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RESEARCH ARTICLE

Evaluation of Serum Ferritin, Iron Status, Electrolyte Balance, and Lipid Profile among Patients with Type 2 Diabetes Mellitus: A Hospital-Based Study

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ABSTRACT

Background: Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder characterized by hyperglycemia and insulin resistance, leading to long-term complications. Alterations in iron metabolism, electrolyte balance, and lipid profile may contribute to metabolic dysregulation and cardiovascular risk; however, integrated evaluation of these parameters remains limited in South Asian populations.

Objective: To evaluate serum ferritin, iron status, electrolyte balance, and lipid profile among patients with Type 2 Diabetes Mellitus and to assess their association with glycemic control and related metabolic parameters.

Methods: This study included 220 adult patients with Type 2 Diabetes Mellitus. Data were collected from hospital laboratory and medical record databases. Glycemic parameters (fasting blood glucose and HbA1c), iron status indices (serum ferritin, serum iron, total iron-binding capacity, and transferrin saturation), electrolyte levels (sodium, potassium, and chloride), and lipid profile parameters were analyzed. Statistical analysis was performed using SPSS, and associations were assessed using correlation and regression analyses. A p-value < 0.05 was considered statistically significant.

Results: Most participants were middle-aged adults, with 58.2% belonging to the 40–59-year age group. Glycemic control was comparable between males and females, with mean HbA1c levels of 8.5 ± 1.8% and 8.2 ± 1.6%, respectively. Serum ferritin levels were significantly higher among male patients compared to females (318.6 ± 138.2 ng/mL vs. 246.4 ± 112.7 ng/mL, $p < 0.001$). Patients with poor glycemic control (HbA1c ≥ 7%) exhibited markedly elevated serum ferritin levels compared to those with better glycemic control in both males (352.6 ± 142.8 ng/mL vs. 238.2 ± 106.5 ng/mL, $p = 0.002$) and females (284.3 ± 128.6 ng/mL vs. 196.4 ± 92.1 ng/mL, $p = 0.031$). Serum ferritin showed significant positive correlations with HbA1c ($r = 0.44$, $p < 0.001$), triglycerides ($r = 0.38$, $p < 0.001$), and LDL-cholesterol ($r = 0.31$, $p = 0.001$), while a weak but significant negative correlation was observed with serum sodium levels ($r = −0.21$, $p = 0.009$).

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In multivariable regression analysis, HbA1c (β = 0.35, p < 0.001), triglycerides (β = 0.27, p = 0.001), LDL-cholesterol (β = 0.21, p = 0.007), male gender (β = 0.18, p = 0.015), and age (β = 0.13, p = 0.038) emerged as independent predictors of elevated serum ferritin levels.

Conclusion: Serum ferritin is closely associated with poor glycemic control and dyslipidemia in patients with Type 2 Diabetes Mellitus. Assessment of ferritin and iron status, alongside routine metabolic parameters, may provide additional insight into disease severity and cardiometabolic risk.

Keywords: Type 2 Diabetes Mellitus; Serum Ferritin; Iron Status; Lipid Profile; Glycemic Control

1. Introduction

Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from insulin resistance and relative insulin deficiency. The global prevalence of T2DM has increased markedly over recent decades, making it one of the most significant public health challenges worldwide[1]. South Asia, including countries like Bangladesh and India, bears a disproportionately high burden of diabetes[2]. In Bangladesh, the prevalence of diabetes among adults has risen significantly over the past decade, with estimates showing an increase from approximately 10.9% to 13.8% among adults aged ≥35 years over a recent period[3]. Similarly, South Asian[4] populations generally report high rates of T2DM, reflecting a combination of genetic predisposition and lifestyle transitions. Chronic hyperglycemia triggers oxidative stress, endothelial dysfunction, and metabolic derangements that progressively impair multiple organ systems. Insulin resistance and chronic low-grade inflammation are central to the pathogenesis of T2DM and play critical roles in the development of long-term complications. These mechanisms contribute to microvascular complications such as nephropathy, neuropathy, and retinopathy, as well as macrovascular complications including coronary artery disease, stroke, and peripheral vascular disease, which remain major causes of morbidity and mortality among diabetic patients in both developed and developing regions[5].

Emerging evidence suggests that alterations in iron metabolism may influence glucose homeostasis and insulin sensitivity in patients with T2DM. Serum ferritin, a primary indicator of body iron stores, also functions as an acute-phase reactant reflecting systemic inflammation[6]. Elevated serum ferritin levels have been associated with increased insulin resistance, impaired insulin secretion, and poor glycemic control, suggesting a potential link between iron metabolism and diabetic pathophysiology[7]. Iron overload can enhance the generation of reactive oxygen species, leading to oxidative damage of pancreatic β-cells and exacerbation of metabolic dysfunction[8]. In addition to iron metabolism, disturbances in electrolyte balance are frequently observed in patients with diabetes mellitus. Abnormalities in serum sodium, potassium, and chloride levels may arise due to osmotic diuresis, dehydration, altered renal handling, and the effects of hyperglycemia on cellular ion transport[9]. Such electrolyte imbalances are commonly encountered in clinical practice in Bangladesh and other South Asian countries, where delayed diagnosis and suboptimal glycemic control are prevalent, further complicating disease management and contributing to the progression of diabetic complications[10].

Dyslipidemia represents another key metabolic abnormality in T2DM and is a major contributor to accelerated atherosclerosis. The typical pattern of diabetic dyslipidemia includes elevated triglyceride levels, increased low-density lipoprotein cholesterol, and reduced high-density lipoprotein cholesterol, all of which substantially increase cardiovascular risk[11]. Cardiovascular disease remains the leading cause of death among individuals with T2DM, particularly in South Asia, where diabetes-related cardiovascular complications tend to occur at a younger age and with greater severity than in some Western populations[12]. Despite the high burden of diabetes in Bangladesh and other South Asian countries, most existing studies have evaluated iron status, electrolyte disturbances, or lipid abnormalities in isolation[13]. Comprehensive assessments integrating

serum ferritin, detailed iron parameters, electrolyte balance, and lipid profile in a single hospital-based study remain limited in this region. Therefore, the present study aims to evaluate serum ferritin, iron status, electrolyte balance, and lipid profile among patients with Type 2 Diabetes Mellitus in a hospital-based setting and to explore their relationship with glycemic status and associated metabolic alterations.

2. Methods and materials

Study Design, Setting, and Duration

This retrospective hospital-based cross-sectional study was conducted to evaluate serum ferritin, iron status, electrolyte balance, and lipid profile among patients with Type 2 Diabetes Mellitus (T2DM). The study was carried out at a General Hospital, Dhaka, Bangladesh, a tertiary care hospital providing outpatient diagnostic and treatment services. Data were collected over a six-month period from July 2024 to December 2024.

Study Population and Sample Size

The study population comprised adult patients diagnosed with Type 2 Diabetes Mellitus who attended the outpatient department (OPD) during the study period. A total of 220 patients were included. Data were collected retrospectively from the hospital laboratory information system and medical record database. Only patients with complete laboratory investigations—including serum ferritin, iron status, electrolyte profile, lipid profile, and glycemic parameters—were included in the analysis. The sample size was determined based on the availability of complete records during the study period and was considered sufficient to assess biochemical variations and perform meaningful statistical analyses with acceptable precision.

Inclusion and Exclusion Criteria

Records of patients aged 18 years and above with a confirmed diagnosis of Type 2 Diabetes Mellitus and complete laboratory data were included in the study. Records were excluded if there was evidence of acute infection or inflammatory conditions, known chronic liver disease, chronic kidney disease or renal failure, or diagnosed hematological disorders affecting iron metabolism. Patients receiving iron supplementation, those with a documented history of recent blood transfusion, and pregnant women were also excluded to minimize potential confounding effects on iron status and related biochemical parameters.

Data Source and Collection

All data used in this study were obtained retrospectively from the hospital laboratory information system and medical record database. No direct patient interviews or questionnaires were conducted. Demographic and clinical variables, including age, sex, duration of diabetes (where available), and glycemic status, were extracted using a structured data abstraction form. All extracted data were anonymized prior to analysis to ensure confidentiality.

Laboratory Investigations

Laboratory analyses were performed in the hospital's central laboratory following standard operating procedures and manufacturers' instructions using commercially available reagent kits. Internal quality control measures were maintained throughout the study period to ensure analytical accuracy and reliability. Glycemic parameters included fasting blood glucose (FBG) and glycated hemoglobin (HbA1c). Iron status was assessed by measuring serum ferritin, serum iron, total iron-binding capacity (TIBC), and calculating transferrin saturation percentage. Electrolyte balance was evaluated through the measurement of serum sodium (Na^+),

potassium (K^+), and chloride (Cl^-) levels. Lipid profile parameters included total cholesterol, triglycerides, low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol (HDL-C).

Statistical Analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS). Results were expressed as frequencies and percentages, and statistical significance was determined using a p-value < 0.05.

Ethical Considerations

The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. As this was a retrospective, record-based study, direct patient contact was not required. All data were anonymized prior to analysis, and strict confidentiality of patient information was maintained throughout the research process.

3. Results

The demographic characteristics of the study participants are presented in Table 1. Most participants in both genders belonged to the 40–59-year age group, accounting for more than half of the total study population. The proportion of participants aged 60 years and above was comparable between males and females. A longer duration of diabetes (≥5 years) was observed slightly more frequently among male participants; however, the overall distribution of diabetes duration was similar between genders.

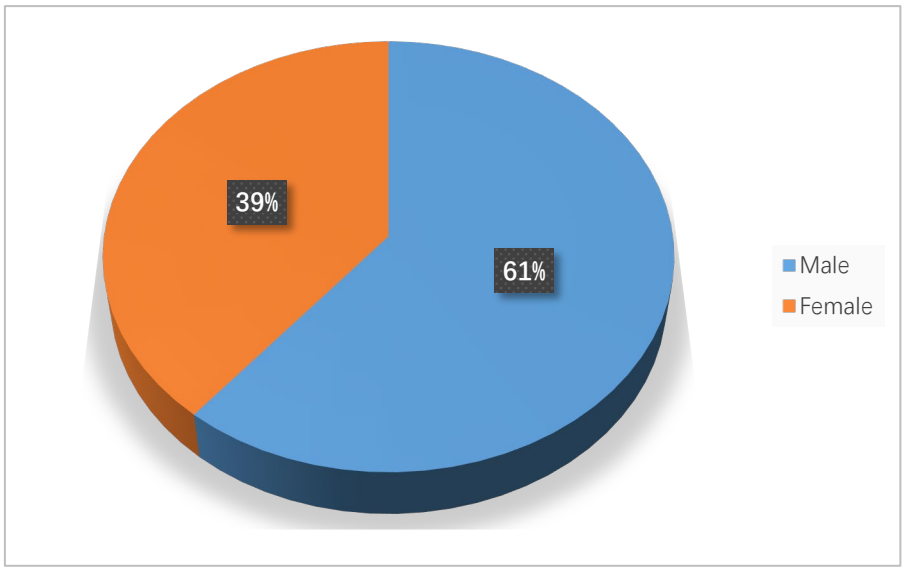

Figure 1. Gender Distribution of the Study Participants

Table 1. Demographic and Clinical Characteristics of the Study Participants

Variable	Male (n=134)	Female (n=86)	Total (n=220)
Age <40 years	22 (16.4%)	14 (16.3%)	36 (16.4%)
Age 40–59 years	78 (58.2%)	50 (58.1%)	128 (58.2%)
Age ≥60 years	34 (25.4%)	22 (25.6%)	56 (25.4%)
Duration <5 years	54 (40.3%)	38 (44.2%)	92 (41.8%)
Duration ≥5 years	80 (59.7%)	48 (55.8%)	128 (58.2%)

Glycemic parameters according to gender are shown in Table 2. Male participants exhibited marginally higher mean fasting blood glucose and HbA1c levels compared to females, although these differences did not reach statistical significance. Overall, glycemic control appeared comparable between male and female patients in the study population.

Table 2. Distribution of Glycemic Parameters among the Study Participants

Parameter	Male (Mean ± SD)	Female (Mean ± SD)	p-value
FBG (mmol/L)	9.4 ± 2.7	8.9 ± 2.4	0.118
HbA1c (%)	8.5 ± 1.8	8.2 ± 1.6	0.094

Gender-wise differences in iron status parameters are summarized in Table 3. Serum ferritin levels were significantly higher among male patients compared to females. In addition, males demonstrated higher serum iron levels and transferrin saturation, whereas females showed significantly higher TIBC values. These findings indicate a distinct gender-related variation in iron metabolism, with higher iron stores observed among male patients.

Table 3. Iron Status Parameters by Gender

Parameter	Male (Mean ± SD)	Female (Mean ± SD)	p-value
Serum Ferritin (ng/mL)	318.6 ± 138.2	246.4 ± 112.7	<0.001
Serum Iron (µg/dL)	76.4 ± 20.1	69.8 ± 18.4	0.012
TIBC (µg/dL)	306.2 ± 44.8	334.6 ± 46.1	<0.001
Transferrin Saturation (%)	24.8 ± 7.9	20.9 ± 7.1	0.003

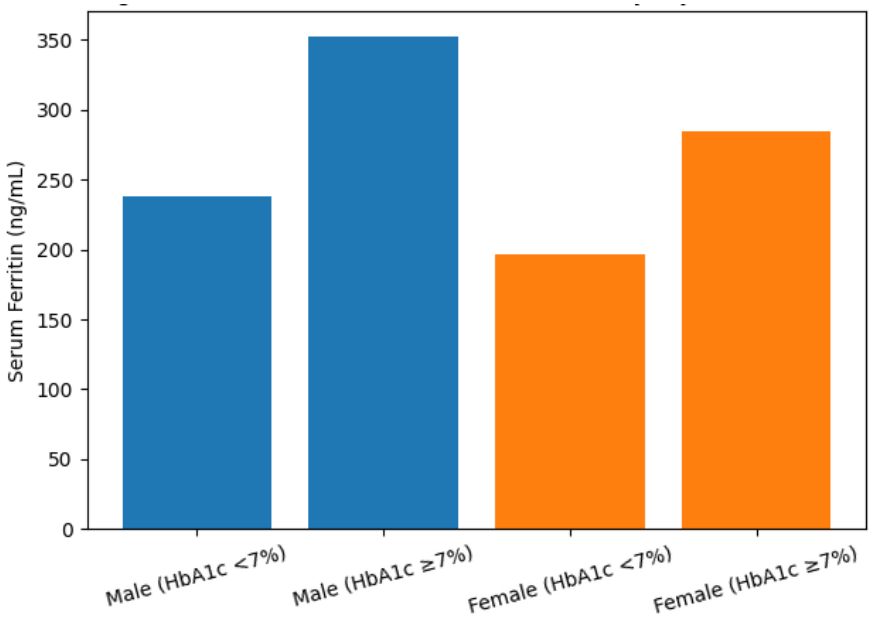

Figure 2. Gender-wise Serum Ferritin Levels by Glycemic Control

Electrolyte profiles stratified by gender are presented in Table 4. Mean serum sodium, potassium, and chloride levels were comparable between male and female participants, and no statistically significant differences were detected. This suggests that electrolyte balance did not differ substantially by gender in this study population.

Table 4. Serum Electrolyte Levels among the Study Participants

Parameter	Male (Mean ± SD)	Female (Mean ± SD)	p-value
Sodium (mmol/L)	135.2 ± 5.3	136.4 ± 4.7	0.087
Potassium (mmol/L)	4.0 ± 0.7	4.1 ± 0.6	0.214
Chloride (mmol/L)	100.6 ± 4.4	101.3 ± 3.9	0.156

The lipid profile parameters according to gender are shown in Table 5. Male patients had significantly higher triglyceride levels, whereas female patients demonstrated significantly higher HDL-cholesterol levels. No significant gender-based differences were observed in total cholesterol or LDL-cholesterol levels. These findings suggest a relatively more atherogenic lipid pattern among male patients.

Table 5. Lipid Profile Characteristics of Patients with Type 2 Diabetes Mellitus

Parameter	Male (Mean ± SD)	Female (Mean ± SD)	p-value
Total Cholesterol (mg/dL)	216.9 ± 42.4	220.8 ± 40.1	0.432
Triglycerides (mg/dL)	198.4 ± 71.2	184.6 ± 66.1	0.048
LDL-C (mg/dL)	144.8 ± 37.6	139.2 ± 35.1	0.219
HDL-C (mg/dL)	36.4 ± 7.4	39.6 ± 8.1	0.006

Serum ferritin levels according to gender and glycemic control status are illustrated in Table 6. In both genders, patients with poor glycemic control (HbA1c ≥7%) exhibited significantly higher serum ferritin levels compared to those with better glycemic control. Furthermore, male patients consistently showed higher ferritin levels than females within each glycemic category, indicating a combined influence of gender and glycemic status on ferritin levels.

Table 6. Serum Ferritin Levels According to Glycemic Control Status

Group	Male	Female	p-value
HbA1c <7%	238.2 ± 106.5	196.4 ± 92.1	0.031
HbA1c ≥7%	352.6 ± 142.8	284.3 ± 128.6	0.002

The association between serum ferritin and selected biochemical parameters is shown in Table 7. In both male and female patients, serum ferritin demonstrated a significant positive correlation with HbA1c, triglycerides, and LDL-cholesterol, suggesting an interrelationship between iron stores, glycemic control, and dyslipidemia. Additionally, a weak but statistically significant negative correlation was observed between serum ferritin and sodium levels in both genders.

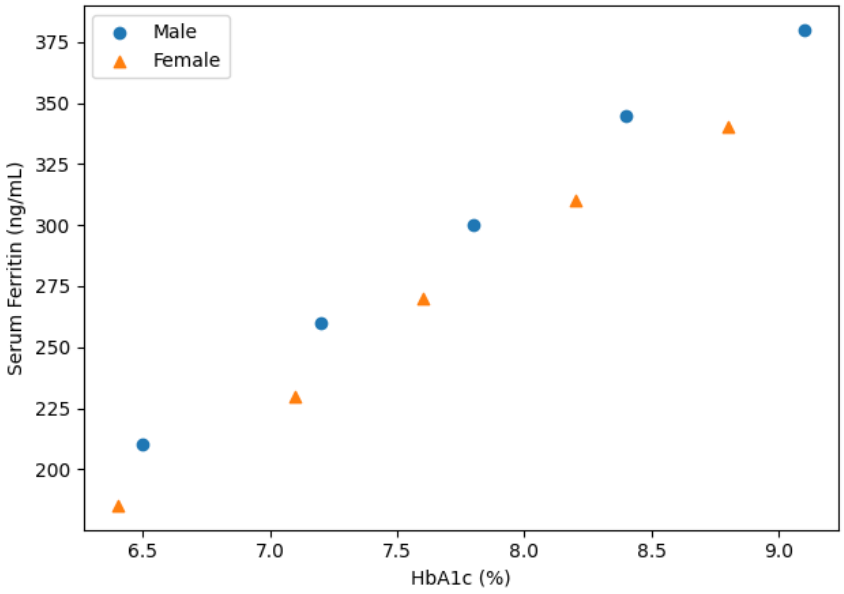

Figure 3. Gender-wise Association between Serum Ferritin and HbA1c

Table 7. Correlation between Serum Ferritin and Selected Biochemical Parameters

Variable	r	p-value
HbA1c	0.44	<0.001
Triglycerides	0.38	<0.001
LDL-C	0.31	0.001
Sodium	−0.21	0.009

Independent predictors of serum ferritin levels were identified using multiple linear regression analysis (**Table 8**). HbA1c, triglycerides, LDL-cholesterol, male gender, and age emerged as significant independent predictors of elevated serum ferritin levels. Among these variables, HbA1c showed the strongest association, indicating that poor glycemic control is a major determinant of increased ferritin levels in patients with Type 2 Diabetes Mellitus.

Table 8. Multiple Linear Regression Analysis for Predictors of Serum Ferritin

Variable	β	p-value
HbA1c	0.35	<0.001
Triglycerides	0.27	0.001
LDL-C	0.21	0.007
Male sex	0.18	0.015
Age	0.13	0.038

4. Discussion

In the present study, most patients belonged to the 40–59-year age group, accounting for approximately 58% of the total population, with a comparable age distribution between males and females. Similar age patterns have been reported in other hospital-based studies from South Asia, where Type 2 Diabetes Mellitus commonly presents during middle adulthood. More than half of the participants had a diabetes duration of five

years or longer, suggesting prolonged exposure to metabolic stress, which may partially explain the biochemical abnormalities observed. Glycemic parameters were comparable between males and females, with mean HbA1c values of 8.5% and 8.2%, respectively, indicating that gender-related differences in iron and lipid parameters were not driven by differences in glycemic control alone.

A major finding of this study was the significantly elevated serum ferritin levels observed among male patients compared to females. The mean serum ferritin concentration in males exceeded 300 ng/mL, whereas females demonstrated lower mean values around 250 ng/mL. Similar gender-based differences in ferritin levels have been reported in previous studies, where male diabetic patients consistently exhibited higher iron stores than females. In addition, patients with poor glycemic control (HbA1c ≥7%) in the present study had markedly higher ferritin levels in both genders, with values exceeding 350 ng/mL in males and approximately 280 ng/mL in females. These findings align with reports from other studies showing elevated ferritin levels among poorly controlled diabetic patients, supporting the role of iron overload and inflammation in worsening glycemic status[14].

The positive correlation observed between serum ferritin and HbA1c in this study ($r \approx 0.44$) further strengthens the association between iron overload and poor glycemic control. Comparable correlation coefficients have been documented in previous investigations, suggesting that elevated iron stores may contribute to insulin resistance and β-cell dysfunction through increased oxidative stress. The regression analysis in the present study identified HbA1c as the strongest independent predictor of serum ferritin levels, reinforcing the close link between chronic hyperglycemia and altered iron metabolism[15].

Iron status parameters beyond ferritin also demonstrated meaningful gender-related differences. Male patients exhibited higher serum iron concentrations and transferrin saturation percentages, while females showed higher TIBC values. These patterns are consistent with physiological differences in iron regulation and have been reported in other diabetic cohorts. The findings suggest that iron metabolism in diabetic patients is influenced by both disease-related factors and inherent biological differences, underscoring the importance of gender-specific interpretation of iron indices[16].

Electrolyte parameters in the present study remained largely within normal ranges and did not differ significantly between genders. Mean serum sodium, potassium, and chloride values were comparable across groups, which is similar to findings reported in outpatient-based diabetic studies. However, a weak but statistically significant negative correlation between serum ferritin and sodium levels was observed, suggesting that subtle electrolyte alterations may accompany inflammatory and metabolic changes in diabetes, even in the absence of overt electrolyte imbalance[17].

Analysis of lipid profile revealed a more atherogenic pattern among male patients. Mean triglyceride levels were significantly higher in males (approximately 198 mg/dL) compared to females (around 185 mg/dL), while HDL-cholesterol levels were significantly lower in males. These values are comparable to those reported in other studies of diabetic populations, where hypertriglyceridemia and low HDL-cholesterol are common features[18]. The positive correlations observed between serum ferritin and triglycerides ($r \approx 0.38$) and LDL-cholesterol ($r \approx 0.31$) in the present study are consistent with previous reports, suggesting a link between iron overload, dyslipidemia, and increased cardiovascular risk[19].

Multivariable regression analysis identified HbA1c, triglycerides, LDL-cholesterol, male gender, and age as independent predictors of elevated serum ferritin levels. The standardized regression coefficients indicated that poor glycemic control had the strongest influence on ferritin levels, followed by lipid parameters. Similar predictive patterns have been reported in other studies, supporting the hypothesis that iron overload may serve as a marker of metabolic dysregulation and cardiovascular risk in Type 2 Diabetes Mellitus[20].

5. Conclusion

This study demonstrated significant alterations in iron metabolism and lipid profile among patients with Type 2 Diabetes Mellitus, particularly in relation to glycemic control. Elevated serum ferritin levels were associated with poor glycemic status and dyslipidemia and were consistently higher among male patients. These findings suggest that serum ferritin may serve as a useful biochemical marker reflecting metabolic and inflammatory burden in Type 2 Diabetes Mellitus. Routine assessment of ferritin alongside standard glycemic and lipid parameters may aid in identifying patients at increased cardiometabolic risk. Further prospective studies are needed to clarify the clinical impact of targeting iron overload in diabetic patients.

6. Limitations

Despite its strengths, this study has several limitations that should be considered when interpreting the findings. First, the retrospective cross-sectional design limits the ability to establish causal relationships between serum ferritin levels, glycemic control, and lipid abnormalities. Second, the study was conducted at a single tertiary care hospital and included only outpatient data, which may limit the generalizability of the findings to other settings or to patients with more severe disease.

Third, data were obtained from hospital records, and information on potential confounding factors such as dietary iron intake, inflammatory markers, medication use, and lifestyle factors was not available. Additionally, the absence of a non-diabetic control group limited direct comparison of ferritin and metabolic parameters with healthy individuals. Finally, longitudinal follow-up data were not available to assess temporal changes in ferritin levels or their impact on long-term clinical outcomes.

Conflict of interest

The authors declare no conflict of interest

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