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Research Article

Iron Status in Type 2 Diabetes Mellitus Patients: A Tertiary Care Hospital Study

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Abstract

Background: Diabetes Mellitus is a leading cause of death and disability world wide. Glycated haemoglobin (HbA1c) is recommended for screening and diagnosis of Type 2 Diabetes Mellitus. Iron is a transitional metal and a potential catalyst in cellular reactions that produces reactive oxygen species. Ferritin is an index of body iron stores and acts as an iron overload marker. Many cross sectional studies suggest a link between body iron excess and insulin metabolism.

Objectives: To evaluate the association of iron status parameters with glycemic status in Type 2 DM.

Methods: A cross sectional study was conducted in the Department of Biochemistry, Dhaka Medical College (DMC), Dhaka; from July 2015 to June 2016. According to selection criteria a total 50 diagnosed patients of Type 2 DM attending in the Department of Endocrinology & Metabolism, Dhaka Medical College Hospital were selected as Group A and same number of age and sex matched apparently healthy individuals were selected (from same hospital staff, patient attendants and visitors by personal contact) as Group B. All the study subjects were subjected to detailed clinical history, physical examinations and laboratory biochemical investigations. After an overnight fast venous sample was taken from all subjects. Fasting plasma glucose was estimated enzymatically by glucose oxidase method, Glycated hemoglobin was measured by high performance liquid chromatography and estimation of serum iron, serum ferritin, total iron binding capacity were done by using Automatic Biochemistry Analyzer. Then data was analyzed by using Statistical Package for Social Science (SPSS) 20.0.

Results: Mean serum iron in Group A and Group B were 112.7 μg/dl and 87.6 μg/dl respectively. Mean serum ferritin concentration in Group A and Group B were 199.3 μg/dl and 107.0 μg/dl respectively. There was statistically significant increase in serum iron and serum ferritin concentrations in group A ($p < 0.0001$) compare to Group B ($p < 0.0001$). Both serum ferritin and serum iron levels show strong positive correlations with HbA1C (($r = 0.724$, $p < 0.001$, $r = 0.724$, $p < 0.001$) and FPG (($r = 0.724$, $p < 0.001$, $r = 0.724$, $p < 0.001$). The mean TIBC level was found 184 g/dl in Group A and 318.8 g/dl in Group B. TIBC levels were significantly lower in Group A than Group B and negative correlation was found between TIBC with HbA1c and FPG.

Conclusion: In comparison with healthy individuals, Type 2 DM patients had increased serum ferritin and serum iron levels and decreased TIBC with strong correlations of these parameters with glycemic control of diabetic's patients. Thus, routine screening for iron status along with Glycemic control in diabetic patients might help preventing complications.

Keyword: Diabetes Mellitus; Glycated Haemoglobin (HbA1c); Iron Status

Introduction

Diabetes mellitus is a clinical syndrome characterized by increase in plasma glucose [1]. Type 2 diabetes mellitus is a heterogeneous disorder caused by a combination of genetic factors related to impaired insulin secretion, insulin resistance and environmental factors such as obesity, over eating, lack of exercise and stress as well as aging [2]. It is typically a multifactorial disease involving multiple genes and environmental factors to varying extents [3]. Lack of insulin affects the metabolism of carbohydrate, protein and fat and can cause significance disturbance of water and electrolytes homeostasis; death may result from acute metabolic decomposition. Long standing metabolic dearrangement is associated with functional and structural changes in many organs particularly of vascular system; which lead to clinical complications of diabetes [1]. Diabetes Mellitus is assuming epidemic proportions worldwide and the incidence of the disease is increasing day by day. Diabetes is responsible for increased cardiovascular mortality and over all low quality of life. Globally, an estimated 422 million adults are living with diabetes mellitus, according to the latest 2016 data from the world health organization. Diabetes prevalence is increasing rapidly; previous 2013 estimates from the International Diabetic Federation put the number at 381 million people having diabetes. The number is projected to almost double by 2030. Type 2 diabetes is the predominant form of diabetes and accounts for at least 90% of all cases of diabetes mellitus [4]. In most epidemiological studies, it is observed that the subjects with Type 2 DM at greater risk of cardiovascular disease (CVD) and it is therefore, a leading cause of death globally. Current estimates 21.9% of total death by CVD are projected to increase to 26.3% by 2030 [5]. In Bangladesh which had a population of 149.8 million in 2011, a recent meta-analysis showed that the prevalence of diabetes among adults had increased substantially from 4% in 1995 to 2000 and 5% in 2001 to 2005 to 9% in 2006 to 2010. According to the international diabetes federation, the prevalence will be 13% by 2030. Diabetes mellitus comprises a group of common metabolic disorders that share common phenotype of hyperglycemia. Hyperglycemia not only defines the disease but is the cause of its most characteristic symptoms and long-term complications [6]. Because the development of complications is linked to the accumulation of glycation adducts in tissue proteins. The core of the issue is glycemic control. Among the various markers of glycemic control, glycated hemoglobin has now been established as the most reliable marker [7]. Optimal monitoring of glycemic control involves plasma glucose measurement and measurement of HbA1c. These measurements are complementary: the patient's glucose measurements provide a picture of short-term glycemic control, whereas the HbA1c reflects average glycemic control over the previous 2 to 3months. Glycosylated hemoglobin is formed by the glycosylation of hemoglobin. HbA1c should thus be kept to less than 7% for patients in general and to less than 6% for individual patients. HbA1c is the primary target for glycemic control [8]. Iron is essential to nearly all cells but the amount of iron required by individual tissues varies during development. At the same time body must protect itself from free iron, which is highly toxic. Its toxicity comes from its propensity to generate free radicals that causes cell damage. Body iron status can be assessed by estimating serum ferritin and serum iron. Serum ferritin is by the far most single measure of iron status because it accurately reflects body iron stores. It is not affected by day to day fluctuation in iron intake. Insulin is known to cause a rapid and marked stimulation of iron uptake by fat cells due to redistribution of transferrin receptors from intracellular membrane compartment to cell surface [9]. Reciprocally, iron influence insulin action by insulin inhibition of glucose production by liver [10]. In diabetes mellitus, due to defect in insulin action, there is decrease in uptake of iron and increase circulatory pool of catalytic iron. Increase blood glucose in diabetes mellitus stimulates non enzymatic glycosylation of several proteins including hemoglobin [11]. Glycation of transferrin decreases its ability to bind ferrous iron, hence increases free iron pool which in turn facilitates ferritin synthesis [12]. Effect of glycosylation on iron-mediated free radical reactions of hemoglobin demonstrated that H_2O_2 induced iron release is more from HbA1c than that from non-glycosylated hemoglobin (HbA0). In the presence of H_2O_2, HbA1c degrades arachidonic acid and deoxyribose more efficiently than HbA0, which suggests that iron release is more with HbA1c compared to HbA0. Increased rate of oxidation of HbA1c in the presence of nitro blue tetrazoliumis indicated by an increase in methemoglobin formation. HbA1c exhibits less peroxidase activity than HbA0. These findings on glycosylation-induced functional properties of hemoglobin suggest a mechanism of increased formation of free radicals and oxidative stress in diabetes mellitus [13]. In normal physiological state, iron is tightly bound within protoporphyrin ring of heme pocket.Under specific circumstances (DM), iron is

released from heme and ligated to another moiety, perhaps the distal histidine in the heme pocket this iron termed 'free reactive iron' can be detected by ferrozine reaction [14]. Iron is an essential nutrient with limited bioavailability. When present in excess, iron poses a threat to cells and tissues, and therefore iron homeostasis has to be tightly controlled. Iron's toxicity is largely based on its ability to catalyze the generation of radicals, which attack and damage cellular macromolecules and promote cell death and tissue injury [15]. Iron is reversibly oxidized and reduced. This property, while essential for its metabolic functions, makes iron potentially hazardous because of its ability to participate in the generation of powerful oxidant species such as hydroxyl radical [16]. Emerging scientific evidences has disclosed unsuspected influence between iron metabolism and Type 2 diabetes. The relationship is bi-directional - iron affects glucose metabolism, and glucose metabolism impinges on several iron metabolic pathways. Oxidative stress and inflammatory cytokines influences these relationships, amplifying and potentiating the initiated events. Iron induced damage might also modulate the development of chronic diabetes complications [17]. Iron is a transitional metal and a potential catalyst in cellular reactions that produces oxygen reactive species such as hydroxyl radical (OH^-) and superoxide anion ($O2^-$) via Fenton and Haber weiss reactions that can initiate and propagate the cascade leading to oxidative stress which impair insulin signaling in skeletal muscle and liver and cause β-cell destruction due to an insufficient β-cell deficient antioxidant defense [18]. Poor glycemic control causes increased Glycation of proteins, especially hemoglobin, which releases the iron in its free state. Hence increased presence of free iron in its Fe3+ state in association with hyperglycemia might have caused decreased in the levels of protein bound thiols and increase in lipid hydro peroxides. This increased presence of free iron pool will enhance oxidant generation leading damage to bio molecules and lead to complications [13]. Ferritin is also a positive acute-phase reactant and increases in various acute or chronic disease conditions [18]. Elevated serum ferritin levels independently predicted the incidence of Type 2 Diabetes Mellitus in a prospective study in apparently healthy men and women [19,20]. Elevated ferritin level has also been associated with hypertension, dyslipidemia, elevated fasting insulin glucose and adiposity [21]. Serum Ferritin has even been suggested to be considered as a part of insulin resistance syndrome. Also, elevated serum ferritin concentrations early in gestation are associated with increased risk of gestational diabetes mellitus [22]. From ferritin, Iron is released by the action of reducing agents that convert Fe3+ into Fe2+ [23]. Synthesis of ferritin is stimulated by glycation of transferrin by reducing its ability to bind ferrous iron and by increasing the amount of free iron. Glycated holo transferrin also facilitates the production of free oxygen radicals, such as hydroxide, that accelerates the oxidative effects of iron. Physiological action of insulin causes increased uptake iron. Other factors such as aging, repeated infections, weight gain, periodontitis causing hyperinsulinemia also amplifies this process, resulting in increased deposition of iron, which further worsens insulin resistance [10]. Since variable findings have been obtained for iron profile status in different studies therefore, present study has been intended to see iron status parameters in Type 2 diabetes mellitus in Bangladeshi patients.

Objectives

General objective

To evaluate the association of iron status parameters with glycemic status in Type 2 DM.

Specific objectives

- To measure glycemic status (FPG and HbA1c) in both groups.
- To measure Iron status (Serum iron, serum ferritin, TIBC) in both groups.
- To compare statistically serum iron status parameters between Type 2 DM patients and healthy individuals.
- To find out the relationship between iron status and HbA1c in Type 2 DM patients.
- To find out the relationship between iron status and FPG in Type 2 DM patients.

Methodology

This was a cross sectional study conducted in the department of Biochemistry, Dhaka Medical College, Dhaka, Bangladesh from July 2015 to June 2016. A total of 100 study population were recruited in this study as study population. Purposive sampling method was for sample selection. The total participants were divided in two groups. In group A 50 diagnosed patients of type 2 DM selected as case group & in group B 50 healthy individuals as control group.

Inclusion criteria for both groups

Diagnosed patients of Type 2 DM: Patients was selected any one of the following findings. (4 options: FPG, 2-hr PG, HbA1c, Random PG by American Diabetes Association- 2016). a) HbA1c ≥ 6.5%. b) Fasting plasma glucose ≥ 7.0 mmol/L (126 mg/dl). c) Two-hour plasma glucose ≥11.1 mmol/L (200 mg/dl) during an oral glucose tolerance test. d) Random PG ≥ 200 mg/dl (11.1 mmol/L).

- Age group: 40-65 years.
- Both male and female.
- Age and sex matched apparently healthy individuals.

Exclusion criteria for both groups

- Pregnant women and lactating mothers.
- Patients of any chronic inflammatory disease like rheumatoid arthritis and chronic systemic illness (CLD, CKD, COPD).
- Malignancy.
- Chronic smokers and Chronic alcoholics.
- Patients on iron therapy.
- Patients with recent history of blood transfusions.
- Haemorrhagic diseases.
- Type 2 DM with severe complications
- Known cause of iron overload
- Study Procedure

Data collection method

According to selection criteria a total 50 diagnosed patients of Type 2 DM attending in the Department of Endocrinology and Metabolism, Dhaka Medical College Hospital were selected as Group A and same number of age and sex matched apparently healthy individuals (from the same hospital stuff, patient attendants and visitors by personal contact) were selected as Group B. After selection of the subjects, the objectives, natures, purpose and potential risk of all procedures used for the study were explained in details and informed written consent were taken from both the patients and the healthy individuals. Particulars, detail history, clinical and physical examinations were taken in a predesigned data collection form, from all the subjects.

Blood sampling technique

After 10-12 hours overnight fasting 6 ml venous blood sample was collected from median cubital vein of each study participants by disposable syringe, with all aseptic precautions. Out of 6 ml blood, 2 ml was mixed with potassium EDTA tube with gentle push to avoid hemolysis and used for estimation of HbA1c, another 2 ml was mixed with potassium EDTA tube and NaF (to prevent glycolysis) is used for measurement of FPG and rest 2 ml blood transferred immediately into a dry, clean and plain test-tube and kept in slanting position till formation of clot. Samples for plasma and serum were centrifuged at 3000 rpm for 10 minutes. The serum and plasma were separated and then separated serum and plasma were aspirated for biochemical assay. All the biochemical tests were carried out as early as possible. Whenever there was a delay, the serum was stored in freezer at or below -20°C, to avoid loss of bioactivity and contamination. Iron status, HbA1c was estimated in the Biochemistry Department of BSMMU and FPG was performed at the Department of Biochemistry, Dhaka Medical College, Dhaka.

Laboratory investigations

- **Fasting plasma glucose:** Fasting plasma glucose was estimated enzymatically by 'Glucose Oxidase' (GOD-POD) method [24]. Reading was taken by Evolution-3000 semi-automated analyzer.
- **Estimation of serum ferritin:** Serum ferritin levels were estimated by 'Dimension RxL Max' (Automatic Biochemistry Analyzer) [25].
- **Estimation of serum iron:** Serum iron levels were estimated by Dimension ® Clinical Chemistry System (Automatic Biochemistry Analyzer) [26].
- **Estimation of TIBC:** Total iron binding capacity is the maximum concentration of iron that the serum proteins can bind. TIBC were estimated by automated chemistry analyzers. [27].
- **Estimation of HbA1C:** Estimation of Haemoglobin A1c in human whole blood done by ion-exchange high-performance liquid chromatography (HPLC) [28].

Statistical analysis

After meticulous checking and rechecking all data were recorded in a predesigned data collection sheet. The mean values were calculated for continuous variables. The quantitative observations were indicated by frequencies and percentages.

Continuous variables were expressed as mean ± SD and were compared between groups of patients by student's unpaired 't' test. Categorical variables were compared using a chi-square test. Pearson's correlation coefficient was used to test the relationship between the parameters. The result was considered as statistically significant when p value was less than 0.05 at the level of 95% confidence interval. All analysis was done using the SPSS version 20 package for windows.

Ethical clearance

The ethical clearance of this study was taken from the concerned Department and Ethical Review Committee of Dhaka Medical College.

Results

Age and gender	Group		p value
	Group A n = 50 n (%)	Group B n = 50 n (%)	
Age (years)			
Mean ± SD	52.30 ± 6.25	51.76 ± 6.91	0.683
Gender			
Male	35 (70.0)	29 (58.0)	0.211
Female	15 (30.0)	21 (42.0)	

Table 1: Distribution of the study subjects according to age and gender. (N = 100).

Table 1 showed distributions of study subjects according to age and gender. There was no significant difference of study subjects according to age and gender between two groups. The study subjects are age and sex matched.

Serum ferritin (µg/L)	Group		p value
	Group A n (%)	Group B n (%)	
< 150	23 (46.0)	45 (90.0)	< 0.001
≥150	27 (54.0)	5 (10.0)	

Table 2: Distribution of study subject according to serum ferritin level in group A and group B. (N = 100).

Table 2 showed distribution of study subject according to serum ferritin level in both groups. Serum ferritin levels were higher in Group A than Group B and the difference was statistically significant. In group A, 46% patients had serum ferritin levels < 150 µg/L and 54% had serum ferritin levels ≥ 150 µg/L.

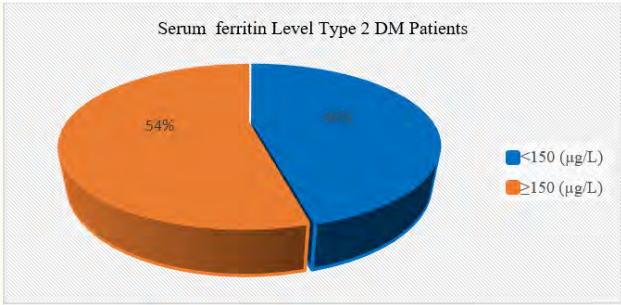

Figure 1: Pie chart of serum ferritin level distribution in Type 2 DM Patients. (n = 30).

Serum iron (µg/dl)	Group		p value
	Group A n (%)	Group B n (%)	
< 100	22 (44.0)	39 (78.0)	< 0.001
≥100	28 (56.0)	11 (22.0)	

Table 3: Distribution of study subject according to serum iron level in group A and group B. (N = 100).

Table 3 showed distribution of study subjects according to serum iron level in both groups. Serum iron levels were higher in group A than Group B and the difference was statistically significant. In group A, 44% patients had serum iron levels < 100 µg/dl and 56% had serum iron levels ≥ 150 µg/dl.

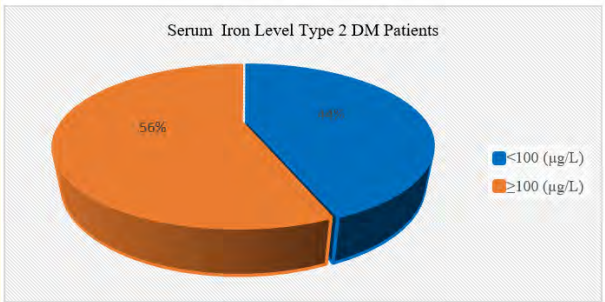

Figure 2: Pie chart of serum iron level distribution in Type 2 DM Patients. (n = 30).

Parameters	Group		p value
	Group A (mean ± SD)	Group B (mean ± SD)	
Serum Ferritin (µg/L)	199.3 ± 74.8	107.0 ± 30.4	< 0.001
Serum Iron (µg/dl)	112.7 ± 34.1	87.6 ± 20.9	< 0.001
TIBC (µg/dl)	184.0 ± 79.5	318.8 ± 14.0	< 0.001

Table 4: Distribution of biochemical parameters in group A and group B. ((N = 100).

Table 4 shows biochemical parameters of the study subjects in group A and group B. Serum ferritin and serum iron were significantly higher in Group A than Group B. TIBC levels were significantly lower in Group A than Group B.

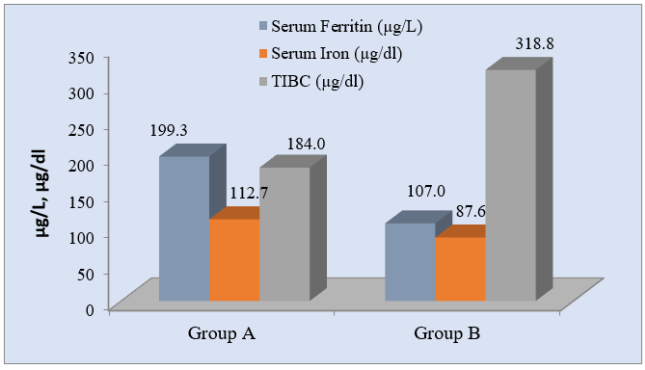

Figure 3: Bar chart showed mean serum ferritin, serum iron and TIBC status of group A and group B.

Biochemical parameters		r value	p value
Iron status	FPG		
Serum Ferritin		0.705	< 0.001
Serum Iron		0.920	< 0.001
TIBC		-0.747	< 0.001

Table 5: Correlation of Iron status with FPG. (n = 50)

Pearson's correlation test was done to measure the level of significance.

Level of significance p < 0.05.

Table 5 shows Pearson's correlation coefficient test of Iron status with FPG. There was strong positive correlation found between serum ferritin with FPG and serum iron with FPG respectively. Negative correlation between TIBC with FPG was found.

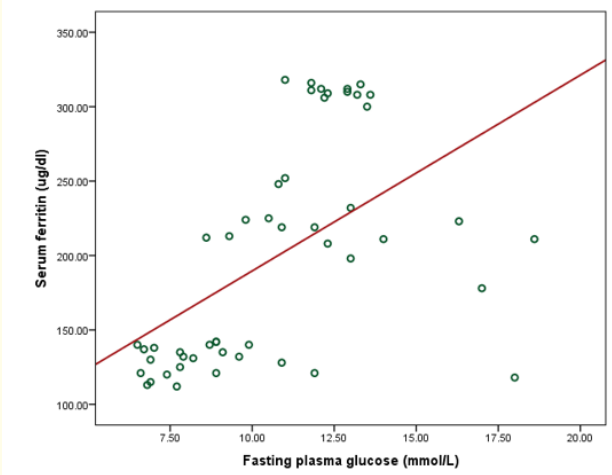

Figure 4: Correlation of fasting plasma glucose with serum ferritin in Type 2 DM. (n = 50).

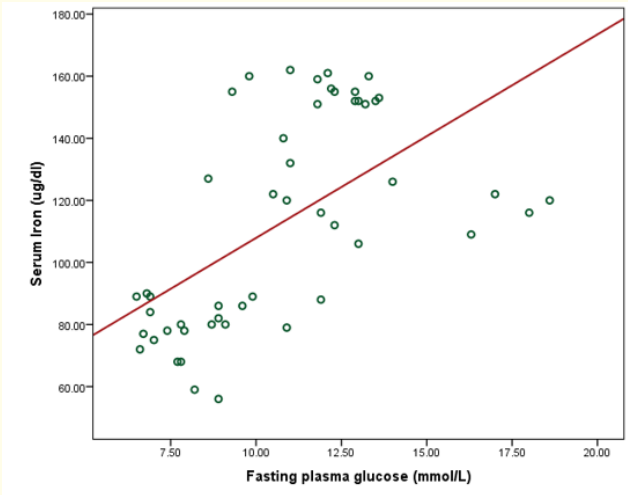

Figure 5: Correlation of fasting plasma glucose with serum iron in Type 2DM. (n = 50).

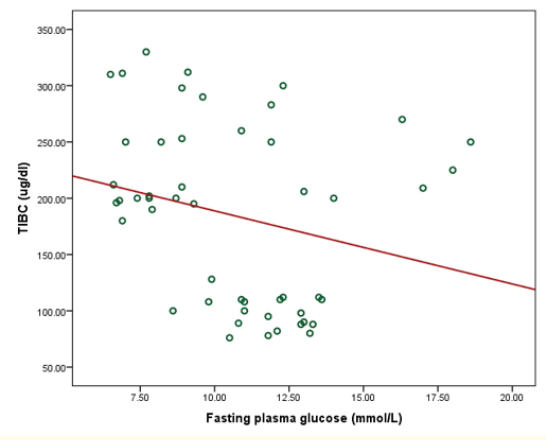

Figure 6: Correlation of fasting plasma glucose with TIBC in Type 2 DM. (n = 50).

Biochemical parameters		r value	p value
Iron status	HbA1c		
Serum Ferritin		0.705	< 0.001
Serum Iron		0.920	< 0.001
TIBC		-0.747	< 0.001

Table 6: Correlation of Iron status with HbA1c. (n = 50).

Pearson's correlation test was done to measure the level of significance.

Level of significance $p < 0.05$.

Table 6 shows Pearson's correlation coefficient test of Iron status with HbA1c. There was strong positive correlation found between serum ferritin with HbA1c and Serum iron with HbA1c respectively. Negative correlation between TIBC with HbA1c was found.

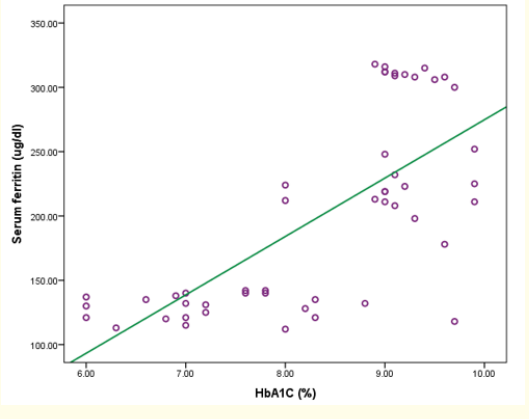

Figure 7: Correlation of HbA1c with serum ferritin in Type 2 DM. (n = 50).

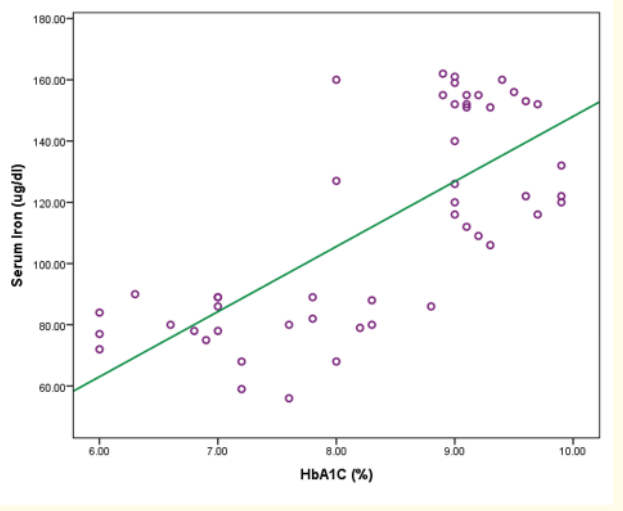

Figure 8: Correlation of HbA1c with serum iron in Type 2 DM. (n = 50).

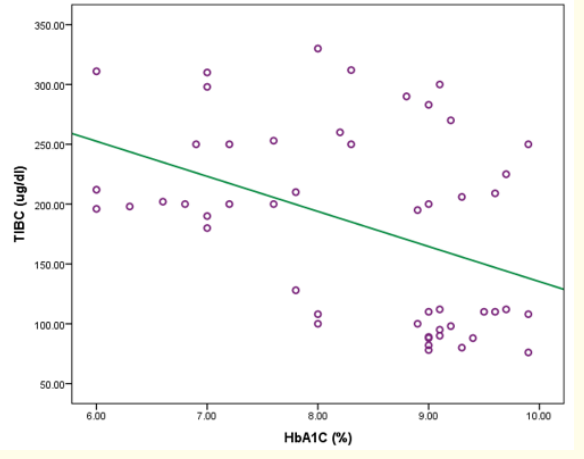

Figure 9: Correlation of HbA1c with TIBC in Type 2 DM. (n = 50).

Discussion

In this present study, mean serum iron concentration in Group A and Group B were 112.7 and 87.6 respectively. Mean serum ferritin concentration in Group A and Group B were 199.3 and 107.0 respectively. There was statistically significant increase in serum iron and serum ferritin concentration in group A ($p < 0.0001$) compare to Group B ($p < 0.0001$). These results of the study were in agreement with the studies conducted earlier. Studies done by Bozzini., *et al*., 2005, Jiang., *et al*., 2004 [29,30] observed an important and a highly significant association between serum

iron and serum ferritin with Type 2 DM. Sudhakar., *et al.,* 2014 [17] also found high serum iron and serum ferritin concentrations in patients with Type 2 diabetes Mellitus with poor controls. His study design was also a cross sectional study consists of 450 patients. High serum ferritin concentrations was also found in Kashinakunti., *et al*., 2016, Pramiladevi., *et al*., 2013 [31,32] studies when compared to normal individuals. In 2012 Senghor., *et al.* [33] found mean serum ferritin levels was significantly higher in diabetes with the increased duration as compared with the pre-diabetic group. From this study the mean value of TIBC was found 184.0 ± 79.5 in Group A and 318.8 ± 14 in Group B. TIBC levels were significantly lower in Group A than Group B. This result was to contrast with the result found by Kapoor and Sharma, 2015. [9] They have studied on 30 Type 2 DM patients and 30 ages, sex matched healthy controls. According to their result low TIBC, UIBC and increased transferrin saturation was seen in Type 2 DM patients. The correlation between TIBC with FPG and HbA1c was done. There showed negative correlations between TIBC with FPG (r = -0.747) and HbA1c (r = 0.747). Kapoor and Sharma, 2015 [9] also found negative correlation between TIBC with FPG and HbA1c. But these results do not agree with the results of Senghor., *et al*., 2012 [33]. They did not observe any correlations between TIBC with FPG and HbA1c. In this present study the mean HbA1C was found 8.3 ± 1.2 in Group A and 5.0 ± 0.6 in Group B. There was statistically significant increase of mean value of HbA1c in group A ($p < 0.0001$) compare to Group B ($p < 0.0001$). Fernandez., *et al*., 2002 [23] studies were in consistent with the present result. Dhawale., *et al*., 2015 and Sharifi., *et al*., 2008 [34,35] results are not in harmony with the present study. In their study serum ferritin levels were increased but HbA1c was in normal range. Correlation of serum ferritin and serum iron with HbA1c was done. Both serum ferritin and serum iron levels shows strong positive correlation with HbA1C. The correlation coefficient was r = 0.705 and $p < 0.001$ and r = 0.920 and $p < 0.001$ respectively. This results were in harmony with the study done by Wrede., *et al*., 2006 [36] who reported a significant correlation between serum ferritin and HbA1c in a large represented population. There's was a nationwide epidemiological survey on 1200 populations. Shetty., *et al*., 2008 [11] has shown relationship between free iron and glycated hemoglobin in uncontrolled Type 2 diabetes patients associated with complications. Kar., *et al*., (2001) [13] have studied Effect of glycosylation on iron-mediated free radical reactions of hemoglobin and demonstrated that H_2O_2 induced iron release is more from HbA1c than that from non-glycosylated hemoglobin (HbA0). These findings on glycosylation-induced functional properties of hemoglobin suggest a mechanism of increased formation of free radicals and oxidative stress in diabetes mellitus. The findings of the present study were also found to be similar to the following studies- Kim., *et al*., 2000, Maheshwari., *et al*., 2015 and Padmaja, Shabana and Shariq, 2015. [37-39] But present result was in conflict with the two studies done by Pramiladevi., *et al.,* 2013 and Dhawale., *et al*., 2015. [32,34] In their results level of serum ferritin and serum iron were not correlating with HbA1c. There was strong positive correlation between FPG with serum ferritin (r = 0.705) and serum iron (r = 0.920). TIBC shows negative correlation with FPG. These findings were similar to findings of Padmaja, Shabanas and Shariq, 2015. [39] They found statistically increase of FPG, HbA1c and serum ferritin in Type 2 DM group than control group. Sudhakar., *et al*., 2014 [17] also found positive correlation between FPG with serum ferritin and serum iron. Positive correlation between iron status and FPG found by Chandrashekhar., *et al*., [40]. Also, Vari., *et al*., 2007 [41] reported that fasting plasma glucose, insulin resistance was significantly correlated with serum ferritin. So from the above discussion it may be concluded that in comparison with healthy individuals, Type 2 DM patients had increased serum ferritin and serum iron level and decreased TIBC. Levels of serum ferritin and serum iron were directly correlating with the glycemic control of diabetic patients (HbA1c). Therefore, it is suggested that serum ferritin and serum iron could be added to routine evaluation of Diabetes Mellitus and prediabetes; this would help us identify a subgroup of individuals at risk of iron related tissue damage, in whom further investigations and therapeutic options may be appropriate.

Conclusion

In comparison with healthy individuals, Type 2 DM patients had increased serum ferritin and serum iron level and decreased TIBC with strong correlations of these parameters with glycemic control of diabetic's patients. That iron overload may aggravate diabetic complications such as CAD, insulin resistance syndrome, metabolic syndrome, atherosclerosis etc. Thus, routine screening for iron along with glycemic control in Type 2 DM patients might help preventing complications.

Limitations

- The present study was conducted at a very short period of time. Small sample size was also a limitation of the present study.
- The sample was taken purposively, so there may be a chance of bias which can influence the result.
- Dietary history was not taken which could have been an important reason for low or high serum ferritin in that particular patient.
- Patients were not matched for their area of residence (socio-economic) status which can have an effect on serum ferritin (iron stores) levels.
- Present Study was a cross sectional study and serum transferrin level, % saturations and transferrin receptors were not evaluated in this study which could have provided with more precise information.

Recommendations

- Further studies including large sample size can be undertaken.
- Random iron supplementations should be avoided in diabetic patients.
- Further study of other predictors (serum transferrin level, % saturations and transferrin receptors) which are associated with Iron status can be done.

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