

An Evaluation of Lipid Profile among Patients with Type 2 Diabetes Mellitus using Total Cholesterol (TC), Triglycerides (TG), High-Density Lipoprotein Cholesterol (HDL-C), and Low-Density Lipoprotein Cholesterol (LDL-C)

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Abstract

The study sought to evaluate the lipid profile among type 2 diabetic patients using total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) in type 2 diabetic patients. In carrying out the study, a comparative cross-sectional design was adopted. The study population consisted of one hundred (100) diagnosed type 2 diabetic patients and one hundred (100) apparently healthy, age- and sex-matched non-diabetic individuals who served as controls. All participants were aged between 30 and 70 years. Ten (10) mL of venous blood samples were collected from each participant after overnight fast using standard aseptic procedures and distributed into appropriate tubes for the determination of fasting plasma glucose (FPG), glycated hemoglobin (HbA1c), insulin, lipid profile, and oxidative stress markers. Serum and plasma were prepared by centrifugation at 3000 rpm for 10 minutes, while whole blood was used for selected analyses. The samples were analyzed using standard laboratory methods. Data obtained were analyzed using Statistical Package for Social Sciences (SPSS) version 25.0. Results were expressed as Mean $\pm$ Standard Deviation. The test of significance was determined using independent samples t-test, while Pearson correlation analysis was used to assess relationships between variables, with $p < 0.05$ considered statistically significant. There were significantly higher mean levels of total cholesterol, triglycerides, and low-density lipoprotein cholesterol ($p = 0.000$ for all) in Type 2 diabetic patients (6.60 ± 0.57 mmol/L, 2.68 ± 0.52 mmol/L, and 4.42 ± 0.59 mmol/L, respectively) when compared to controls (4.16 ± 0.42 mmol/L, 1.16 ± 0.19 mmol/L, and 2.35 ± 0.46 mmol/L, respectively). There was a significantly lower mean level of high-density lipoprotein cholesterol ($p = 0.000$) in Type 2 diabetic patients (1.02 ± 0.14 mmol/L) compared to controls (1.54 ± 0.17 mmol/L). The study concluded that Type 2 diabetes is frequently accompanied by abnormalities in lipid metabolism, which may manifest as elevated TC, TG, and LDL-C levels together with reduced HDL-C levels. One of the recommendations made was that Lipid profile testing, including TC, TG,

HDL-C, and LDL-C, should be carried out routinely among type 2 diabetic patients to facilitate early detection and management of lipid abnormalities.

Keywords: Lipid Profile, Type 2 Diabetic, Patient, Cholesterol (Tc), Triglycerides (Tg), High-Density, Lipoprotein Cholesterol (Hdl-C), Low-Density, Lipoprotein Cholesterol (Ldl-C)

Introduction

Dyslipidemia is a common feature of type 2 diabetes mellitus and contributes significantly to the increased cardiovascular risk observed in diabetic patients[1][2]. The characteristic diabetic lipid profile includes elevated triglycerides, decreased HDL-cholesterol, and increased small dense LDL particles. These abnormalities result from insulin resistance affecting lipid metabolism in the liver and peripheral tissues[3]. These lipid abnormalities contribute to the increased cardiovascular risk observed in obese diabetic patients[4][5]. Beyond glycemic status, the study revealed a significant state of dyslipidemia among Type 2 diabetic patients in Owerri, Total cholesterol levels were significantly higher in type 2 diabetic patients compared to the control group.

Feingold and Grunfeld provided a comprehensive review of diabetes and dyslipidemia, noting that poor glycemic control increases serum triglyceride and non-HDL cholesterol levels while decreasing HDL-C levels. The authors emphasized that lipid management is a critical component of diabetes care, with statins being the first-line therapy for cardiovascular risk reduction in diabetic patients. They noted that most patients with diabetes will require statin therapy, with intensity of therapy based on cardiovascular risk[6]. The biochemical profile of diabetic patients can vary significantly based on genetic, environmental, dietary, and lifestyle factors. Previous research has demonstrated that diabetic patients in different populations may exhibit distinct patterns of glycemic control, lipid abnormalities, oxidative stress markers, and inflammatory parameters[7].

Biochemical variations—including dysregulated glucose metabolism, dyslipidemia characterized by elevated triglycerides and reduced high-density lipoprotein cholesterol, and chronic low-grade inflammation marked by elevated inflammatory mediators such as tumor necrosis factor-alpha (TNF- α), interleukin-6 (IL-6), and C-reactive protein (CRP)—constitute fundamental pathophysiological mechanisms driving insulin resistance and β -cell dysfunction in T2DM patients[8][9]. Studies have shown that African populations may have different patterns of lipid abnormalities compared to Caucasian populations, with potentially higher HDL-cholesterol levels and different relationships between BMI and diabetes risk. Understanding these patterns in the local context of Owerri is essential for developing appropriate diagnostic and therapeutic strategies tailored to this population.

Statement Of Problem

Despite the growing burden of type 2 diabetes mellitus in Nigeria, there is limited information on the prevalence and specific patterns of dyslipidemia among diabetic patients in Owerri and surrounding areas. Although dyslipidemia is an important metabolic abnormality associated with diabetes and contributes substantially to cardiovascular complications, existing studies have largely focused on other regions of Nigeria or have examined diabetic populations without sufficient attention to local geographic differences. Diabetic patients may present with different lipid patterns depending on genetic predisposition, dietary habits, obesity, glycaemic control, lifestyle, and environmental factors. Consequently, findings from other populations may not accurately represent the lipid profile characteristics of diabetic patients in Owerri. There is therefore a need to establish the prevalence of dyslipidemia in this population and determine the extent to which individual lipid parameters, including total cholesterol, triglycerides, low-density lipoprotein (LDL) cholesterol, and high-density lipoprotein (HDL) cholesterol, are abnormal [10].

Furthermore, the limited availability of local data makes it difficult for healthcare providers to identify the predominant lipid abnormalities among diabetic patients in Owerri and to develop appropriate strategies for cardiovascular risk assessment and management. The relationship between diabetes and

lipid abnormalities is influenced by the broader metabolic disturbances associated with insulin resistance, adiposity, and poor glycaemic control, yet these relationships have not been adequately characterized in the local population. Without reliable information on the prevalence of dyslipidemia and the specific lipid fractions most commonly affected, opportunities for early detection, targeted treatment, and prevention of diabetes-related cardiovascular complications may be missed. This study therefore seeks to address this gap by determining the prevalence of dyslipidemia and identifying the specific lipid profile abnormalities among diabetic patients in Owerri, thereby providing locally relevant evidence for improved clinical management and risk stratification.

Objectives

The specific objectives of this study are to:

1. Evaluate the lipid profile including total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) in type 2 diabetic patients.

Research Questions

This study seeks to answer the following research questions:

1. What is the prevalence of dyslipidemia and what are the specific lipid profile abnormalities in this diabetic population?

Theoretical Framework

The theoretical framework for investigating the prevalence of dyslipidemia and specific lipid profile abnormalities among type 2 diabetic patients in Owerri is anchored primarily on the **metabolic syndrome paradigm**, supported by the **twin cycle hypothesis** and the **adipose tissue expandability hypothesis** presented in the existing framework. The metabolic syndrome paradigm explains that type 2 diabetes is associated with a cluster of metabolic abnormalities arising from insulin resistance and adipose tissue dysfunction, including elevated triglycerides, reduced high-density lipoprotein (HDL) cholesterol and abnormalities in other lipid fractions. Based on these theoretical perspectives, the study expects dyslipidemia among the diabetic population to be expressed through specific abnormalities such as **elevated total cholesterol, increased triglycerides, elevated low-density lipoprotein (LDL) cholesterol and reduced HDL cholesterol**, with the prevalence and severity of these abnormalities potentially influenced by central obesity, disease duration, glycaemic control, lifestyle and other metabolic factors.

The Metabolic Syndrome Paradigm

The metabolic syndrome construct provides a comprehensive theoretical framework linking anthropometric variations to biochemical abnormalities and cardiovascular risk. Originally described by Reaven[11] as “Syndrome X” and subsequently refined by multiple organizations including the World Health Organization this paradigm conceptualizes T2DM not as an isolated disorder of glucose metabolism but as one component of a broader constellation of interrelated metabolic disturbances.

Central to this framework is the recognition that central obesity, measured through anthropometric indices such as waist circumference, waist-to-hip ratio, and body mass index (BMI), serves as the phenotypic marker for underlying insulin resistance and adipose tissue dysfunction[12][13]. The expanded adipose tissue mass, particularly in visceral depots, functions not merely as passive energy storage but as an active endocrine organ secreting adipokines, inflammatory mediators, and other bioactive substances that modulate systemic metabolism[14]. This theoretical understanding predicts that T2DM patients in Owerri will demonstrate characteristic anthropometric patterns, including increased central adiposity, and that these measurements will correlate with biochemical parameters such as elevated triglycerides, reduced high-density lipoprotein (HDL) cholesterol, elevated blood pressure, and impaired fasting glucose—the classic components of metabolic syndrome[15].

The American Diabetes Association Standards of Care 2023, 2024 incorporate this framework by emphasizing that diabetes management must address the complete cardiovascular risk profile rather than glycemic control alone, recognizing that anthropometric assessment provides essential information for risk stratification and treatment selection. For the Owerri population, this theoretical perspective suggests that anthropometric variations will not merely describe body composition but will serve as surrogate indicators for the severity of underlying metabolic dysfunction and the risk of diabetes complications.

Lipid Profile Abnormalities

Dyslipidemia is a common feature of type 2 diabetes mellitus and contributes significantly to the increased cardiovascular risk observed in diabetic patients. The characteristic diabetic lipid profile includes elevated triglycerides, decreased HDL-cholesterol, and increased small dense LDL particles. These abnormalities result from insulin resistance affecting lipid metabolism in the liver and peripheral tissues.

Feingold and Grunfeld provided a comprehensive review of diabetes and dyslipidemia, noting that poor glycemic control increases serum triglyceride and non-HDL cholesterol levels while decreasing HDL-C levels. The authors emphasized that lipid management is a critical component of diabetes care, with statins being the first-line therapy for cardiovascular risk reduction in diabetic patients. They noted that most patients with diabetes will require statin therapy, with intensity of therapy based on cardiovascular risk.

Kalra and Raizada further elaborated on dyslipidemia in diabetes, highlighting that weight loss can significantly improve lipid levels. A 5-10% reduction in body weight can decrease triglycerides by up to 30% and increase HDL-cholesterol by up to 15%. The authors noted that combination therapies may be beneficial in reducing cardiovascular disease risk in patients with diabetes, particularly those with mixed dyslipidemia.

The Heart Outcomes Prevention Evaluation (HOPE) study demonstrated the cardiovascular benefits of intensive lipid management in diabetic populations. The study showed that statin therapy reduced the risk of major cardiovascular events by approximately 25% in diabetic patients, similar to the benefit observed in non-diabetic patients. These findings support the aggressive management of dyslipidemia in diabetes.

Pathophysiological Foundation: The “Twin Cycle Hypothesis” and β -Cell Dysfunction

The fundamental theoretical underpinning of T2DM pathophysiology derives from the understanding that the disease represents a progressive disorder of glucose metabolism characterized by two primary defects: insulin resistance in peripheral tissues and progressive β -cell dysfunction leading to relative insulin deficiency. The “twin cycle hypothesis” proposed by Taylor and subsequently elaborated provides a mechanistic explanation for these phenomena, suggesting that chronic energy excess leads to ectopic fat accumulation in the liver and pancreas, creating a vicious cycle where hepatic insulin resistance drives increased hepatic glucose production while pancreatic fat deposition impairs β -cell function.

This theoretical perspective is particularly relevant to the Nigerian context, where rapid nutrition transition has resulted in increased caloric intake coupled with decreased physical activity, creating conditions favorable for ectopic lipid deposition. The hypothesis predicts that individuals in Owerri, experiencing similar environmental pressures, would demonstrate characteristic biochemical signatures including elevated fasting plasma glucose, impaired glucose tolerance, and compensatory hyperinsulinemia during early disease stages, progressing toward β -cell exhaustion and relative hypoinsulinemia as the disease advances. The biochemical variations observed in this population—including dyslipidemia, altered liver enzyme profiles, and markers of insulin resistance—can be theoretically understood as downstream consequences of this ectopic fat deposition and subsequent metabolic organ dysfunction.

Pathophysiology of Type 2 Diabetes Mellitus

Insulin Resistance and Beta-Cell Dysfunction

Type 2 diabetes mellitus is characterized by two fundamental pathophysiological defects: insulin resistance and progressive beta-cell dysfunction. Insulin resistance refers to the diminished ability of insulin to stimulate glucose uptake in peripheral tissues (primarily skeletal muscle and adipose tissue) and to suppress hepatic glucose production. In the early stages of the disease, pancreatic beta cells compensate for insulin resistance by increasing insulin secretion, maintaining normoglycemia. This compensatory phase may last for years or even decades before beta-cell function deteriorates to the point where relative insulin deficiency and hyperglycemia develop.

The mechanisms underlying insulin resistance are complex and involve multiple tissues and signaling pathways. In skeletal muscle, insulin resistance results in reduced glucose uptake and utilization, contributing to postprandial hyperglycemia (Shi et al., 2022). Recent research has highlighted the role of mitochondrial dynamics and endoplasmic reticulum (ER) stress in muscle insulin resistance. Mitochondria-associated ER membranes (MAMs) serve as critical sites for calcium, lipid, and metabolite exchange, and their dysregulation has been implicated in the pathogenesis of muscle insulin resistance. Additionally, alterations in mitochondrial dynamics and elevated levels of mitophagy—specifically the PINK1-Parkin-mediated pathway—have been linked to the onset of insulin resistance in type 2 diabetes. ER stress activates the unfolded protein response (UPR) through three major sensors: PKR-like ER kinase (PERK), inositol requiring enzyme 1 (IRE-1), and activating transcription factor 6 (ATF6).

Glucotoxicity impairs beta-cell function through multiple mechanisms, including increased oxidative stress, activation of stress signaling pathways, and impaired insulin gene transcription. Lipotoxicity contributes to beta-cell dysfunction through the accumulation of ceramides and other toxic lipid metabolites. Exposure of beta-cells to palmitate recapitulates key features of beta-cell failure, inducing apoptosis, raising basal insulin secretion, and inhibiting glucose-stimulated insulin secretion (GSIS). The molecular mechanisms underlying lipo- and glucolipotoxicity include ER stress, oxidative stress with excessive ROS production, mitochondrial dysfunction, inflammation, and impaired autophagic flux. Beta-cells from type 2 diabetes donors show signs of dysregulated autophagy, with more abundant autophagic vacuoles and autophagosomes, which can be induced by in vitro exposure of human islets to free fatty acids.

Dyslipidemia

Dyslipidemia in T2DM is characterized by a specific pattern of lipid abnormalities including elevated fasting triglycerides (≥ 150 mg/dL or 1.7 mmol/L), reduced HDL cholesterol (< 40 mg/dL or 1.0 mmol/L in men, < 50 mg/dL or 1.3 mmol/L in women), increased small dense LDL particles, and elevated apolipoprotein B. This atherogenic lipid profile results from insulin resistance-induced increases in free fatty acid flux, enhanced hepatic VLDL synthesis, reduced lipoprotein lipase activity, and altered cholesteryl ester transfer protein function. The American Diabetes Association emphasizes that dyslipidemia management is integral to comprehensive diabetes care, with statin therapy recommended for most diabetic patients regardless of baseline lipid levels given the markedly elevated cardiovascular disease risk.

Methodology

In carryout this study, comparative cross-sectional was adopted. The study population consisted of one hundred (100) diagnosed type 2 diabetic patients and one hundred (100) apparently healthy, age- and sex-matched non-diabetic individuals who served as controls. All participants were aged between 30 and 70 years. Ten (10) mL of venous blood samples were collected from each participant after an overnight fast using standard aseptic procedures and distributed into appropriate tubes for the determination of fasting plasma glucose (FPG), glycated hemoglobin (HbA1c), insulin, lipid profile,

and oxidative stress markers. Serum and plasma were prepared by centrifugation at 3000 rpm for 10 minutes, while whole blood was used for selected analyses. The samples were analyzed using standard laboratory methods. Data obtained were analyzed using Statistical Package for Social Sciences (SPSS) version 25.0. Results were expressed as Mean $\pm$ Standard Deviation. The test of significance was determined using independent samples t-test, while Pearson correlation analysis was used to assess relationships between variables, with $p < 0.05$ considered statistically significant.

Result and Dicussion

Lipid Profile in Type 2 Diabetic Patients Versus Controls

There were significantly higher mean levels of total cholesterol, triglycerides, and low-density lipoprotein cholesterol ($p = 0.000$ for all) in Type 2 diabetic patients (6.60 ± 0.57 mmol/L, 2.68 ± 0.52 mmol/L, and 4.42 ± 0.59 mmol/L, respectively) when compared to controls (4.16 ± 0.42 mmol/L, 1.16 ± 0.19 mmol/L, and 2.35 ± 0.46 mmol/L, respectively).

There was a significantly lower mean level of high-density lipoprotein cholesterol ($p = 0.000$) in Type 2 diabetic patients (1.02 ± 0.14 mmol/L) compared to controls (1.54 ± 0.17 mmol/L) (Table 1).

Table 1. Mean $\pm$ SD Levels of Lipid Profile Parameters in Type 2 Diabetic Patients Versus Controls

Variables (Mean $\pm$ SD)	Type 2 Diabetics (n=100)	Control (n=100)	t-value	p-value
TC (mmol/L)	6.60 ± 0.57	4.16 ± 0.42	34.414	0.000
TG (mmol/L)	2.68 ± 0.52	1.16 ± 0.19	27.560	0.000
HDL-C (mmol/L)	1.02 ± 0.14	1.54 ± 0.17	-24.296	0.000
LDL-C (mmol/L)	4.42 ± 0.59	2.35 ± 0.46	27.660	0.000

Key:

Values are expressed as Mean $\pm$ Standard Deviation

$p \leq 0.05$ is considered statistically significant

TC: Total Cholesterol

TG: Triglycerides

HDL-C: High Density Lipoprotein Cholesterol

LDL-C: Low Density Lipoprotein Cholesterol

Beyond glycemic status, the study revealed a significant state of dyslipidemia among Type 2 diabetic patients in Owerri. Total cholesterol levels were significantly higher in type 2 diabetic patients compared to the control group. This elevation suggests an imbalance in cholesterol homeostasis, which may be attributed to increased hepatic synthesis and reduced clearance of cholesterol-containing lipoproteins. In insulin-resistant states, the inhibitory effect of insulin on hepatic very-low-density lipoproteins (VLDL) production is diminished, leading to increased secretion of cholesterol-rich particles.

Conclusion

In conclusion, the evaluation of lipid profile among type 2 diabetic patients using total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) provides important information about the cardiovascular risk associated with

diabetes mellitus. Type 2 diabetes is frequently accompanied by abnormalities in lipid metabolism, which may manifest as elevated TC, TG, and LDL-C levels together with reduced HDL-C levels. Such lipid abnormalities can increase the likelihood of atherosclerosis, coronary heart disease, stroke, and other cardiovascular complications among diabetic patients. Therefore, regular assessment of the lipid profile should form an essential component of diabetes management, alongside proper glycaemic control, healthy dietary practices, physical activity, weight management, and appropriate lipid-lowering treatment. Early identification and management of dyslipidaemia can help reduce cardiovascular complications and improve the overall health and quality of life of individuals living with type 2 diabetes. Lipid profile testing, including TC, TG, HDL-C, and LDL-C, should be carried out routinely among type 2 diabetic patients to facilitate early detection and management of lipid abnormalities. Diabetic patients should be encouraged to adopt healthy lifestyle practices, including consumption of a balanced diet low in saturated fats and refined sugars, regular physical activity, maintenance of a healthy body weight, and avoidance of smoking and excessive alcohol consumption. Healthcare professionals should ensure timely management of patients with abnormal lipid levels through individualized treatment, including dietary counselling and lipid-lowering medications such as statins where clinically indicated, together with regular monitoring of treatment response.

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