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Nutritional Strategies in Diabetes Mellitus: Interactions Between Dyslipidemia, Hyperglycemia, and Dietary Patterns

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Abstract
Glucose and lipid metabolism are closely linked. Changes in lipid levels can stem from diabetes and disrupt glucose metabolism. Dyslipidemia is often associated with inflammation and an excess of energy-dense nutrients, influenced by poor diet, Obesity, inactivity, and poorly managed blood glucose levels. This study analyzed dietary and non-dietary risk factors among 200 type 2 diabetic patients with and without metabolic syndrome in Khyber Pakhtunkhwa, Pakistan, based on written consent. Conducted in the Endocrinology Ward of Lady Reading Hospital (LRH), it utilized a self-constructed questionnaire to collect demographic, anthropometric, and biochemical data. Anthropometric results showed no significant differences in weight ($p = 0.659$) or BMI ($p = 0.106$) between genders, although females had a higher average BMI (26.12 ± 5.43) than males (24.00 ± 3.70). Biochemical analysis indicated elevated glycemic indices in both groups, with HbA1c levels (9.37 ± 2.41) showing no significant difference ($p = 0.813$ and $p = 0.108$). Lipid profiles for males were within reference ranges without substantial differences in total cholesterol, triglycerides, LDL, or HDL. Multiple regression analysis revealed that BMI significantly predicted triglyceride levels ($\beta = 0.009$, $p = 0.006$) in females, while Age was inversely related to all lipid components ($p < 0.001$). In males, Age positively correlated with triglycerides and HDL ($p = 0.003$ and $p = 0.030$, respectively) and negatively with total cholesterol ($p = 0.007$). HbA1c was inversely related to HDL ($\beta = -0.042$, $p < 0.001$) and total cholesterol ($p < 0.001$). In conclusion, poorly managed hyperglycemia, often due to inadequate dietary intake, significantly increases the risk of dyslipidemia among type 2 diabetics, highlighting the need for nutritional interventions and nutrition education.

Keywords: Type 2 diabetes Mellitus, hyperglycemia, dyslipidemia, body mass index, macronutrients

Highlights

- Overweight and Obesity are more common in patients with type 2 Diabetes Mellitus
- The macronutrient intake pattern of the patients was mush poor and imbalanced
- Patients with T2DM suffer from dyslipidemia
- BMI, Age, and HbA1c are the strongest predictors of dyslipidemia in T2DM

1. Introduction

Diabetes mellitus is a chronic metabolic disease characterized by persistent hyperglycemia due to defects in insulin secretion, insulin action, or both. It is broadly classified into three types: Type 1 diabetes, Type 2 diabetes mellitus (T2DM), and gestational diabetes. T2DM is the most prevalent among these, accounting for more than 90% of all diabetes cases worldwide (DeFronzo et al., 2015).

The global prevalence of diabetes has increased significantly over recent decades, primarily driven by lifestyle changes, urbanization, population growth, and an aging population. As reported by the International Diabetes Federation (2021), approximately 537 million adults aged 20 to 79 were living with diabetes in 2021. This number is expected to rise to 643 million by 2030 and 783 million by 2045. The rising incidence of T2DM among children and adolescents is particularly concerning and is attributed to increasing rates of childhood obesity and sedentary behavior (World Health Organization [WHO], 2021). In Pakistan, the burden of T2DM is particularly severe. According to a meta-analysis of studies from 1995 to 2018, over 24 million individuals are affected, with a pooled prevalence of 10.0% (Khan et al., 2021). The National Diabetes Survey of Pakistan (NDSP) 2016–2017 revealed that 26.3% of the population had diabetes, with higher rates in urban (28.3%) than rural areas (25.3%) (Basit et al., 2018.

In T2DM, a distinct pattern known as diabetic dyslipidemia commonly emerges (Taskinen et al., 2019). Dyslipidemia is a frequent metabolic disorder that greatly elevates the risk of cardiovascular disease. It is typically marked by increased levels of triglycerides, total cholesterol, and low-density lipoprotein cholesterol (LDL-C), along with decreased high-density lipoprotein cholesterol (HDL-C) (Goldberg, 2024). Insulin resistance, a key feature of T2DM, is central to the pathophysiological connection between diabetes and dyslipidemia. It contributes to increased hepatic production of very-low-density lipoproteins (VLDL), impaired triglyceride-rich lipoproteins clearance, and atherogenic LDL particles' development (Bahiru et al., 2021, Mooradian, 2009). Additionally, chronic hyperglycemia and systemic inflammation in

diabetes exacerbate lipid abnormalities, promote endothelial dysfunction, and accelerate atherosclerosis (Vergès, 2015; Fujihara et al., 2013).

A balanced intake of macronutrients, particularly carbohydrates, fats, and proteins, plays a crucial role in glycemic control, improving lipid profiles, and preventing complications in individuals with T2DM (Paddon-Jones et al., 2008). Diets high in simple sugars and refined carbohydrates contribute to postprandial glucose spikes and worsening insulin resistance (Ley et al., 2014), while complex carbohydrates found in whole grains, legumes, and vegetables are associated with improved glycemic control (Slavin, 2013). Proteins can aid glycemic regulation by enhancing satiety and modulating insulin response, mainly derived from lean sources such as fish, poultry, and legumes (Frost et al., 2014; Van Loon et al., 2004). Fat quality is equally essential; diets rich in unsaturated fats, such as those in olive oil and nuts, have improved insulin sensitivity, whereas high saturated fat intake is linked to increased insulin resistance (Pereira et al., 2008). The current study aims to analyze dietary and non-dietary risk factors among diabetic patients with and without metabolic syndrome in Khyber Pakhtunkhwa, Pakistan.

2. Materials and Methods

2.1. Study Design

The Endocrinology Department at Lady Reading Hospital, a tertiary care facility in District Peshawar, conducted this case-control cross-sectional study. Ethical approval was obtained from the Institutional Ethical Approval Committee of the College of Home Economics, University of Peshawar, and the Institutional Ethical Review Board (IERB) of the Lady Reading Hospital. The study adhered to the Helsinki Declaration, ensuring patient confidentiality and safety. The estimated sample size was 189 based on a 95% confidence interval and a 1% probability of comorbidities; however, a total of 200 adult patients with Type 2 Diabetes Mellitus were randomly selected after obtaining written informed consent, with data collection conducted from December 2022 to March 2023.

Inclusion Criteria

The inclusion criteria for the study include only type 2 diabetic patients aged 25 to 60 years.

Exclusion Criteria

The exclusion criteria for the study include type 2 diabetic patients with imputations, any history of infection, and pregnant and lactating women.

2.2. Sample

A written consent sample of 200 male and female patients with type II Diabetes Mellitus was selected randomly from the Endocrinology ward in Lady Reading Hospital (LRH), Peshawar.

2.3. Mode of Data Collection

A self-developed questionnaire and a standardized semi-quantitative Food Frequency Questionnaire (FFQ) designed and validated by a team of nutrition experts was utilized to collect data based on the ABCD (Anthropometric, Biochemical, Clinical, and Dietary) assessment approach.

2.4. Demographic Data

Demographic section includes: gender, Age, marital status, patient occupation, family income and family system respectively.

2.5. Anthropometric Measurement

2.5.1. Age: The ages of all the respondents were taken in years.

2.5.2. Height: The height board or measuring scales measured the Height.

2.5.3. Weight: The weight of all the respondents was taken in kilograms through a weight machine.

2.5.4. Body Mass Index

BMI was calculated through weight and Height. The formula used for BMI was:

BMI = weight in kg/ (Height in m)^2

According to the World Health Organization (WHO), BMI can be classified as follows:

- Below 18.5 means a person is underweight
- between 18.5 and 24.9 means a person is of a "normal," or healthy, weight
- between 25 and 29.9 indicates a person is overweight
- Above 30 indicates a person has Obesity

2.6. Biochemical Analysis

Biochemical data were collected to assess the different values, including blood glucose level (Fasting blood glucose (FBG), Random blood glucose (RBG), and HbA1c), lipid profile (High density lipoprotein (HDL), Low-density lipoprotein (LDL), Cholesterol, and Triglyceride) as per standard laboratory procedures.

2.7. Dietary Assessment

The dietary evaluation involved a detailed assessment of an individual's food intake over 24 hours. Respondents were asked to recall everything they had consumed in the previous 24 hours to evaluate their nutrient intake. Nutrient analysis was subsequently performed using WinDiets Software (2005).

2.8. Statistical Analysis:

Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 20 for entering and analyzing collected data. Descriptive statistics determined the mean and standard deviation for different variables. For comparison of means, one-way ANOVA and regression were used to find out differences between means and variables

3. Results and Discussion

3.1. Anthropometric Indices of the Patients

Table (1) presents the distribution of male and female participants across BMI categories and compares their anthropometric measurements, including Height, weight, and BMI. Female participants had weights ranging from 47 to 100 kg, with a mean of 73.24 ± 12.07 kg, slightly higher than males, whose weights ranged from 48 to 108 kg, with a mean of 70.79 ± 11.63 kg. However, the difference in mean weight between sexes was not statistically significant (p = 0.659). Both means exceeded the respective reference weight ranges (males: 56–71 kg; females: 55–59 kg). Male Height ranged from 164 to 187 cm (mean 172.75 ± 4.45 cm). In comparison, females ranged from 151 to 169 cm (mean 163.42 ± 3.83 cm), showing a statistically significant difference (p = 0.009), with males being taller, consistent with standard reference values (males: 170.18–175.20 cm; females: 162.56–167.64 cm). In terms of BMI, females had a higher mean (26.12 ± 5.43) compared to males (24.00 ± 3.70); although this exceeded the normal BMI range (18.5–24.5), the difference was not statistically significant (p = 0.106). These findings align with previous research by Narayan (2007), IDF (2022), Piché et al. (2020), and Rohm et al. (2022).

Table 1. Anthropometric Profiles of the Patients

Parameters	Male		Female		P Value*	Reference Values
	Range Min - Max	Mean ± SD (P value)	Range Min - Max	Mean ± SD (P value)		
Weight	48 – 108	70.79 ± 11.63 (0.574)	47 - 100	73.24 ± 12.07 (0.854)	0.659	Male = 56 – 71 Female = 55 - 59
Height	164 – 187	172.75 ± 4.45 (0.231)	151 - 169	163.42 ± 3.83 (0.497)	0.009	Male = 170.18 – 175.20 Female =162.56 – 167.64
BMI	16.60 – 34.50	24.00 ± 3.70 (0.296)	19 - 40	26.12 ± 5.43 (0.005)	0.106	Male = 18.5 – 24.5 Female = 18.5 – 24.5

*At 95% confidence interval the values are significant at $P \leq 0.05$

3.2. Blood Lipid & Glycemic Profiles of the Patients

Table (2) provides details of the participants' biochemical parameters, including their ranges, means, standard deviations (SD), p-values, and corresponding reference values. The mean fasting blood glucose level was 172.61 ± 47.36 mg/dL, ranging from 105 to 277 mg/dL substantially higher than the reference range of 100–125 mg/dL indicating possible poor glycemic control or undiagnosed diabetes within the cohort. However, the difference was not statistically significant (p = 0.813). The mean random blood glucose level was 285.88 ± 60.40 mg/dL (range: 201–560 mg/dL), significantly exceeding the normal reference range of 140–199 mg/dL, with a p-value of 0.003, confirming the presence of hyperglycemia. Glycated hemoglobin (HbA1c), a marker of long-term glycemic control, averaged 9.37 ± 2.41% (range: 6.3–14.2%), above the recommended 4.5–7.0% range, indicating chronic hyperglycemia. Despite this, the variation in values rendered the difference statistically non-significant (p = 0.108).Regarding lipid profiles, the mean total cholesterol level was 181.20 ± 17.70 mg/dL (range: 139–220 mg/dL), which is within the acceptable limit of ≤199 mg/dL, with no statistically significant deviation (p = 0.143). Mean triglyceride levels were 149.96 ± 26.58 mg/dL (range: 100–199 mg/dL), bordering the upper limit, though not significantly different from the reference value (p = 0.976). LDL cholesterol averaged 141.98 ± 26.75 mg/dL (range: 100–198 mg/dL), remaining within the normal range of 100–159 mg/dL, with a non-significant p-value (p = 0.938). Conversely, HDL cholesterol averaged 51.44 ± 7.77 mg/dL (range: 40–79 mg/dL), aligning well with the recommended range of 40–60 mg/dL, with no significant difference (p = 0.591). In summary, while blood glucose indicators—particularly random glucose revealed significant dysregulation, lipid parameters largely remained within or close to normal limits, without statistically significant deviations. The results of the current study emphasize the importance of strict lipid control in patients with diabetes to reduce the risk of cardiovascular events. To effectively address dyslipidemia in these patients, a combination of lifestyle changes and intensive drug therapy is necessary. The modern approach to managing diabetic dyslipidemia ensures that this vulnerable group, characterized by high lipid levels, receives adequate treatment to lower the risk of adverse cardiovascular outcomes associated with type 2 diabetes mellitus, as suggested by Kalra and Raizada (2024). Another substantial approach towards the management of hyperglycemia and subsequent dyslipidemia is theutilization of natural sources of bioactive compounds found in herbs, medicinal, and other botanical sources. The study of Naz et al (2023) provides a positive approach to hyperglycemia management by utilizing the essential oil extracted from the leaves of *C. sativa.*

Table 2: Glycemic & Lipid Profiles of the Male Patients

Parameters	Range Min - Max	Mean ± SD	P Value*	Reference Value
		Blood Glucose		
Fasting Blood Glucose	105 – 277	172.61 ± 47.36	0.813	100 – 125 mg/dL
Random Blood Glucose	201 - 560	285.88 ± 60.40	0.003	140 – 199 mg/ dL
HbA1C	6.3 - 14.20	9.37 ± 2.41	0.108	4.5 – 7.0 %
		Lipid Profile		
Total Cholesterol	139 - 220	181.20 ± 17.70	0.143	≤ 199 mg/dL
Triglyceride	100 - 199	149.96 ± 26.58	0.976	≤ 149 mg/dL
LDL	100 - 198	141.98 ± 26.75	0.938	100 – 159 mg/dL
HDL	40 - 79	51.44 ± 7.77	0.591	40 – 60 mg/dL

*At 95% confidence interval the values are significant at P≤0.05

Table (3) presents female participants' blood glucose and lipid profile data, revealing elevated glucose levels across all parameters. Fasting blood glucose ranged from 100 to 275 mg/dL, with a mean of 159.72 ± 42.11 mg/dL above the reference range of 100 to 125 mg/dL. However, this increase was not statistically significant (p = 0.485), likely due to considerable participant variability. Random blood glucose values spanned 200 to 500 mg/dL, with a mean of 290.13 ± 70.42 mg/dL, again exceeding the normal range of 140 to 199 mg/dL. However, the difference remained statistically non-significant (p = 0.551), potentially due to sample size or variability. HbA1c values, reflecting long-term glycemic control, ranged from 6.3 to 14%, with a mean of 9.00 ± 2.15%. The difference was not statistically significant despite being above the recommended range of 4.5 to 7.0% (p = 0.388). These findings suggest suboptimal glycemic control among female patients, although statistical significance was not achieved. In contrast, the lipid profile appeared more favorable. Total cholesterol ranged from 135 to 236 mg/dL, with a mean of 181.70 ± 20.07 mg/dL within the acceptable range (≤199 mg/dL), with no significant difference (p = 0.845). Triglyceride levels ranged from 100 to 199 mg/dL, averaging 143.06 ± 26.47 mg/dL, slightly below the upper threshold (≤149 mg/dL), and were not significantly different (p = 0.391). LDL cholesterol ranged from 100 to 199 mg/dL, with a mean of 145.16 ± 28.58 mg/dL, remaining within the recommended limit (100–159 mg/dL), with no statistical significance (p = 0.637). HDL cholesterol ranged from 41 to 69 mg/dL, with a mean of 52.90 ± 7.86 mg/dL—well within the ideal range (40 to 60 mg/dL) and statistically non-significant (p = 0.863). Although mean values for both male and female participants generally fell within normal ranges, the upper extremes were elevated in many cases. These averages were influenced by a subset of patients on medication, including insulin therapy, while only a few managed their diabetes through dietary modifications. These findings are consistent with previous research by Wajpeyi (2020), Bułdak et al. (2019), Cirilo et al. (2013), and Rohm et al. (2022).

Table 3: Glycemic & Lipid Profiles of the Female Patients

Parameters	Range Min – Max	Mean ± SD	P- Value	Reference Value
		Blood Glucose		
Fasting Blood Glucose	100 - 275	159.72 ± 42.11	0.485	100 – 125 mg/dL
Random Blood Glucose	200 – 500	290.13 ± 70.42	0.551	140 - 199 mg/dL
HbA1c	6.3 – 14	9.00 ± 2.15	0.388	4.5 – 7.0 %
		Lipid Profile		
Total Cholesterol	135 – 236	181.70 ± 20.07	0.845	≤ 199 mg/dL
Triglycerides	100 – 199	163.06 ± 26.47	0.391	≤ 149 mg/dL
LDL	100 – 199	145.16 ± 28.58	0.637	100 – 159 mg/dL
HDL	41 – 69	52.90 ± 7.86	0.863	40 – 60 mg/dL

*At 95% confidence interval the values are significant at P≤0.05

3.3. Macro-Nutrient Analysis of the respondents

3.3.1. Nutrient Intake Patterns of Male Patients

The nutritional assessment of dietary intake among male respondents is summarized in Table (4). Among the macronutrients, fats emerged as the primary source of energy, with a mean intake of 77.89 ± 9.09 g/day. This level exceeds the Recommended Dietary Allowance (RDA) of 45–75 g/day. Saturated fat consumption was also elevated, averaging 19.77 ± 8.57 g/day, above the RDA threshold of less than 15 g/day. In contrast, intakes of polyunsaturated fatty acids (18.57 ± 5.78 g/day) and monounsaturated fatty acids (24.22 ± 8.98 g/day) were within recommended limits. Despite the excessive intake of total and saturated fats, both associated with increased risk of cardiovascular disease, lipid profiles among the male respondents remained within normal ranges, likely due to the use of antihyperlipidemic medications prescribed by their endocrinologist. Protein intake averaged 43.23 ± 7.91 g/day, falling below the recommended 50–60 g/day. Carbohydrate intake was considerably high, with a mean of 349.44 ± 31.65 g/day, exceeding the RDA of 225–325 g/day. Sugar intake, however, remained within acceptable limits at 11.55 ± 3.81 g/day, well below the recommended maximum of 36 g/day. Starch intake was also elevated, averaging 142.73 ± 31.93 g/day, surpassing the RDA of 130 g/day. Water intake was notably insufficient, with a mean consumption of 804.55 ± 235.33 g/day—substantially lower than the recommended 2160 g/day. Cholesterol intake averaged 246.17 ± 28.31 mg/day, exceeding the 200 mg/day RDA. Finally, the total caloric intake from macronutrients averaged 2362.28 ± 380.19 kcal/day, surpassing the recommended daily intake of 2200 kcal. In conclusion, the dietary analysis indicates that the male respondents were not adhering to appropriate dietary guidelines. Excessive intake of carbohydrates, starch, cholesterol, and overall calories likely contributed to the elevated levels of HbA1c, fasting blood glucose (FBG), and random blood glucose (RBG) observed in this group. The macronutrient intake of the respondents was compared with Age by applying a one-way ANOVA test, and the results are presented in the column P-value. If we go through the data, we can see that none of the macronutrients showed any significance in comparison with Age. These findings align the recommendations of Bell et al. (2014), Islam et al. (2012) and necessitate adherence to the Clinical Nutrition Guidelines for overweight and obese adults with type 2 diabetes.

Table 4: Macronutrient Intake of Male Respondents.

Nutrients	Range	Mean ± SD	P-Value* (Age)	RDA/ day-
	Min - Max			
Calories	1698 - 3388	2362.28 ± 380.19	0.389	2200 kcal/ day
Carbohydrate	278 – 399.10	349.44 ± 31.65	0.762	225 – 325 g/ day
Protein	14.90 – 54.40	43.23 ± 7.91	0.623	50 – 60 g/ day
Fats	62.00 - 96.00	77.89 ± 9.09	0.230	45 - 75 g/ day
Saturated Fatty acids	10.00 - 44.60	19.77 ± 8.57	0.069	<15 g/ day
Polyunsaturated Fatty acids	10.00 - 39.20	18.57 ± 5.78	0.209	<22 g/ day
Monounsaturated Fatty acids	10.60 - 45.80	24.22 ± 8.98	0.181	<44 g/ day
Sugar	4.00 - 20.10	11.55 ± 3.81	0.253	36 g/ day
Starch	81.00 - 199.00	142.73 ± 31.93	0.699	130 g/ day
Water	348.60 - 1330.30	804.55 ± 235.33	0.842	2160 g/ day
Cholesterol	210 - 300	246.17 ± 28.31	0.335	200 mg/ day

*At 95% confidence interval the values are significant at $P \leq 0.05$

3.3.2. Macro-Nutrient Intake Patterns of Female Patients

The nutritional assessment of dietary intake among female respondents is detailed in Table (5). Fats were identified as the primary energy source, with a mean intake of 80.42 ± 8.68 grams, surpassing the Recommended Dietary Allowance (RDA) of 45–75 grams daily. Saturated fat intake exceeded recommended levels, averaging 19.29 ± 5.66 grams, compared to the RDA of less than 15 grams daily. In contrast, the mean intakes of polyunsaturated (17.06 ± 4.41 grams) and monounsaturated fatty acids (21.89 ± 9.99 grams) were below the recommended values. Despite the elevated consumption of total and saturated fats, both known risk factors for cardiovascular disease, the lipid profiles of the female respondents remained within normal limits, likely due to the use of antihyperlipidemic medications prescribed by their endocrinologists. Protein intake averaged 45.30 ± 9.34 grams, falling short of the RDA of 50–60 grams per day. Carbohydrate intake was significantly high, with a mean of 349.10 ± 34.67 grams, exceeding the recommended range of 225–325 grams daily. Mean sugar intake was 15.48 ± 5.94 grams, below the RDA of 25 grams per day, while starch consumption averaged 146.72 ± 33.54 grams, exceeding the RDA of 130 grams per day. Water intake was insufficient, with an average of 761.35 ± 211.84 grams, well below the recommended 2160 grams daily. Cholesterol intake was also elevated, with a mean of 244.09 ± 27.06 milligrams, surpassing the RDA of 200 milligrams daily. The mean caloric intake from macronutrients among female respondents with Type 2 Diabetes Mellitus (T2DM) was 2388.31 ± 328.25 kcal/day, exceeding the recommended daily intake of 2200 kcal. A one-way ANOVA was conducted to examine the relationship between macronutrient intake and Age; the resulting p-values indicated no statistically significant differences for any macronutrient across age groups. These findings are in strong agreement with Koloverou E, Panagiotakos (2016), Paddon-Jones et al who proposed the introduction of an individualized nutritional concept that proposes carbohydrate over lipid restriction, substitution of SFAS with MUFAs and PUFAS, and adequate intake of dietary fiber, which are key factors in optimizing diabetes management.

Table 5: Macronutrient Intake of Female Respondents

Nutrients	Range Min - Max	Mean ± SD	P-Value* (Age)	RDA/ day
Calories	1715 - 3001	2388.31 ± 328.25	0.285	2200 kcal/ day
Carbohydrate	273.40 – 398.50	349.10 ± 34.67	0.476	225 – 325 g/ day
Protein	20.40 – 55.50	45.30 ± 9.34	0.212	50 – 60 g/ day
Fats	56.40 – 98.70	80.42 ± 8.68	0.382	45 - 75 g/ day
Saturated Fatty acids	10.00 - 29.90	19.29 ± 5.66	0.716	<15 g/ day
Polyunsaturated Fatty acids	10.00 - 32.70	17.06 ± 4.41	0.711	<22 g/ day
Monounsaturated Fatty acids	10.10 - 46.78	21.89 ± 9.99	0.225	<44 g/ day
Sugar	4.50 - 29.10	15.48 ± 5.94	0.364	25 g/ day
Starch	88.00 - 193.00	146.72 ± 33.54	0.316	130 g/ day
Water	382.20 - 1330.30	761.35 ± 211.84	0.981	2160 g/ day
Cholesterol	209 - 299	244.09 ± 27.06	0.047	200 mg/ day

*At 95% confidence interval the values are significant at P≤0.05

3.4. Regression Statistics of the Preventable and Non-Preventable Factors and Dyslipidemia among Females

Table (6) presents the results of a multiple linear regression analysis exploring the relationships between dependent variables (lipid profile parameters) including Triglycerides, LDL, HDL, and Total Cholesterol and three independent variables**:** Body Mass Index (BMI)**,** Age**,** and HbA1c (glycated haemoglobin)**.** The Table includes unstandardized coefficients (B)**,** standard errors**,** standardized coefficients (Beta)**,** t-values**,** and significance levels (Sig./p-values)**.** The predictability of the BMI and triglycerides showed a positive relationship (Beta = 0.009) with a significant p-value (0.006), meaning higher BMI is significantly associated with slightly higher triglyceride levels.BMI & LDL: A negative relationship (Beta = -0.023), significant at p = 0.000, suggesting that as BMI increases, LDL tends to decrease, though this is counterintuitive and may be influenced by confounding variables or sample-specific factors.BMI & HDL: Also negatively related (B = -0.041), with significance (p = 0.000), implying higher BMI is associated with lower HDL ("good" cholesterol).BMI & Total Cholesterol: Positive relation (Beta = 0.049), but not statistically significant (p = 0.082). Age being a risk of dyslipidemia showed that Age has an inverse association with all lipid parameters. However, the magnitude of the effect is small (Beta = -0.001 for triglycerides), indicating that increasing Age may not be a factor, and these blood lipids are more of the result of the diet and hyperglycemic effects. All associations are statistically significant (p = 0.000), suggesting Age is meaningfully associated with decreases in lipid levels, which might be due to medication use, dietary changes with ageing, or selective sampling. Notably, the Beta values are low, meaning the strength of these associations is weak despite being statistically significant. The predictability of HbA1c and triglycerides showed a statistically significant positive relationship (B = 0.018, p = 0.038), meaning that poor long-term glycemic control is associated with higher triglyceride levels. HbA1c with LDL/HDL/Cholesterol showed statistically insignificant relationships (p > 0.05), suggesting that HbA1c does not significantly influence these lipid parameters in this cohort. In short, BMI significantly correlates with triglycerides, LDL, and HDL. Notably, higher BMI is linked to higher triglycerides and lower HDL. Age shows a weak but consistent negative association with all lipid parameters, potentially due to confounding effects such as medication or health behaviour changes. HbA1c is positively associated with triglycerides, reflecting that poor glycemic control worsens this aspect of the lipid profile. However, it does not significantly affect LDL, HDL, or total cholesterol. These results in agreement with the studies of Wajpeyi (2020), Bułdak (2019), Lingvay et al, (2022), Bhowmik et al (2018) and Mooradian (2009) suggesting the substantial impact of diet, Age, and poorly managed hyperglycemia to be a major of predictors of diabetic dyslipidemia and its subsequent role in many cardio vascular disorders.

Table 6: Regression Model for Lipid Profile of Females

Parameters	Unstandardized Coefficients		Standardized Coefficients	t- Value	Significance
	ßeta	**Std. Error**	**Beta**		
			Body Mass Index		
Triglycerides	0.009	0.022	0.046	0.431	0.006
BMI LDL	-0.023	0.020	-0.124	-1.185	0.000
HDL	-0.041	0.071	-0.059	-0.571	0.000
Total Cholesterol	0.049	0.028	0.184	1.760	0.082

Parameters	Unstandardized Coefficients ßeta	Std. Error	Standardized Coefficients ßeta	t-value	Significance
		Age			
Triglycerides	-0.001	0.043	-0.003	-0.030	0.000
LDL	-0.039	0.039	-0.107	-1.013	0.000
HDL	-0.131	0.141	-0.098	-0.930	0.000
Total Cholesterol	-0.012	0.055	-0.024	-0.223	0.000
		HbA1c			
Triglycerides	0.018	0.009	0.216	2.110	0.038
LDL	0.008	0.008	0.107	1.038	0.302
HDL	-0.003	0.029	-0.009	-0.086	0.931
Total Cholesterol	0.008	0.011	0.071	0.688	0.493

3.5. Regression Statistics of the Preventable and Non-Preventable Factors and Dyslipidemia among Male Patients

Table (6) summarizes a multiple linear regression analysis showing the relationship between three independent variables. Body Mass Index (BMI)**,** Age, and HbA1c and four dependent variables representing components of the lipid profile**:** Triglycerides, LDL, HDL, and Total Cholesterol. The results among males showed a non-significant relationship between BMI and lipid profile parameters. However, HDL (Beta = 0.183, p = 0.068) and Total Cholesterol (Beta = 0.155, p = 0.120) showed a trend toward significance, suggesting that higher BMI may be weakly associated with higher HDL and cholesterol levels, though a large cohort is needed to confirm the findings of the current study. Results of Age being a predictor for dyslipidemia among the male patients showed that triglycerides (p = 0.003) and HDL (p = 0.030) are significantly influenced by Age. However, the effects are small, as evident from the Beta values. Total cholesterol showed a weak but significant negative association with Age (Beta = -0.019, p = 0.007). LDL is close to significance (p = 0.068), suggesting a possible positive trend with Age. The predictability of the HbA1c with the lipid profiles showed all relationships between HbA1c and lipid profile parameters to be statistically significant (p = 0.000). As evident from the beta values of 0.008 for triglycerides, Beta = -0.070 for LDL, Beta = -1.383 for HDL, and Beta = -1.223 for total cholesterol are indicative of the strong association of HbA1c with the lipid profiles. In short, BMI does not significantly affect lipid levels in males in the current study, though trends are seen for HDL and cholesterol. Age shows some weak but significant effects, especially for triglycerides and cholesterol. HbA1c is significantly associated with HDL and cholesterol, suggesting poor glycemic control may suppress good cholesterol levels. The findings of Zhu (2015), Chan (2009), Hsu et al (2015), Mostafa et al (2006), Millán et al (2009) that increased serum concentrations of total cholesterol (TC), total triglycerides (TG), and low-density lipoprotein cholesterol (LDL-C), as well as low HDL-C, are considered lipid parameters that could predict the risk of coronary heart disease among the diabetic population.

Table 7: Regression Model for Lipid Profile of Males

Parameters	Unstandardized Coefficients		Standardized Coefficients	t-value	Significance
	ßeta	Std. Error	ßeta		
		Body Mass Index			
Triglycerides	0.005	0.014	0.039	0.392	0.696
LDL	0.011	0.013	0.082	0.835	0.406
HDL	0.086	0.047	0.183	1.845	0.068
Total Cholesterol	0.032	0.021	0.155	1.570	0.120
		Age			
Triglycerides	0.005	0.034	0.016	0.159	0.003
LDL	0.061	0.033	0.183	1.845	0.068
HDL	0.010	0.116	0.009	0.088	0.030
Total Cholesterol	-0.019	0.051	-0.037	-0.364	0.007
		HbA1c			
Triglycerides	-0.005	0.009	0.001	0.008	0.000
LDL	-0.001	0.009	-0.007	-0.070	0.000
HDL	-0.042	0.031	-0.139	-1.383	0.000
Total Cholesterol	-0.016	0.013	-0.123	-1.223	0.000

Conclusion

This study highlights key gender-based differences in lipid and haematological parameters among individuals with Type 2 Diabetes Mellitus (T2DM). Males exhibited elevated LDL-C levels, while females showed increased LDL-C and triglycerides with Age. Additionally, both groups had high carbohydrate intakes, contributing to poor glycemic control. Haematological parameters were significantly different between genders, with several values approaching the upper limit of normal, indicating potential systemic inflammation or metabolic stress. Notably, strong associations between lipid and haematological markers suggest interrelated pathophysiological mechanisms. These findings emphasize the need for gender-specific and individualised approaches to dyslipidemia management in T2DM patients.

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Conflict of Interest

It is declared that there is no conflict of interest among the Authors

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