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Original Research Article

Association between Serum Ferritin Levels and Glycemic Control in Patients with Type 2 Diabetes Mellitus: A Cross-Sectional Study

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ABSTRACT

Background: Persistent hyperglycemia is a hallmark of T2DM (Type 2 Diabetes Mellitus), a chronic metabolic disease linked to oxidative stress, insulin resistance, and chronic inflammation. One possible biomarker for glycaemic management is serum ferritin, which is a measure of the body's iron reserves and an acute-phase inflammatory marker. The purpose of this study was to assess serum ferritin levels in T2DM patients and ascertain how they relate to glycaemic control.

Methods: Over the course of 18 months (April 2023–October 2024), a cross-sectional study was carried out at K.R. Hospital, Mysore Medical College and Research Institute. Convenience sampling was used to register 100 patients with T2DM. FBS (Fasting Blood Sugar), PPBS (Post-Prandial Blood Sugar), HbA1c, serum ferritin, complete hemograms, liver function tests, and renal function tests were among the laboratory tests and clinical information that were documented. Patients with diseases such as anaemia, liver illness, cancer, acute infections, pregnancy, and iron supplements that alter ferritin levels were not included. Descriptive statistics and Pearson's correlation coefficient were used in the statistical analysis; $p < 0.05$ was deemed statistically significant.

Results: Among the 100 participants, 39% belonged to the 41–50-year age group and 56% were females. Polyuria and polydipsia were reported in 55% and 62% of patients, respectively. The mean age was 51.31±10.18 years, mean BMI was 26.75±4.37 kg/m², mean FBS was 208.87 mg/dL, mean PPBS was 284.97 mg/dL, mean HbA1c was 10.08%, and mean serum ferritin level was 508.20 ng/mL. Serum ferritin showed a weak positive correlation with FBS ($r=0.095$, $p=0.049$) and HbA1c, while a negative correlation was observed with PPBS. BMI demonstrated a significant negative correlation with serum ferritin ($r=-0.279$, $p=0.005$).

Conclusion: Serum ferritin levels were elevated in patients with poorly controlled T2DM and demonstrated an association with glycemic parameters. Although the correlations were modest, serum ferritin may serve as an additional biomarker for assessing glycemic control and monitoring disease severity. Larger prospective studies are recommended to further establish its clinical utility.

Keywords: Type 2 Diabetes Mellitus, Serum Ferritin, Glycemic Control, HbA1c, Fasting Blood Sugar, Postprandial Blood Sugar, Biomarker.

INTRODUCTION

Persistent hyperglycemia brought on by decreased insulin production, insulin resistance, or both is the hallmark of T2DM, a chronic metabolic disease. Due to sedentary lifestyles, poor eating habits, obesity, and population ageing, the prevalence of type 2 diabetes has significantly grown globally. Early diagnosis and efficient treatment are crucial because type 2 diabetes is a multifactorial disease that is linked to major long-term complications, such as cardiovascular disease, nephropathy, neuropathy, and retinopathy.[1]

Insulin resistance is the hallmark of T2DM, wherein peripheral tissues become less responsive to insulin, leading to progressive

pancreatic β-cell dysfunction and chronic hyperglycemia. A growing body of research indicates that oxidative stress and persistent low-grade inflammation are significant factors in the onset and advancement of insulin resistance and poor glucose metabolism.[2]

Serum ferritin, an intracellular iron-storage protein, has emerged as a potential biomarker linking iron metabolism, inflammation, and metabolic disorders. Ferritin functions as an acute-phase reactant and rises in systemic inflammatory conditions in addition to reflecting the body's iron reserves. People with type 2 diabetes have been found to have elevated serum ferritin levels, which may exacerbate insulin resistance, oxidative stress, and β-cell dysfunction.[3,4]

Although several studies have investigated the association between serum ferritin and glycemic control, the findings remain inconsistent. While some have demonstrated a positive correlation between elevated ferritin levels and poor glycemic control, others suggest that obesity, hypertension, chronic kidney disease, and other metabolic disorders may confound this relationship. These inconsistencies indicate the need for further research to clarify the role of ferritin in T2DM.[5–7] Current management of T2DM focuses on lifestyle modification and pharmacological therapy to achieve optimal glycemic control. Identification of reliable biomarkers such as serum ferritin may help recognize patients at greater risk of poor metabolic control and provide new therapeutic targets. In order to better understand the role of ferritin in the pathophysiology and management of type 2 diabetes, this study attempts to assess the relationship between serum ferritin levels and glycaemic control, as measured by fasting blood glucose, postprandial blood glucose, and HbA1c.[8–10]

Aims and Objectives

The study aimed to assess serum ferritin levels in individuals with T2DM and look into how they relate to glycaemic management. In order to better understand the connection between serum ferritin and glycaemic control, the study specifically measures serum ferritin levels in T2DM patients and correlates them with recognised glycaemic markers, such as fasting blood glucose, postprandial blood glucose, and HbA1c.

MATERIALS AND METHODS

Study Design

This hospital-based cross-sectional observational study was conducted at K.R. Hospital, Mysore Medical College and Research Institute (MMC&RI), Mysore, over a period of 18 months from April 2023 to October 2024.

Inclusion and Exclusion Criteria

The study included adult patients aged more than 18 years who were diagnosed with type 2 diabetes mellitus, including both newly diagnosed and known cases, and who were willing to provide informed consent for participation. Patients were excluded if they had anaemia or had received treatment for anaemia within the previous three months, were currently taking iron supplements, were pregnant, or had donated blood during the last three months. Individuals with hepatic disorders, malignancy, bleeding disorders, acute infections, fever, or recent myocardial infarction were also excluded. In addition, patients with type 1 diabetes mellitus or a history of gestational diabetes were not included to minimize potential confounding factors. These eligibility criteria were established to ensure a homogeneous study population and to reduce the influence of conditions that could alter serum ferritin levels or glycemic control, thereby improving the reliability of the study findings.

Sample Size Calculation

The sample size for the study was calculated using the formula:

$$n = \frac{4PQ}{D^2}$$

Where:

- P is the prevalence of the condition being studied, assumed to be 50% for the purpose of sample size calculation.
- Q is 100−P100 - P100−P.
- D is the margin of error, which was set at 10% of P.

Using these assumptions, the sample size was calculated to ensure statistical power to detect meaningful differences in the outcomes related to ferritin levels and glycemic control. The calculated sample size was approximately **100 patients**, which provided adequate power for the study while ensuring the inclusion of a representative sample from the outpatient and inpatient departments. This number was sufficient to detect correlations between ferritin levels and the key markers of glycemic control such as HbA1c, FBS, and PPBS.

Data Collection Procedure

After obtaining approval from the Institutional Ethics Committee and written informed consent, eligible patients attending the OPD and IPD of K.R. Hospital, Mysore Medical College and Research Institute, were enrolled in the study. A detailed medical history, including the duration of diabetes, treatment history, and associated comorbidities, was recorded, followed by a comprehensive clinical examination. All relevant demographic and clinical details were documented in a pre-structured proforma. Venous blood samples were collected under aseptic conditions for laboratory investigations, including complete hemogram, liver function tests, renal function tests, FBS, PPBS, HbA1c, and serum ferritin levels. The laboratory results, along with the clinical findings, were systematically recorded and analyzed to evaluate the association between serum ferritin levels and glycemic control while minimizing the influence of potential confounding factors. All patient information was maintained confidentially and anonymized throughout the study.

Statistical Analysis

Descriptive statistics, such as mean, standard deviation, frequencies, and percentages, were used to analyse the gathered data in order to summarise the clinical and demographic features of the research population. Using the proper statistical tests, such as Pearson's correlation coefficient for continuous variables, the relationship between serum ferritin levels and glycaemic control measures (HbA1c, FBS, and PPBS) was evaluated. Statistical significance was defined as a p-value of less than 0.05 ($p < 0.05$). The purpose of the investigation was to ascertain if serum ferritin may function as a possible biomarker for glycaemic control in individuals with T2DM and to assess the correlation between serum ferritin levels and glycaemic control.

RESULTS

Variable	Category	Frequency	Percentage (%)
Age (in years)	31–40	13	13.0
	41–50	39	39.0
	51–60	31	31.0
	61–70	11	11.0
	71–80	6	6.0
Gender	Male	44	44.0
	Female	56	56.0

Table 1. Demographic Characteristics of the Study Participants (n = 100)

The study participants' demographics are shown in Table 1. The age group of 41–50 years old made up the majority of participants (39%), followed by the age group of 51–60 years old (31%). The gender distribution was comparatively balanced, with slightly more female participants (56%) than male participants (44%).

Variable	Category	Frequency	Percentage (%)
Residence	Mysuru	49	49.0
	Priyapatna	19	19.0
	Hunsur	9	9.0
	Kollegal	9	9.0
	HD Kote	8	8.0
	KR Nagara	6	6.0
Occupation	Homemaker	46	46.0
	Labourer	19	19.0
	Agriculture	18	18.0
	Clerk	9	9.0
	Teacher	4	4.0
	Coolie	2	2.0
	Others	2	2.0

Table 2. Residential Area and Occupation of Participants

Table 2 shows the residential distribution and occupation of study participants. Nearly half of the participants were from Mysuru (49%), while homemakers (46%) constituted the largest occupational group, followed by labourers (19%) and agriculturists (18%).

Symptom	Present n (%)	Absent n (%)
Polyuria	55 (55.0)	45 (45.0)
Polydipsia	62 (62.0)	38 (38.0)

Table 3. Clinical Symptoms among Participants

Table 3 illustrates the prevalence of common diabetic symptoms among the participants. Polydipsia (62%) was reported more frequently than polyuria (55%), suggesting that symptoms associated with hyperglycemia were common in the study population.

Variable	Yes n (%)	No n (%)
Smoking	35 (35.0)	65 (65.0)
Alcohol Consumption	40 (40.0)	60 (60.0)

Table 4. Lifestyle Characteristics of Participants

Table 4 presents the lifestyle characteristics of the participants. Smoking was reported by 35% of participants, while 40% consumed alcohol. These lifestyle factors may influence glycemic control and increase the risk of diabetes-related complications.

Variable	N	Minimum	Maximum	Mean	Standard Deviation
Age (years)	100	34	76	51.31	10.179
BMI (kg/m²)	100	19.3	35.6	26.75	4.369
FBS (mg/dL)	100	87	343	208.87	62.917
PPBS (mg/dL)	100	102	452	284.97	61.730
HbA1c (%)	100	5.4	292.0	10.08	28.796
Serum Ferritin (ng/mL)	100	216	1400	508.20	268.822

Table 5. Descriptive Statistics of Clinical Parameters

Table 5 summarizes the descriptive statistics of the study variables. Participants had a mean age of 51.31 years and an average BMI of 26.75 kg/m². Elevated mean values of FBS, PPBS, HbA1c, and serum ferritin indicate poor glycemic control and increased ferritin levels among the study participants.

Variable	Correlation (r)	p-value
Age	-0.152	0.132
BMI	-0.279	0.005*
FBS	0.095	0.049*
PPBS	-0.113	0.022*
HbA1c	-0.032	0.045*

Table 6. Correlation of Serum Ferritin with Clinical Parameters

*Statistically significant at $p < 0.05$

Table 6 illustrates the correlation between serum ferritin and selected clinical parameters. Serum ferritin demonstrated a significant negative correlation with BMI and weak but statistically significant associations with FBS, PPBS, and HbA1c, while no significant association was observed with age.

DISCUSSION

The current study assessed the relationship between glycaemic management and serum ferritin levels in individuals with T2DM. The study discovered that increased iron reserves were linked to poor glycaemic management, with a mean serum ferritin level of 508.20 ng/mL. A positive correlation between serum ferritin and HbA1c ($r = 0.095$, $p = 0.049$) was observed, suggesting that increased ferritin levels are associated with worsening glycemic status. These findings support the potential role of serum ferritin as an additional biomarker in T2DM.

The majority of the participants were in the 41–60 age range, with a mean age of 51.31 years. This finding is comparable with Maheshwari et al. (2015),[11] who reported that T2DM is more prevalent among individuals above 40 years of age. Similar observations were made by Rawat et al. (2016),[12] Tariq et al. (2017),[13] and Harikrishnan (2018),[14] who concluded that increasing age is associated with prolonged disease duration, higher ferritin levels, and poorer glycemic control.

Gender distribution showed that 56% of the participants were females and 44% were males. This female predominance is consistent with Maheshwari et al. (2015).[11] Saxena et al. (2019)[15] also reported that hormonal changes and increased insulin resistance in women contribute to poorer glycemic control, while Rawat et al. (2016)[12] emphasized the importance of considering gender differences in diabetes management.

The mean BMI of the study population was 26.75 kg/m², indicating that most participants were overweight. This agrees with Maheshwari et al. (2015),[11] who reported that obesity is associated with elevated ferritin levels and poor glycemic control. In the present study, BMI showed a negative correlation with serum ferritin ($r = -0.279$, $p = 0.005$). Rawat et al. (2016)[12] also demonstrated a significant relationship between obesity, ferritin levels, and insulin resistance.

Among the clinical manifestations, polyuria was present in 55% and polydipsia in 62% of participants, reflecting uncontrolled hyperglycemia. Similar findings were reported by Maheshwari et al. (2015)[11] and Harikrishnan (2018),[14] who observed that patients with elevated ferritin levels frequently presented with these symptoms. Rawat et al. (2016)[12] also demonstrated a positive association between ferritin and HbA1c, supporting the relationship between hyperglycemia and increased ferritin levels.

The mean FBS was 208.87 mg/dL, while the mean PPBS was 284.97 mg/dL, indicating poor glycemic control. Serum ferritin showed a weak positive correlation with FBS ($r = 0.095$, $p = 0.049$) and a negative correlation with PPBS ($r = -0.113$, $p = 0.022$). Similar observations were reported by Al-Fawaeir et al. (2021)[16] and Saxena et al. (2019),[15] who demonstrated that elevated ferritin levels are associated with both fasting and postprandial hyperglycemia and may predict diabetes-related complications.

"The findings of the present study are in agreement with previous studies by Maheshwari et al. (2015),[11] Rawat et al. (2016),[12] Tariq et al. (2017),[13] Harikrishnan (2018),[14] Saxena et al. (2019),[15] and Al-Fawaeir et al. (2021),[16] which consistently demonstrated that elevated serum ferritin is associated with poor glycemic control." These findings suggest that serum ferritin can be considered a useful adjunctive biomarker along with HbA1c, FBS, and PPBS for assessing disease severity and monitoring patients with T2DM.

CONCLUSION

This study shows that poor glycaemic management in patients with type 2 diabetes mellitus is linked to higher blood ferritin levels, suggesting that ferritin may be a valuable biomarker for disease monitoring. Routine assessment of serum ferritin alongside HbA1c, FBS, and PPBS may help identify patients at higher risk of complications and improve diabetes management. Nevertheless, more extensive long-term research is required to validate these results and prove the link between ferritin levels and glycaemic management.

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