterol (VLDL-C), and reduced high-density lipoprotein cholesterol (HDL-C).⁸ Insulin resistance alters lipid metabolism by increasing hepatic very-low-density lipoprotein production, reducing lipoprotein lipase activity, and enhancing free fatty acid flux from adipose tissue,

thereby promoting the accumulation of atherogenic lipoproteins. These lipid abnormalities accelerate atherosclerosis and substantially increase cardiovascular risk among individuals with diabetes.^{8,6,9,10}

Among lipid fractions, elevated LDL cholesterol remains the principal atherogenic lipoprotein responsible for cholesterol deposition within arterial walls and the subsequent formation of atherosclerotic plaques.⁸ Increased total cholesterol further contributes to vascular dysfunction and cardiovascular disease progression, while reduced HDL cholesterol impairs reverse cholesterol transport and antioxidant protection.⁹ Consequently, routine assessment of lipid profiles is an essential component of diabetes management and cardiovascular risk stratification.^{10,11}

Hypertension is another common comorbidity in patients with diabetes mellitus, with both conditions sharing several pathophysiological mechanisms, including insulin resistance, endothelial dysfunction, oxidative stress, sympathetic nervous system activation, chronic inflammation, and activation of the renin–angiotensin–aldosterone system.⁷ The coexistence of diabetes and hypertension markedly increases the risk of myocardial infarction, stroke, heart failure, chronic kidney disease, and cardiovascular mortality compared with either condition alone.^{5,7,12} Consequently, current clinical guidelines recommend routine blood pressure monitoring and aggressive cardiovascular risk reduction in individuals with diabetes.^{7,11,13}

Blood pressure classification has become an important clinical tool for identifying individuals at increased cardiovascular risk before the onset of overt hypertension.^{13,14} Categorization into normal blood pressure, elevated blood pressure, Stage 1 hypertension, and Stage 2 hypertension provides valuable information regarding cardiovascular risk and guides therapeutic interventions.^{14,15} Emerging evidence suggests that diabetic patients are more likely to exhibit abnormal blood pressure patterns owing to impaired vascular compliance, endothelial injury, arterial stiffness, and metabolic disturbances associated with chronic hyperglycaemia.⁷

Although previous studies have examined dyslipidaemia and hypertension independently among patients with diabetes, relatively few have simultaneously evaluated lipid profile alterations

alongside blood pressure patterns in Nigerian populations, particularly in the South-South geopolitical zone.^{7,16,17} Regional differences in genetics, dietary practices, socioeconomic status, healthcare access, and lifestyle behaviours may influence the prevalence and severity of cardiovascular risk factors.^{1,16,19,17,18} Consequently, locally generated evidence is essential for improving cardiovascular risk assessment and informing evidence-based clinical practice within the Nigerian context.

Therefore, this study aimed to compare lipid profiles and blood pressure patterns between diabetic and non-diabetic adults in Calabar, Nigeria. Specifically, the study compared serum concentrations of total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), very-low-density lipoprotein cholesterol (VLDL-C), and selected atherogenic lipid indices and blood pressure patterns between diabetic participants and apparently healthy non-diabetic controls to determine the extent of dyslipidaemia associated with type 2 diabetes mellitus.

The findings are expected to provide further insight into the cardiovascular risk profile of patients with diabetes and contribute to the development of evidence-based strategies for early detection, prevention, and management of diabetes-related cardiovascular complications in resource-limited settings.

2.0 Materials and Methods

2.1 Study Design

This study employed a hospital-based comparative cross-sectional design to achieve the objectives of the study.

2.2 Study Area

This study was conducted at the University of Calabar Teaching Hospital (UCTH), Calabar, Cross River State, Nigeria. UCTH is a leading tertiary healthcare institution and a major referral center serving Cross River State and other states within the South-South geopolitical zone of Nigeria. The hospital provides comprehensive specialist healthcare services through various clinical departments and serves a large and diverse patient population.

2.3 Sample Size Determination and Sampling Technique

2.3.1 Sample size determination

The sample size was determined using the formula for comparing two independent means, which is appropriate for the comparative cross-sectional design of the study involving patients with type 2 diabetes mellitus (T2DM) and apparently healthy non-diabetic controls. The calculation was based on the expected difference in the primary continuous outcome between the two groups, assuming a two-sided significance level of 1% ($\alpha = 0.01$), 80% statistical power, and equal allocation between groups. The formula used was:

where n represents the minimum required number of participants per group, s is the standard normal deviate corresponding to the selected significance level (2.576), $z_{1-\beta}$ is the standard normal deviate corresponding to 80% statistical power (0.842), σ is the pooled standard deviation of the primary outcome, and Δ represents the expected difference in means between the two groups. Based on the anticipated standardized effect size of 0.81 obtained from a comparable previous study,^{16,21} the calculated minimum sample size was approximately 36 participants per group. After adjusting for 10% non-response rate, the final sample size was 80 participants, comprising 40 patients with T2DM and 40 apparently healthy non-diabetic controls.

2.3.2 Participant Recruitment and Sampling Technique

Participants were recruited using a consecutive sampling technique. Recruitment was conducted over the study period without interruption, thereby reducing the likelihood of investigator-related selection bias and enhancing the representativeness of the study population.

2.4 Ethical Considerations

Ethical approval for this study was obtained from the Health Research Ethics Committee (HREC) of the University of Calabar Teaching Hospital (UCTH), Calabar, Cross River State, Nigeria, prior to the commencement of the study (Approval No.: UCTH/HREC/33/VOL.IV/077; Date of Approval: 5 June 2025). The study was conducted in accordance with the ethical principles governing research involving human participants as outlined in the Declaration of Helsinki and its subsequent

amendments. Participation in the study was entirely voluntary, and participants were informed of their right to withdraw from the study at any stage without any consequences to their medical care and, to ensure confidentiality and privacy, all personal identifiers were removed from the dataset, and participant information was coded and securely stored, with access restricted to the research team.

2.5 Data Collection and Blood Sample Collection

Data collection was conducted over a three-week period using standardized procedures to ensure the accuracy, consistency, and reliability of the study data. Following ethical approval and written informed consent, eligible participants were consecutively recruited from the Endocrinology Clinic of the University of Calabar Teaching Hospital. A trained research assistant administered a pre-tested, structured questionnaire to obtain relevant information on participants' socio-demographic characteristics (including age, sex, and occupation), medical history (such as duration of diabetes, existing diabetic complications, hypertension, and current medications), lifestyle and behavioural factors (including dietary habits, physical activity, and smoking status), and family history of diabetes mellitus. Clinical information was corroborated, where necessary, using participants' medical records to improve data accuracy and completeness.

Participants, following questionnaire administration, were instructed to observe an overnight fast of 10–12 hours before blood sample collection. Approximately 10 mL of fasting venous blood was aseptically collected from the antecubital vein by a certified phlebotomist using standard venipuncture techniques. The blood samples were dispensed into appropriately labelled vacutainer tubes according to the intended laboratory analyses: ethylenediaminetetraacetic acid (EDTA) tubes for glycated haemoglobin (HbA1c) analysis, and plain tubes for serum separation and fasting lipid profile estimation. Blood collected into plain tubes was allowed to clot at room temperature and subsequently centrifuged at 3,000 rpm for 10 minutes to obtain serum. All specimens were labelled with unique participant identification numbers to ensure traceability and confidentiality. Separated serum samples were aliquoted into sterile cryovials and stored at -20°C until batch biochemical analyses

were performed within one week of collection to preserve sample stability and analytical integrity, in accordance with established laboratory best practices for clinical biochemical investigations.

2.6 Assay Procedures

2.6.1 Determination of Triglycerides, Total Cholesterol, and High-Density Lipoprotein – Cholesterol

Serum lipid parameters, including triglycerides (TG), total cholesterol (TC), and high-density lipoprotein cholesterol (HDL-C), were determined using commercially available enzymatic colorimetric assay kits (BIOLABOR, France) in accordance with the manufacturer's instructions.

2.6.2 Determination of Low-Density Lipoprotein Cholesterol (LDL-C)

Plasma low-density lipoprotein cholesterol (LDL-C) concentration was estimated using the Friedewald equation, which is widely employed in clinical and epidemiological studies when fasting serum triglyceride concentrations are below 4.52 mmol/L (400 mg/dL).

$\text{LDL-C (mmol/L)} = \text{Total Cholesterol} - \text{HDL-C} - (\text{Triglycerides} / 2.2)$

2.6.3 Measurement of Anthropometric Indicators of Participants

Anthropometric measurements were obtained using standardized procedures to ensure accuracy, reliability, and reproducibility of the data. Body weight was measured to the nearest 0.1 kg using a calibrated Tanita HD-358 digital weighing scale (Tanita Corporation, Tokyo, Japan), with participants wearing light clothing and no footwear. Body height was measured to the nearest 0.01 m using a calibrated stadiometer while participants stood erect on a flat surface with the head positioned in the Frankfort horizontal plane. Body mass index (BMI) was subsequently calculated as weight (kg) divided by the square of height (m^2) and classified according to the World Health Organization (WHO) criteria.^{22,23}

Waist circumference (WC) and hip circumference (HC) were measured using a flexible, non-stretchable measuring tape to the nearest 0.5 cm following the World Health Organization standardized anthropometric protocol. The waist-to-hip ratio (WHR) was calculated by dividing waist

circumference by hip circumference and was used as an indicator of central adiposity and cardiometabolic risk, while, to minimize measurement error, each anthropometric parameter was measured twice by trained personnel, and the average of the two measurements was recorded for statistical analysis.

2.6.4 Measurement of Cardiovascular Indicators

Resting cardiovascular measurements were performed in a quiet, temperature-controlled laboratory (21–24°C) between 08:00 and 10:00 h to minimize environmental and circadian influences on blood pressure. Participants were instructed to abstain from caffeine, alcohol, smoking, and vigorous physical activity for at least 12 h before assessment. Following an overnight fast, participants rested quietly in the supine position for 10 min before measurements were obtained. During the measurement period, participants were instructed to remain relaxed, silent, and avoid unnecessary movement to ensure measurement accuracy.

Three consecutive blood pressure measurements were obtained at 5-min intervals, and the average of the second and third readings was used for statistical analysis to reduce measurement variability. Heart rate (pulse rate) was determined simultaneously after the resting period and expressed as beats per minute (bpm). All measurements were performed by the same trained investigator using standardized procedures to minimize inter-observer variability and improve measurement reliability.

2.7 Statistical Analysis

Data obtained from the study were entered into Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) for initial coding and validation before being exported to the Statistical Package for the Social Sciences (SPSS) version 25.0 (IBM Corp., Armonk, NY, USA) for statistical analysis. Data cleaning was performed to identify and correct missing values, outliers, entry errors, and inconsistencies prior to analysis, thereby ensuring data integrity and accuracy. Comparisons between participants with type 2 diabetes mellitus and apparently healthy non-diabetic controls were performed using the independent samples Student's t-test for normally distributed continuous variables. Associations between categorical variables were evaluated using the Chi-square (χ^2) test or Fisher's

exact test when expected cell counts were less than five. All statistical tests were two-tailed, and a p-value of less than 0.01 was considered statistically significant.

3.0 Results

3.1 Socio-demographic Characteristics of Study Participants

Gender distribution of the study participants is presented in Table 1. Females constituted the majority of the study population, accounting for 52 (65.0%) participants, while males comprised 28 (35.0%). The distribution was identical between the diabetic and non-diabetic groups, with each group consisting of 26 (65.0%) females and 14 (35.0%) males.

Table 1: Sociodemographic Characteristics of Diabetic and Non-diabetic Study Participants

Variables	Diabetic group (n=40)	Non-diabetic (n=40)	Total (N=80)
Age Category			
Less than 40	3 (7.5%)	12 (30.0%)	15 (18.8%)
40 above	37 (92.5%)	28 (70.0%)	65 (81.2%)
Gender			
Male	14 (35.0%)	14 (35.0%)	28 (35.0%)
Female	26 (65.0%)	26 (65.0%)	52 (65.0%)
Marital Status			
Single	3 (7.5%)	6 (15.0%)	9 (11.2%)
Married	34 (85.0%)	34 (85.0%)	68 (85.0%)
Divorced	1 (2.5%)	0 (0.0%)	1 (1.2%)
Widow/widower	2 (5.0%)	0 (0.0%)	2 (2.5%)
Tribe			
Efik	19 (47.5%)	10 (25.0%)	29 (36.2%)
Ejagham	11 (27.5%)	18 (45.0%)	29 (36.2%)
Igbo	3 (7.5%)	11 (27.5%)	14 (17.5%)
Others	7 (17.5%)	1 (2.5%)	8 (10.0%)
Level of Education			
No Education	3 (7.5%)	0 (0.0%)	3 (3.8%)
Primary	3 (7.5%)	3 (7.5%)	6 (7.5%)
Secondary	6 (15.0%)	6 (15.0%)	12 (15.0%)
Tertiary	28 (70.0%)	31 (77.5%)	59 (73.8%)
Occupation			
Unemployed	2 (5.0%)	3 (7.5%)	5 (6.2%)
Civil Servant	16 (40.0%)	16 (40.0%)	32 (40.0%)
Public Servant	10 (25.0%)	14 (35.0%)	24 (30.0%)
Trader	8 (20.0%)	3 (7.5%)	11 (13.8%)
Retiree	3 (7.5%)	1 (2.5%)	4 (5.0%)
Others	1 (2.5%)	3 (7.5%)	4 (5.0%)
Level of Income			
Below 50,000	9 (22.5%)	10 (25.0%)	19 (23.8%)
50 to 100,000	17 (42.5%)	11 (27.5%)	28 (35.0%)
Above 100,000	14 (35.0%)	19 (47.5%)	33 (41.2%)

3.2 Lipid Profile of Study Participants

Table 2 presents the lipid profile of diabetic and non-diabetic study participants. Independent samples t-test analysis revealed that diabetic participants had significantly higher low-density lipoprotein (LDL) cholesterol levels (4.64 ± 2.40 mmol/L) than non-diabetic participants (3.27 ± 1.78 mmol/L) ($t = 2.91$,

$p = 0.005$). Similarly, total cholesterol was significantly elevated in the diabetic group (6.79 ± 2.45 mmol/L) compared with the non-diabetic group (5.56 ± 1.88 mmol/L) ($t = 2.52$, $p = 0.004$). In contrast, no statistically significant differences were observed in high-density lipoprotein (HDL) cholesterol (1.42 ± 0.44 vs. 1.54 ± 0.67 mmol/L; $t = -0.93$, $p = 0.356$), triglycerides (1.60 ± 0.65 vs. 1.66 ± 0.76 mmol/L; $t = -0.37$, $p = 0.712$), or very low-density lipoprotein (VLDL) cholesterol (0.73 ± 0.30 vs. 0.76 ± 0.35 mmol/L; $t = -0.36$, $p = 0.723$) between diabetic and non-diabetic participants (Table 2). Overall, these findings indicate that diabetes mellitus was associated with significantly elevated atherogenic lipid fractions, particularly LDL cholesterol and total cholesterol, while HDL cholesterol, triglycerides, and VLDL cholesterol were comparable between the two study groups.

Table 2: Lipid Profile of Diabetic and Non-diabetic Participants

Variables	Diabetics	Non-diabetics	Total	t-test	p-value
N	40 (50.0%)	40 (50.0%)	80 (100.0%)		
HDL cholesterol	1.42(0.44)	1.54 (0.67)	1.48 (0.57)	-0.93	0.356
Triglyceride	1.60(0.65)	1.66(0.76)	1.63 (0.70)	-0.37	0.712
VLDL cholesterol	0.73(0.30)	0.76 (0.35)	0.74 (0.32)	-0.36	0.723
LDL cholesterol	4.64(2.40)	3.27 (1.78)	3.95 (2.21)	2.91	0.005*
Total cholesterol	6.79(2.45)	5.56 (1.88)	6.18 (2.26)	2.52	0.004*

*P-value significant at $p < 0.01$

3.3 Physico-Clinical Parameters of Study Participants

Independent samples t-test analysis showed no statistically significant differences in the physical and clinical parameters between diabetic and non-diabetic participants at the 1% significance level ($p < 0.01$). Although diabetic participants had slightly higher mean values for weight (80.15 ± 17.02 kg vs. 79.70 ± 15.15 kg), body mass index (29.76 ± 5.96 kg/m² vs. 28.97 ± 5.44 kg/m²), waist-hip ratio (0.91 ± 0.11 vs. 0.85 ± 0.21), systolic blood pressure (125.03 ± 13.01 mmHg vs. 123.78 ± 15.46 mmHg), and pulse rate (78.15 ± 11.75 bpm vs. 76.50 ± 9.93 bpm), while non-diabetic participants had a slightly greater mean height (1.66 ± 0.07 m vs. 1.64 ± 0.08 m) and diastolic blood pressure (81.85 ± 11.45 mmHg vs. 79.05 ± 9.11 mmHg), none of these differences reached statistical significance ($p > 0.01$ for all variables).

3.4 Blood Pressure Patterns of Study Participants

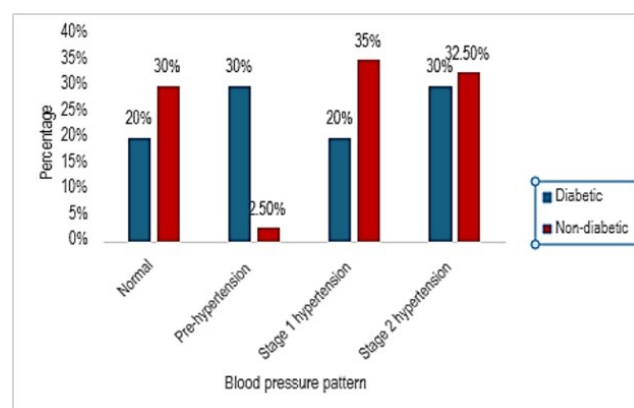
Figure 1 illustrates the distribution of blood pressure

Table 3: Physical and Clinical Parameters of Study Participants

Parameter	Diabetic (n=40)	Non-diabetic (n=40)	t-value	p-value
Mean (SD)				
Weight (kg)	80.15 (17.02)	79.70 (15.15)	0.13	0.901
Height (m)	1.64 (0.08)	1.66 (0.07)	-1.19	0.238
BMI (kg/m ²)	29.76 (5.96)	28.97 (5.44)	0.62	0.538
Waist Hip ratio	0.91 (0.11)	0.85 (0.21)	1.60	0.115
Systolic Pressure (mmHg)	125.03(13.01)	123.78(15.46)	0.39	0.697
Diastolic Pressure (mmHg)	79.05 (9.11)	81.85 (11.45)	-1.21	0.230
Pulse (bpm)	78.15 (11.75)	76.50 (9.93)	0.68	0.500

*P-value considered significant at $p < 0.01$

patterns among diabetic and non-diabetic participants. A higher proportion of non-diabetic participants had normal blood pressure (30.0%) when compared with diabetic participants (20.0%). Conversely, elevated blood pressure (pre-hypertension/elevated blood pressure) was more prevalent among diabetic participants (30.0%) than non-diabetic participants (2.5%) (Figure 1). Stage 1 hypertension was observed in 20.0% of diabetic participants and 35.0% of non-diabetic participants, while the prevalence of Stage 2 hypertension was comparable between the diabetic (30.0%) and non-diabetic (32.5%) groups. Overall, the distribution of blood pressure categories differed significantly between diabetic and non-diabetic participants ($\chi^2 = 11.78$, $p = 0.008$) (Figure 1), thereby indicating a significant association between diabetic status and blood pressure pattern. These findings suggest that individuals with diabetes were more likely to exhibit abnormal blood pressure profiles, particularly elevated blood pressure, compared with non-diabetic controls.



*P-value considered significant at $p < 0.01$

Figure 1: Blood Pressure Patterns of Diabetic and Non-diabetic Study Participants

3.5 Classification and Distribution of Cardiometabolic Parameters of Study Participants

The distribution of hypertension categories differed significantly between diabetic and non-diabetic participants ($\chi^2 = 11.78$, $p = 0.008$). Among the diabetic group, 20.0% had normal blood pressure, 30.0% had elevated blood pressure, 20.0% had stage 1 hypertension, and 30.0% had stage 2 hypertension (Table 4). In contrast, 30.0% of the non-diabetic participants had normal blood pressure, 2.5% had elevated blood pressure, 35.0% had stage 1 hypertension, and 32.5% had stage 2 hypertension. These findings indicate a significant difference in the distribution of blood pressure patterns between the two groups, with elevated blood pressure being more prevalent among diabetic participants.

Similarly, glycated haemoglobin (HbA1c) levels varied significantly between diabetic and non-diabetic participants ($\chi^2 = 23.76$, $p < 0.001$). Among diabetic participants, 70.0% had HbA1c values within the diabetic range ($\geq 6.5\%$), 17.5% were classified as pre-diabetic (5.7–6.4%), and only 12.5% had normal HbA1c levels ($< 5.7\%$) (Table 4). Conversely, none of the non-diabetic participants had HbA1c values in the diabetic range; 52.5% had normal HbA1c levels, while 30.0% and 17.5% were classified as pre-diabetic and diabetic, respectively. Overall, the findings demonstrate a significant association between diabetic status and both hypertension pattern and HbA1c classification, with diabetic participants exhibiting poorer glycaemic control and a less favourable blood pressure profile than non-diabetic controls.

Table 4: Classification and Distribution of Hypertension Patterns and Glycated Haemoglobin Levels Between Diabetic Participants and Controls

Variable	Diabetic status		Fischer Exact	p-Value
	Diabetic group	Non-diabetic group		
Hypertension				
Normal	8 (20.0%)	12 (30.0%)	11.78	0.008
Elevated	12 (30.0%)	1 (2.5%)		
Stage 1	8 (20.0%)	14 (35.0%)		
Stage 2	12 (30.0%)	13 (32.5%)		
HbA1c				
Normal (< 5.7)	5 (12.5%)	21 (52.5%)	23.76	< 0.001
Pre-diabetic (5.7–6.4)	7 (17.5%)	12 (30.0%)		
Diabetic (≥ 6.5)	28 (70.0%)	0 (0%)		

4.0 Discussion

Sex influences glucose metabolism, insulin sensitivity, adipose tissue distribution, and cardiovascular risk. Therefore, gender distribution is important when interpreting metabolic outcomes and assessing potential confounding.^{21,24} In this study, females constituted 65.0% and males 35.0% of participants, with an identical distribution in both diabetic and non-diabetic participants. This comparable gender composition reduces the likelihood of sex-related confounding and strengthens the internal validity of comparisons between the studied groups.

The female predominance is consistent with reports from Nigeria and sub-Saharan Africa, where women may have greater healthcare utilization and participation in health screening programmes. Uloko et al. reported a slight female predominance among adults receiving diabetes care in Nigeria,¹⁷ while the International Diabetes Federation and Kautzky-Willer et al. highlighted regional, behavioural, socioeconomic, and healthcare-access factors influencing sex differences in diabetes and healthcare utilization.^{1,17,24} Although the balanced distribution minimizes potential gender-related bias, larger studies need to consider sex-stratified analyses to further investigate gender-specific metabolic and cardiovascular responses in T2DM.

Diabetic dyslipidaemia is a major metabolic consequence of type 2 diabetes mellitus (T2DM) and contributes substantially to atherosclerosis and cardiovascular disease.⁹ Insulin resistance alters lipid metabolism through increased hepatic production of apolipoprotein B-containing lipoproteins, reduced lipoprotein lipase activity, enhanced adipose tissue lipolysis, and increased circulating free fatty acids, resulting particularly in elevated LDL-C and total cholesterol (TC) in T2DM.^{6,8,9,10}

In the present study, diabetic participants had significantly higher LDL-C and TC concentrations than non-diabetic controls, indicating predominantly atherogenic dyslipidaemia and impaired lipid homeostasis. Chronic insulin resistance promotes adipose tissue lipolysis and hepatic lipid synthesis, while persistent hyperglycaemia may enhance LDL oxidation and glycation, increasing its atherogenic potential.⁶ These findings are consistent with previous reports identifying LDL-C as a principal lipid determinant of cardiovascular risk in diabetes and supporting LDL-C reduction as a major

therapeutic target.^{10,11} Similarly, Olamoyegun et al. reported significantly higher TC and LDL-C among Nigerian patients with T2DM.¹⁶ further supporting the present findings.

Conversely, HDL-C, triglycerides, and VLDL-C did not differ significantly between groups. Although diabetic dyslipidaemia commonly includes elevated triglycerides and reduced HDL-C, these findings may reflect differences in metabolic control, lipid-lowering therapy, dietary and lifestyle factors, biological variability, and population characteristics.^{1,6} The findings differ from reports describing hypertriglyceridaemia and reduced HDL-C as common features of insulin resistance^{11,17}, but are comparable with Olamoyegun et al., who observed that LDL-C and TC abnormalities may predominate in some African populations.¹⁶ Thus, T2DM in this population was associated predominantly with elevated LDL-C and TC, while HDL-C, triglycerides, and VLDL-C remained comparable between groups. Such variations may reflect differences in ethnicity, dietary patterns, obesity, medication use, glycaemic control, and genetic factors that influence lipid metabolism.

These findings underscore the importance of routine lipid profiling, particularly LDL-C monitoring, for cardiovascular risk assessment and early management of dyslipidaemia in patients with T2DM.^{2,23} The key contribution of this study is the identification of a predominantly cholesterol-rich pattern of dyslipidaemia among patients with T2DM in Calabar, characterized by significantly higher LDL-C and total cholesterol compared with non-diabetic controls, while HDL-C, triglycerides, and VLDL-C remained comparable between groups. This finding provides locally relevant evidence that LDL-C and total cholesterol may be particularly important lipid parameters for cardiovascular risk assessment among patients with T2DM in this population and supports their routine monitoring in diabetes care.

Anthropometric and clinical parameters are important indicators of metabolic and cardiovascular health in T2DM^{22,26} although their differences between diabetic and non-diabetic individuals may be influenced by disease duration, glycaemic control, lifestyle, treatment, and demographic characteristics.^{6,11,19,24} In the present study, no statistically significant differences were observed in weight, height, BMI, WHR, systolic or diastolic

blood pressure, or pulse rate between the groups. The comparable anthropometric and clinical profiles suggest that these factors were unlikely to substantially confound the subsequent biochemical comparisons.

The similar BMI and WHR findings support evidence that substantial anthropometric differences are not invariably present between diabetic and non-diabetic individuals, particularly among treated patients, and that anthropometric measures alone may not adequately reflect underlying metabolic dysfunction. This agrees with Magkos et al. and Petersen and Shulman, who reported that metabolic dysfunction and insulin resistance may occur without marked differences in body weight or BMI.^{6,19} Similarly, the absence of significant differences in blood pressure and pulse rate may reflect effective clinical management among diabetic participants, consistent with observations by Williams et al. and Einarson et al.^{5,27}

However, other studies have reported higher BMI and blood pressure in T2DM, particularly among untreated or poorly controlled populations, indicating that these parameters may vary with disease severity, treatment, and population characteristics.^{11,16} Nevertheless, the comparable anthropometric and clinical characteristics strengthen the internal validity of the study and support the interpretation that the observed biochemical differences primarily reflect metabolic consequences of diabetes rather than differences in body composition or routine clinical parameters.

Hypertension is a common cardiovascular comorbidity of type 2 diabetes mellitus (T2DM), and their coexistence increases the risk of cardiovascular disease, stroke, chronic kidney disease, and premature mortality.^{11,13} Chronic hyperglycaemia promotes oxidative stress and endothelial dysfunction, while activation of the renin-angiotensin-aldosterone system (RAAS) and sympathetic activity further contribute to vascular stiffness and elevated blood pressure.^{6,7,13} Thus, blood pressure assessment is an essential component of cardiovascular risk evaluation and diabetes management.

In the present study, blood pressure patterns differed significantly between diabetic and non-diabetic participants. Elevated blood pressure was more prevalent among diabetic participants, whereas normal blood pressure was more common among

non-diabetic participants. Interestingly, Stage 1 hypertension was more prevalent among non-diabetic participants, while Stage 2 hypertension showed a comparable distribution between the groups. The higher prevalence of elevated blood pressure among diabetic participants is biologically plausible because insulin resistance and chronic hyperglycaemia promote endothelial dysfunction, oxidative stress, sodium retention, and sympathetic activation, all of which favour increased vascular resistance and blood pressure.^{5,11,27} These findings are consistent with reports linking diabetes with impaired vascular function, arterial stiffness, and increased cardiovascular risk.^{5,6}

The unexpected predominance of Stage 1 hypertension among non-diabetic participants may reflect antihypertensive treatment among diabetic participants, the relatively small sample size, the cross-sectional design, or other determinants such as obesity, physical inactivity, dietary sodium intake, age, and genetic susceptibility.^{16,27,28} The comparable distribution of Stage 2 hypertension further suggests that severe hypertension is influenced by multiple factors beyond diabetes status, including vascular, metabolic, renal, and neurohormonal factors.^{12,10,27}

A significant association was also observed between diabetes status and HbA1c classification, with diabetic participants demonstrating poorer long-term glycaemic control than non-diabetic participants. HbA1c reflects average glycaemic exposure over the preceding two to three months and results from non-enzymatic glycation of haemoglobin; consequently, sustained hyperglycaemia increases HbA1c concentrations.^{11,29}

This finding is consistent with previous reports identifying HbA1c as a reliable marker of long-term glycaemic control and diabetes-related risk, while clinical recommendations support individualized glycaemic targets to reduce microvascular and macrovascular complications.^{2,3,11}

The coexistence of poor glycaemic control and abnormal blood pressure profiles among diabetic participants may reflect the shared metabolic pathways linking chronic hyperglycaemia, insulin resistance, oxidative stress, endothelial injury, and vascular dysfunction. Persistent hyperglycaemia promotes the formation of advanced glycation end products (AGEs), activates protein kinase C, increases reactive oxygen species production, and stimulates inflammatory cytokine release, all of

which impair vascular function and contribute to hypertension and cardiovascular disease.^{6,7} Thus, deterioration in glycaemic control is frequently accompanied by worsening cardiovascular risk factors, including elevated blood pressure.

Overall, the findings of this study demonstrate that diabetic participants had significantly poorer long-term glycaemic control and a less favourable blood pressure profile than non-diabetic controls. The significant associations between diabetes status, hypertension classification, and HbA1c highlight the close biochemical and clinical interplay between chronic hyperglycaemia and cardiovascular dysfunction in T2DM. These also underscore the importance of integrated monitoring of HbA1c and blood pressure as complementary indicators of metabolic control and cardiovascular risk, while reinforcing the need for early intervention and comprehensive management strategies aimed at improving glycaemic control and reducing hypertension-related complications among individuals with diabetes.

4.0 Conclusion

This study demonstrated that type 2 diabetes mellitus is associated with significant alterations in cardiovascular risk factors, particularly dyslipidaemia, abnormal blood pressure patterns, and poor long-term glycaemic control among adults in Calabar, Nigeria. Diabetic participants exhibited significantly higher serum low-density lipoprotein (LDL) cholesterol and total cholesterol concentrations than non-diabetic controls, indicating the presence of atherogenic dyslipidaemia and an increased risk of cardiovascular disease. Although anthropometric indices and routine clinical parameters, including body mass index, waist-hip ratio, systolic and diastolic blood pressure, and pulse rate, were comparable between the two groups, diabetic participants were significantly more likely to exhibit elevated blood pressure and poor glycaemic control, as evidenced by the higher prevalence of elevated blood pressure and diabetic-range HbA1c values.

These findings also highlight the close interplay between chronic hyperglycaemia, dysregulated lipid metabolism, endothelial dysfunction, and cardiovascular risk in type 2 diabetes mellitus. The observed elevations in LDL cholesterol, total cholesterol, and HbA1c underscore the importance

of routine lipid profile assessment, blood pressure monitoring, and glycaemic evaluation for early identification of individuals at increased risk of diabetes-related cardiovascular complications. Overall, the study provides valuable local evidence on the cardiometabolic profile of adults with type 2 diabetes mellitus in Calabar and supports the implementation of comprehensive risk assessment and integrated management strategies aimed at improving metabolic control, reducing cardiovascular morbidity, and preventing long-term complications in resource-limited settings.

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Competing Interest

The authors declare that they have no conflicts of interest related to this study or its publication.

Authors' Contributions

All authors contributed to the conception and design of the study, data collection, analysis and interpretation of the results, and drafting and critical revision of the manuscript. All authors reviewed and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

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