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Original Research Article

Association Between Glycated Hemoglobin (HbA1c) and Lipid Profile in Type 2 Diabetes Mellitus: A Retrospective Cross-Sectional Analysis

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Abstract:

Background: Type 2 diabetes mellitus (T2DM) is associated with dyslipidemia, increasing cardiovascular risk. Glycated hemoglobin (HbA1c) reflects long-term glycemic control and may influence lipid metabolism, though findings remain inconsistent.

Aim: To investigate the association between HbA1c and lipid profile in patients with T2DM.

Methodology: A retrospective cross-sectional study was conducted on 488 adults (≥45 years) with T2DM at Himalaya Medical College and Hospital, Patna, India. Data on demographics, HbA1c, fasting glucose, and lipid parameters (total cholesterol, triglycerides, LDL-c, HDL-c) were extracted from medical records. Pearson correlation, independent t-tests, and multiple linear regression analyses were performed using SPSS v26.

Results: Mean HbA1c was 8.38 ± 1.74%. Dyslipidemia was prevalent: 34.6% had high total cholesterol, 34.8% elevated triglycerides, 59.8% high LDL-c, and 40% low HDL-c. Regression analysis revealed HbA1c was a significant positive predictor of total cholesterol (β=2.502, p=0.043) and triglycerides (β=7.842, p<0.001), but not LDL-c or HDL-c. Gender, age, diastolic blood pressure, and BMI also influenced lipid levels. Females exhibited higher HbA1c and more adverse lipid profiles than males.

Conclusion: Poor glycemic control in T2DM is associated with adverse lipid alterations, particularly elevated total cholesterol and triglycerides. Integrated management addressing both glycemia and lipid abnormalities is essential to reduce cardiovascular risk.

Keywords: Type 2 Diabetes Mellitus, Hba1c, Lipid Profile, Dyslipidemia, Cardiovascular Risk.

Introduction

Diabetes mellitus is one of the most common metabolic disorders worldwide and presents a significant public health problem, considering its rising prevalence and related complications. During the last decades, the trend in the prevalence of diabetes mellitus has increased dramatically in Saudi Arabia, increasing from 3.4% in 1996 to more than 20% lately. This drastic trend is highly related to the sharp alteration of lifestyle, including a decrease in physical activity and the shift toward urbanization and calorie-dense diets [1]. Thus, Saudi Arabia nowadays occupies the seventh rank among the top ten countries in the world with regard to the highest prevalence of diabetes mellitus [2]. The increasing burden of diabetes poses not only individual health problems but also significant economic and healthcare burdens on the national health system.

As stated, diabetes has become one of the main contributors to morbidity and mortality worldwide. In 2011, about 366 million people were reported to have diabetes, with an estimated increase to 552 million in 2030 [3]. The majority are T2DM, which is reportedly affecting an estimated 380 million people throughout the world, while approximately 400 million are with impaired glucose tolerance. Most of the people affected by diabetes are undiagnosed, hence creating an underestimate of the real prevalence of the disease in populations and occurring at the expense of early detection [4]. In Saudi Arabia, it is estimated that about 7 million people are suffering from diabetes, whereas almost 3 million are classified as pre-diabetic [5].

The rise in the incidence of T2DM is closely related to sedentary lifestyles and dietary transitions toward Western-style diets, typically high in refined carbohydrates, sugars, and unhealthy fats [6]. This kind of lifestyle contributes not only to the development of obesity-related diabetes but also to the development of associated metabolic complications. Diabetes is now considered the most prevalent non-communicable disease in Saudi Arabia and plays an important role in increased morbidity, as well as in an increased risk of hypertension, atherosclerosis, and dyslipidemia. These metabolic disturbances underscore the need for effective early detection, monitoring, and management strategies in order to reduce the long-term burden of disease.

Glycated hemoglobin, HbA1c, has emerged as a reliable biomarker for diagnosis and follow-up of diabetes mellitus. According to the American Diabetes Association, an HbA1c level of ≥6.5% is diagnostic for diabetes, while pre-diabetes is defined by HbA1c levels ranging from 5.7% to 6.4% [7]. HbA1c reflects the average plasma glucose concentration over the preceding two to three months, although several advantages over traditional glucose-based tests exist. These advantages include minimal intra-individual variability, independence from fasting status, and ease of measurement, which are all factors that make HbA1c a good marker for monitoring long-term glycemic control. Despite these advantages of HbA1c, factors like hemoglobinopathies, such as sickle cell disease, and ethnic variation, expressed in the population of Asian descent [8], may affect the accuracy and sensitivity of HbA1c. Thus, its level should be interpreted with caution in such conditions.

Dyslipidemia, particularly atherogenic dyslipidemia, is a common metabolic complication among patients with T2DM, characterized by elevated triglycerides, low levels of high-density lipoprotein cholesterol, and increased low-density lipoprotein cholesterol-all of which contribute to the development of both macrovascular and microvascular complications 9. Macrovascular complications include cardiovascular diseases like coronary artery disease and stroke, while microvascular complications include neuropathy, nephropathy, and retinopathy. Several studies have documented that HbA1c could be a good predictor of dyslipidemia and also of cardiovascular risk, thus its role extends beyond monitoring glycemia 10.

However, the relationship between HbA1c and lipid profile is controversial. Although some studies have demonstrated significant correlations of HbA1c with some parameters of lipid profile, others reported weak, negative, or non-significant correlations. For example, Indian diabetic patients in some studies did not show any significant correlation of HbA1c with the lipid profile [11]. Similarly, some studies reported a negative correlation of HbA1c with levels of LDL and a positive correlation with triglycerides. In Saudi Arabia, one study on 206 diabetic patients correlated triglycerides as the only lipid parameter which had a significant association with HbA1c [12]. These conflicting reports clearly indicate more research is needed to establish the exact role of glycemic control as measured by HbA1c and lipid abnormalities in T2DM patients.

Given the increasing prevalence of diabetes and its complications in Saudi Arabia, the interrelationship between HbA1c and lipid profile needs to be understood for risk stratification and management of T2DM. This will help identify those patients who have an increased risk of developing cardiovascular events and enable strategies for their early intervention through lifestyle modification and pharmacotherapy. Thus, this present research tries to identify the association between HbA1c and lipid profile in a relatively large sample of patients with T2DM and contributes to the evidence regarding metabolic risk assessment and comprehensive diabetes management.

Materials and Methods

Study Design and Study Area: This retrospective cross-sectional study was conducted at the Department of General Medicine, Himalaya Medical College and Hospital, Paliganj, Patna, Bihar, India.

Study Duration: The data were collected for the period of one year.

Sample Size and Population: The study included a total of 488 patients diagnosed with T2DM. The sample size was deemed sufficient to identify statistically significant associations between glycated hemoglobin (HbA1c) and lipid profile parameters. Patients were selected using a random sampling technique from the hospital's medical records.

The study population consisted of adult patients (≥45 years) with newly diagnosed or previously confirmed T2DM who had complete records of HbA1c and lipid profile tests.

Inclusion Criteria

Patients were included in the study if they met the following criteria:

- Adults aged 45 years or older.
- Diagnosed with T2DM according to the American Diabetes Association (ADA) criteria:
    - HbA1c ≥ 6.5%
    - Fasting plasma glucose (FPG) ≥ 126 mg/dL (7.0 mmol/L)
    - 2-hour postprandial plasma glucose ≥ 200 mg/dL (11.1 mmol/L) during oral glucose tolerance test (OGTT)
    - Random plasma glucose ≥ 200 mg/dL (11.1 mmol/L)

Exclusion Criteria

Patients were excluded if they:

- Were receiving lipid-lowering therapy.
- Had cardiovascular diseases, liver or renal impairment, or other endocrinal disorders.
- Had mental health conditions that could interfere with data collection.
- Had incomplete or missing laboratory records.

Data Collection: Data were collected retrospectively from patient medical records. Information on demographics, including age, sex, marital status, occupation, and educational level, was recorded. Clinical variables such as body mass index (BMI), blood pressure, HbA1c levels, and lipid profile parameters (total cholesterol, HDL-c, LDL-c, and triglycerides) were also extracted. All collected data were anonymized and entered into a structured data collection sheet to ensure patient confidentiality and maintain data integrity.

Procedure: Medical records of patients meeting the inclusion criteria were identified and reviewed. Relevant laboratory and clinical data were systematically extracted and entered into a secure database for analysis. The primary focus was to evaluate potential associations between patients' HbA1c levels and their lipid profile parameters, providing insight into the relationship between glycemic control and lipid metabolism.

Statistical Analysis: Data analysis was performed using SPSS version 26. Descriptive statistics were employed to summarize demographic and clinical characteristics, with continuous variables presented as mean ± standard deviation (SD) and categorical variables expressed as frequencies and percentages. The relationship between HbA1c and lipid profile parameters, including total cholesterol, LDL-c, HDL-c, and triglycerides, was assessed using Pearson correlation for continuous variables. Independent t-tests were applied for dichotomous variables, and the Chi-squared test was used for categorical variables. To account for potential confounding factors such as age, sex, BMI, and blood pressure, multiple linear regression analysis was conducted. A p-value of less than 0.05 was considered statistically significant."

Result

Table 1 presents the sociodemographic characteristics of 488 patients with type 2 diabetes mellitus, showing a slightly higher proportion of males (53.3%) than females (46.7%). Most participants were between 55–64 years (43%), followed by 45–54 years (29.1%), while those aged 75+ constituted only 9%. A large majority were non-smokers (86.3%). Most patients were married (79.3%), and employment status varied, with 40.4% unemployed, 34% employed, and 25.6% retired. Educational attainment showed that 43.9% had secondary education, 30.1% primary, and 21.5% university/postgraduate qualifications, while 4.5% were illiterate. Overall, the table reflects a predominantly middle-aged to older adult population with varied socioeconomic backgrounds.

Table 1: Sociodemographic characteristics of T2DM patients (N = 488)

Characteristics	Frequency	Percentage (%)
Gender		
Female	228	46.7
Male	260	53.3
Age		
45–54 years	142	29.1
55–64 years	210	43
65–74 years	92	18.9
75+ years	44	9
Smoking		
Smoker	67	13.7
Non-smoker	421	86.3
Marital status		
Single/Divorced/Widowed	101	20.7
Married	387	79.3
Employment		
Employed	166	34
Unemployed	197	40.4
Retired	125	25.6
Educational level		
Primary	147	30.1
Secondary	214	43.9
University/Postgraduate	105	21.5
Illiterate	22	4.5

Table 2 summarizes the clinical and biochemical characteristics of the 488 participants, showing a high burden of metabolic abnormalities. Most individuals were either overweight or obese, with only 16.0% having normal BMI and more than half falling into Obese I–III categories; the mean BMI was 30.74 ± 5.69. Glycemic measures were markedly abnormal, with 97.1% having elevated HbA1c (mean

8.38 ± 1.74%) and 99.4% showing high fasting glucose (mean 184.9 ± 45.12 mg/dL). Lipid abnormalities were also common: 34.6% had elevated total cholesterol (mean 187.16 ± 46.34 mg/dL), 34.8% had high triglycerides (mean 143.68 ± 79.22 mg/dL), and 59.8% had elevated LDL-c (mean 114.02 ± 39.41 mg/dL). Additionally, 40.0% had low HDL-c (mean 44.62 ± 17.02 mg/dL), highlighting a significant prevalence of dyslipidemia in this population.

Table 2: Clinical and biochemical characteristics (N = 488)

Parameter	Frequency (%)	Min	Max	Mean	SD
BMI					
Underweight	1 (0.2%)	18.1	79.4	30.74	5.69
Normal	78 (16.0%)				
Overweight	161 (33.0%)				
Obese I	153 (31.4%)				
Obese II	70 (14.3%)				
Obese III	25 (5.1%)				
HbA1c (%)					
Normal <6.5%	14 (2.9%)	5.9	15.8	8.38	1.74
High	474 (97.1%)				
Fasting Glucose (mg/dL)					
Normal	3 (0.6%)	118	430	184.9	45.12
High	485 (99.4%)				
Total Cholesterol					
Normal (<200)	319 (65.4%)	70	365	187.16	46.34
High	169 (34.6%)				
Triglycerides					
Normal (<150)	318 (65.2%)	30	710	143.68	79.22
High	170 (34.8%)				
HDL-c					
Low (<40)	195 (40.0%)	5.4	355	44.62	17.02
Normal	293 (60.0%)				
LDL-c					
Normal (<100)	196 (40.2%)	10	279	114.02	39.41
High	292 (59.8%)				

Table 3 shows a gender-wise comparison of biochemical parameters, revealing several significant differences between females and males. Females had significantly higher BMI (31.42 ± 5.38 vs. 30.16 ± 5.88; t = 3.68, p < 0.001), lower diastolic BP (70.9 ± 9.6 vs. 74.4 ± 9.51; t = –5.19, p < 0.001), and higher HbA1c (8.54 ± 1.86 vs. 8.23 ± 1.61; t = 2.71, p = 0.007). Total cholesterol was also significantly higher in females (192.78 ± 47.25) than in males (182.12 ± 45.02; t = 3.41, p = 0.001), as were HDL-c (47.92 ± 19.85 vs. 41.76 ± 11.18; t = 6.88, p < 0.001) and LDL-c levels (116.88 ± 39.14 vs. 111.82 ± 39.62; t = 2.12, p = 0.034). Other parameters—including systolic BP, glucose, and triglycerides—showed no statistically significant gender differences.

Table 3: Gender-wise comparison of biochemical parameters

Parameter	Gender	Mean	SD	Min	Max	t	p
BMI	Female	31.42	5.38	20.2	52.4	3.68	<0.001
	Male	30.16	5.88	18.1	79.4		
SysBP	Female	136.9	19.3	91	260	–1.38	0.17
	Male	138.7	18	100	211		
DiaBP	Female	70.9	9.6	48	112	–5.19	<0.001
	Male	74.4	9.51	49	102		
Glucose	Female	185.4	47.2	118	430	0.26	0.79
	Male	184.5	43.9	122	427		
HbA1c	Female	8.54	1.86	5.9	15.6	2.71	0.007
	Male	8.23	1.61	6.1	15.8		
Total Cholesterol	Female	192.78	47.25	70	351	3.41	0.001
	Male	182.12	45.02	96	365		
Triglycerides	Female	140.34	70.12	30	598	–0.94	0.35

	Male	145.88	85.3	32	710		
HDL-c	Female	47.92	19.85	6	355	6.88	<0.001
	Male	41.76	11.18	5	146		
LDL-c	Female	116.88	39.14	10	231	2.12	0.034
	Male	111.82	39.62	25	279		

Table 4 shows that several factors were significant determinants of total cholesterol levels. Higher total cholesterol was associated with higher diastolic blood pressure ($\beta = 0.388$, $p = 0.019$), higher glucose ($\beta = 0.105$, $p = 0.023$), higher HbA1c ($\beta = 2.502$, $p = 0.043$), being single/divorced ($\beta = 8.114$, $p = 0.033$), being female ($\beta = 10.216$, $p = 0.011$), and having tertiary education ($\beta = 19.334$, $p = 0.032$). In contrast, BMI showed a significant inverse relationship ($\beta = -0.588$, $p = 0.028$). The model demonstrated moderate explanatory strength ($R^2 = 0.083$; adjusted $R^2 = 0.060$; model $p < 0.05$), indicating that these variables collectively contribute to variations in total cholesterol levels.

Table 4: Regression model: Determinants of Total Cholesterol

Variable	**Beta**	**Robust SE**	**T**	**p**	**Model R²; Adj R²; (p-Value)**
BMI	–0.588	0.267	–2.20	0.028	0.083; 0.06; < 0.05
Diastolic BP	0.388	0.165	2.35	0.019	
Glucose	0.105	0.046	2.28	0.023	
HbA1c	2.502	1.231	2.03	0.043	
Single/Divorced	8.114	3.812	2.13	0.033	
Female	10.216	4.012	2.54	0.011	
Tertiary Education	19.334	9.021	2.14	0.032	
Intercept	108.44	17.63	6.15	<0.001	

Table 5 presents the regression model identifying determinants of triglyceride levels. Diastolic blood pressure showed a significant positive association with triglycerides ($\beta = 0.657$, $p = 0.035$). HbA1c was also a strong and statistically significant predictor ($\beta = 7.842$, $p < 0.001$), indicating that higher glycemic levels were associated with increased triglycerides. Gender (female) showed a negative but non-significant association ($\beta = -9.112$, $p = 0.184$). The intercept was not significant ($p = 0.198$). Overall, the model had modest explanatory power ($R^2 = 0.043$; adjusted $R^2 = 0.027$), with diastolic BP and HbA1c emerging as the key determinants of triglyceride levels.

Table 5: Regression model: Determinants of Triglyceride level

Variable	**Beta**	**Robust SE**	**T**	**p**	**Model R²; Adj R²**
Diastolic BP	0.657	0.312	2.11	0.035	0.043; 0.027
HbA1c	7.842	1.982	3.96	<0.001	
Gender (Female)	–9.112	6.854	–1.33	0.184	
Intercept	43.12	33.41	1.29	0.198	

Table 6 presents a regression model evaluating determinants of LDL-cholesterol (LDL-c). Among the predictors, the age group 55–64 years emerged as a significant factor, being associated with higher LDL-c levels ($\beta = 10.12$, $p = 0.046$). BMI showed a negative association with LDL-c ($\beta = -0.384$), and although this trend approached significance, it did not reach statistical significance ($p = 0.086$). Glucose levels also demonstrated a positive but borderline-significant relationship with LDL-c ($\beta = 0.074$, $p = 0.059$). HbA1c was not a significant predictor ($\beta = 1.462$, $p = 0.145$). The model's intercept was significant ($p < 0.001$), and the overall explanatory power was modest ($R^2 = 0.037$; adjusted $R^2 = 0.021$). Overall, only the 55–64 age category showed a statistically significant association with LDL-c.

Table 6: Regression model: Determinants of LDL-c

Variable	**Beta**	**Robust SE**	**T**	**p**	**Model R²; Adj R²**
BMI	–0.384	0.223	–1.72	0.086	0.037; 0.021
Glucose	0.074	0.039	1.9	0.059	
HbA1c	1.462	1.001	1.46	0.145	
Age 55–64	10.12	5.063	2	0.046	
Intercept	73.11	15.02	4.87	<0.001	

Table 7 presents a regression model identifying determinants of HDL-cholesterol (HDL-c). The model shows that diastolic blood pressure is a statistically significant positive predictor of HDL-c (β = 0.097, p = 0.044). Gender also plays a major role, with females having significantly higher HDL-c levels than males (β = 6.514, p < 0.001). HbA1c, however, was not a significant predictor (β = 0.452, p = 0.235). The intercept was significant (p < 0.001), and the model explained a modest proportion of variance in HDL-c (R^2 = 0.048; adjusted R^2 = 0.034). Overall, female gender and higher diastolic BP were the key determinants of HDL-c in this model.

Table 7: Regression model: Determinants of HDL-c

Variable	Beta	Robust SE	T	p	Model R²; Adj R²
Diastolic BP	0.097	0.048	2.02	0.044	0.048; 0.034
Gender (Female)	6.514	1.332	4.89	<0.001	
HbA1c	0.452	0.378	1.19	0.235	
Intercept	28.24	5.16	5.47	<0.001	

Discussion

These findings therefore underscore the profound metabolic dysregulation common in adults with T2DM, as reflected by poor glycemic control and widespread lipid abnormalities. The mean HbA1c levels indicated that nearly all participants had suboptimal glycemic control, a finding that is consistent with evidence from several studies that elevated HbA1c is commonly associated with dyslipidemia in populations with T2DM (Naqvi et al., 2017; Sheth et al., 2015) [13,14]. Consistent with the positive association between triglyceride and HbA1c reported by Bodhe et al. (2012) and Hussain et al. (2017), respectively [15,16]. Our results indicate that chronic hyperglycemia relates to increased triglyceride production through insulin resistance and/or altered lipoprotein metabolism. Likewise, the association of HbA1c with total cholesterol positively in our cohort is consistent with those reported by Bekele et al. (2017) [17] and Naeem et al. (2015) [2], respectively, again emphasizing the possibility that poor glycemic control may further increase overall lipid burden and thereby enhance cardiovascular risk".

Contrasting the strong correlations with triglycerides and total cholesterol, the poor and insignificant correlation of HbA1c with LDL-c in this study is in agreement with several earlier reports by Sarkar & Meshram, 2017; Al Ghadeer et al., 2021 [11,18], while some studies found significant positive correlations between HbA1c and LDL-c as reported by Kundu et al. (2017); Baranwal et al., 2017 [9,10]. HDL-c levels in our study have also shown no meaningful correlation with HbA1c-a pattern noted by Ståhlman et al. (2013) [19] and Samdani et al. (2017) [20] -thereby suggesting that glycemic control may have a limited effect on HDL-c within certain populations or that other factors such as genetic predisposition, hormonal influence, or physical activity may prevail on determining HDL-c.

Gender-wise analysis indicated significantly higher BMI, HbA1c, total cholesterol, LDL-c, and HDL-c in women compared with men, similar to earlier studies that reported higher lipid parameters and glycemic indices in females with T2DM (Naeem et al., 2015; Alzahrani et al., 2019) [2,12]. These differences could be partly due to hormonal influences on fat distribution and lipoprotein metabolism since estrogens have been demonstrated to modulate HDL-c and LDL-c concentrations (Sibley et al., 2006) [21]. However, there are contrasting reports: for example, Baranwal et al. (2017) [10] did not report any significant difference between genders regarding LDL-c and triglycerides, showing that population-specific factors like age distribution, BMI, and duration of diabetes modulate gender-based differences in metabolic profiles. The higher mean BMI (>30 kg/m²) observed in our subjects further confirms the observations made by Firouzi et al. (2015) [22], who demonstrated that obesity promotes poor glycemic control and worsening of the lipid profile and, therefore, emphasizes the importance of weight reduction among interventions for the management of glycemia.

In our study, age was also an important determinant, with higher levels of LDL-c among individuals aged 55-64 years. This finding agrees with the report of Zhang et al. (2021) [23] of a cumulative effect of age on LDL-c exposure and then on cardiovascular risk, pointing out that age-related metabolic changes may contribute to aggravating dyslipidemia in T2DM. Moreover, diastolic blood pressure was positively associated with total cholesterol and triglycerides, which aligns with previous studies reporting that high blood pressure is associated with unfavorable lipid profiles among diabetic patients (Alzahrani et al., 2019; Naqvi et al., 2017) [12,13]. Thus, these relationships point toward the interconnectedness between components of metabolic syndrome, where hypertension, obesity, and hyperglycemia interact and synergistically affect cardiovascular risk.

The prevalence of dyslipidemia in our cohort, especially the elevated LDL-c (60.3%), was higher compared to some regional studies, by Henock et al. (2015) and Qi et al. (2015) [24,25], but agreed with most studies from Gulf populations that usually reported LDL-c prevalence above 50% among T2DM patients, as noted by Alzaheb & Altemani (2020) and Sami & Ab Hamid (2019) [26,27],. These differences could be related to regional eating habits, lifestyle, different health care opportunities, and genetic background. The prevalence of hypercholesterolemia in our study, 34.8%, is lower than the average in Gulf countries and indicates possible benefits of dietary changes and increased health awareness in older diabetic populations, compatible with regional estimates of WHO (WHO, 2019) [28].

Although the current study had a cross-sectional design, its large sample size allowed for a robust evaluation of associations between HbA1c and lipid parameters, thus supporting previous observations that HbA1c can serve as a practical biomarker for predicting dyslipidemia and cardiovascular risk in T2DM (Alzahrani et al., 2019; Sheth et al., 2015) [10,14]. However, it cannot establish a temporal relationship between glycemic control and lipid abnormalities, and therefore longitudinal studies are needed to elucidate causality and the effect of interventions. Single-center data also limit generalizability because lifestyle and sociodemographic factors may vary across regions (Al-Kaabba et al., 2012) [29].

Overall, reinforces the critical link of poor glycemic control with dyslipidemia in patients with T2DM, emphasizing the interaction of gender, age, blood pressure, and obesity in shaping the lipid profile. These findings justify the inclusion of comprehensive metabolic risk assessment, including regular monitoring of HbA1c and lipid parameters for reducing cardiovascular morbidity and guiding individualized management strategies in diabetic populations.

Conclusion

The association between poor glycemic control and adverse lipid changes was clear in this study: increased levels of HbA1c were more likely to be accompanied by unfavorable lipid profiles, especially total cholesterol and triglycerides, from the regression models. Although the strength of these associations varies across lipid fractions, these findings collectively would suggest that chronic hyperglycemia predisposes individuals to dyslipidemia and, hence, possibly to an enhanced cardiovascular risk. Gender and selected sociodemographic factors also seem to influence the lipid parameters, further underscoring the multifactorial nature of metabolic imbalance in diabetes. Overall, the study emphasizes the importance of integrated management strategies that prioritize both optimization of glycemia and regulation of lipids to reduce long-term complications and improve cardiometabolic outcomes in patients with type 2 diabetes.

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