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RESEARCH ARTICLE

Association of Glycemic Control with Metabolic, Electrolyte, Thyroid, and Iron Profiles: A Cross-Sectional Study in Bangladeshi Adults

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ABSTRACT

Background: Diabetes mellitus is a multifactorial metabolic disorder associated with widespread biochemical alterations beyond hyperglycemia. Understanding the relationship between glycemic control and other metabolic parameters is essential for comprehensive disease management. **Objective:** This study aimed to evaluate the association of glycemic control with metabolic, electrolyte, thyroid, iron, renal, and lipid profiles among Bangladeshi adults. **Methods:** This hospital-based cross-sectional analytical study was conducted from June to December 2025 in a tertiary care hospital in Bangladesh. A total of 500 adult participants were included, comprising 250 diabetic and 250 non-diabetic individuals. Data were collected from laboratory reports and clinical records. Biochemical parameters, including glycemic indices (FBS, RBS, HbA1c), electrolytes, thyroid hormones, ferritin, creatinine, and lipid profile, were analyzed. Statistical analysis included independent t-tests, Spearman's correlation, and multiple linear regression. **Results:** Diabetic participants exhibited significantly higher levels of FBS (9.52 vs. 4.94 mmol/L), RBS (13.34 vs. 6.56 mmol/L), and HbA1c (9.04% vs. 5.19%) ($p < 0.001$). Significant electrolyte alterations included lower sodium and calcium and slightly higher potassium and chloride levels ($p < 0.001$). TSH levels were significantly elevated, while Free T4 showed no difference. Ferritin and creatinine levels were markedly higher in diabetics, indicating increased inflammation and renal involvement. Lipid profile showed elevated LDL, triglycerides, and total cholesterol, with reduced HDL ($p < 0.001$). HbA1c demonstrated strong positive correlations with creatinine ($r = 0.52$), LDL ($r = 0.42$), ferritin ($r = 0.35$), and TSH ($r = 0.30$), and negative correlations with HDL ($r = -0.28$), sodium ($r = -0.21$), and calcium ($r = -0.14$). Regression analysis

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identified FBS, RBS, triglycerides, creatinine, and total cholesterol as independent predictors of HbA1c (Adjusted R^2 = 0.54). **Conclusion:** Poor glycemic control is significantly associated with disturbances in electrolyte balance, thyroid function, iron metabolism, renal function, and lipid profile. These findings highlight the need for comprehensive biochemical monitoring in diabetic patients to improve clinical outcomes.

Keywords: Diabetes Mellitus, HbA1c, Electrolyte Imbalance, Ferritin, Dyslipidemia

1. Introduction

Diabetes mellitus represents one of the most significant and rapidly escalating global health challenges of the 21st century, affecting millions of individuals across both developed and developing nations. It is a complex metabolic disorder characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or a combination of both[1]. Persistent hyperglycemia leads to widespread metabolic dysregulation and is strongly associated with the development of both microvascular complications, such as nephropathy, neuropathy, and retinopathy, and macrovascular complications including coronary artery disease, stroke, and peripheral vascular disease[2]. The burden of diabetes is particularly concerning in low- and middle-income countries like Bangladesh, where rapid urbanization, lifestyle transitions, and limited healthcare resources contribute to increasing prevalence and suboptimal disease control[3].

Glycemic control remains the cornerstone of diabetes management, and glycated hemoglobin (HbA1c) is widely accepted as a reliable indicator of long-term glycemic status, reflecting average blood glucose levels over the preceding 2–3 months. Elevated HbA1c levels have been consistently linked with an increased risk of complications and poor clinical outcomes[4]. However, growing evidence indicates that glycemic control extends beyond glucose metabolism alone and is intricately associated with a broader spectrum of physiological and biochemical alterations, including electrolyte imbalances, endocrine dysfunction, iron metabolism disturbances, and lipid abnormalities[5].

Electrolyte disturbances are frequently observed in patients with poorly controlled diabetes. Chronic hyperglycemia induces osmotic diuresis, leading to increased urinary loss of electrolytes such as sodium and calcium, while alterations in insulin activity can affect potassium distribution across cell membranes[6]. These imbalances not only reflect metabolic instability but may also exacerbate cardiovascular and renal complications. In addition, renal dysfunction commonly associated with diabetes further contributes to impaired electrolyte homeostasis, emphasizing the clinical importance of monitoring these parameters alongside glycemic indices[7].

Thyroid dysfunction represents another important yet often under-recognized comorbidity in diabetic patients. The interplay between thyroid hormones and glucose metabolism is complex and bidirectional[8]. Elevated thyroid-stimulating hormone (TSH), indicative of hypothyroid states, has been associated with insulin resistance, altered lipid metabolism, and impaired glucose utilization. Conversely, thyroid hormone abnormalities can influence pancreatic β-cell function and peripheral insulin sensitivity, thereby affecting glycemic control. Understanding this relationship is essential for optimizing metabolic outcomes in diabetic populations[9].

Iron metabolism has also emerged as a critical factor in the pathophysiology of diabetes. Serum ferritin, a marker of body iron stores, is increasingly recognized as an indicator of chronic inflammation and oxidative stress. Elevated ferritin levels have been linked to insulin resistance, β-cell dysfunction, and increased risk of type 2 diabetes[10]. Iron overload can promote the generation of reactive oxygen species, leading to cellular damage and impaired insulin signaling pathways. Therefore, the assessment of iron status provides valuable insight into the metabolic and inflammatory milieu associated with poor glycemic control[11].

In parallel, dyslipidemia is a well-established metabolic abnormality in diabetes and a major contributor to cardiovascular morbidity and mortality. Diabetic dyslipidemia is typically characterized by elevated levels of low-density lipoprotein (LDL) cholesterol and triglycerides, along with reduced high-density lipoprotein (HDL) cholesterol[12]. These lipid abnormalities are closely linked with insulin resistance and poor glycemic control, further amplifying the risk of atherosclerosis and cardiovascular events. The interrelationship between glycemic status and lipid metabolism underscores the need for integrated metabolic assessment in diabetic care[13].

Despite the growing body of evidence highlighting the interconnected nature of these biochemical parameters, there remains a lack of comprehensive studies evaluating the simultaneous association of glycemic control with electrolyte balance, thyroid function, iron metabolism, and lipid profile, particularly in the context of Bangladeshi adults. Most existing studies have focused on individual parameters rather than adopting a holistic approach, thereby limiting a complete understanding of the metabolic interplay underlying diabetes[14]. Therefore, the present study aimed to investigate the association of glycemic control, as measured by HbA1c, with metabolic, electrolyte, thyroid, and iron profiles among Bangladeshi adults in a tertiary care hospital setting.

2. Materials and Methods

2.1. Study Design and Duration

This study was designed as a hospital-based cross-sectional analytical investigation conducted over a six-month period from June 2025 to December 2025. The cross-sectional design was chosen to evaluate the association between glycemic control and multiple biochemical parameters at a single point in time within a defined population.

2.2. Study Setting

The study was carried out in a tertiary care hospital in Bangladesh, which serves a diverse patient population and provides comprehensive diagnostic laboratory services. Data were obtained from routine clinical and laboratory records, ensuring real-world applicability of the findings.

2.3. Study Population

A total of 500 adult participants were included in the study. The study population was divided into two groups: 250 individuals diagnosed with diabetes mellitus and 250 non-diabetic individuals serving as controls. Participants were selected based on the availability of complete biochemical and clinical data during the study period. The diabetic status of participants was determined based on documented clinical diagnosis and laboratory findings.

2.4. Data Collection

Data were retrospectively collected from hospital laboratory reports and patient medical records. Relevant demographic and biochemical parameters were extracted systematically using a structured data collection format. The variables included age as a demographic parameter; glycemic indices such as fasting blood sugar (FBS), random blood sugar (RBS), and glycated hemoglobin (HbA1c); electrolyte parameters including serum sodium, potassium, chloride, and calcium; thyroid function markers including thyroid-stimulating hormone (TSH) and free thyroxine (Free T4); renal function marker creatinine; iron status marker ferritin; and lipid profile parameters including total cholesterol, high-density lipoprotein (HDL), low-density lipoprotein (LDL), and triglycerides.

2.5. Inclusion and Exclusion Criteria

Adult patients aged 18 years and above with complete biochemical records were included in the study. Participants with incomplete or missing data were excluded to ensure analytical accuracy. Additionally, individuals with known chronic conditions that could independently influence the studied biochemical parameters, such as advanced liver disease, malignancy, or other endocrine disorders (where applicable), were excluded to minimize potential confounding effects.

2.6. Statistical Analysis

All statistical analyses were performed using standard statistical software. Continuous variables were presented as mean ± standard deviation (SD), and data normality was assessed prior to analysis. Group differences between diabetic and non-diabetic participants were evaluated using the independent samples t-test. Associations between HbA1c and biochemical parameters were examined using Spearman's rank correlation coefficient. Multiple linear regression analysis was conducted to identify independent predictors of HbA1c, with results expressed as standardized coefficients (β) and model fit assessed using R^2. A two-tailed p-value < 0.05 was considered statistically significant.

3. Results

A total of 500 Bangladeshi adults were included in this study, comprising 250 diabetic and 250 non-diabetic individuals. The mean age of diabetic participants (50.80 ± 15.07 years) was higher than that of the non-diabetic group (45.19 ± 14.63 years). As shown in **Table 1**, all glycemic indices were significantly elevated in the diabetic group compared to non-diabetic controls. Mean FBS (9.52 ± 2.37 vs. 4.94 ± 0.51 mmol/L; t = 29.91, p < 0.001), RBS (13.34 ± 3.78 vs. 6.56 ± 0.62 mmol/L; t = 27.93, p < 0.001), and HbA1c (9.04 ± 1.94% vs. 5.19 ± 0.23%; t = 31.24, p < 0.001) were markedly higher, indicating significantly poorer glycemic control among diabetic participants.

Table 1. Glycemic index comparison between diabatic and non diabatic patients:

Parameters	Diabatic	Non-diabatic	t-value	P value
FBS	9.52 ± 2.37	4.94 ± 0.51	29.91	5.70E-88
RBS	13.34 ± 3.78	6.56 ± 0.62	27.93	1.40E-80
HbA1c%	9.04 ± 1.94	5.19 ± 0.23	31.24	2.55E-89

Table 2 demonstrates significant differences in electrolyte parameters between the two groups. Serum sodium (137.51 ± 5.21 vs. 139.90 ± 2.94 mmol/L; p < 0.0001) and calcium (9.15 ± 0.81 vs. 9.41 ± 0.47 mg/dL; p < 0.0001) were significantly lower in the diabetic group. In contrast, potassium (4.36 ± 0.70 vs. 4.32 ± 0.39 mmol/L; p < 0.0001) and chloride (103.65 ± 5.19 vs. 102.47 ± 2.63 mmol/L; p = 0.00144) were slightly but significantly higher.

Table 2. Comparison of Serum Electrolyte Levels Between Diabetic and Non-Diabetic Groups

Electrolyte	Diabatic	Non-diabatic	P value
Sodium	137.51 ± 5.21	139.90 ± 2.94	<0.0001
Potassium	4.36 ± 0.70	4.32 ± 0.39	<0.0001
Chloride	103.65 ± 5.19	102.47 ± 2.63	0.00144
Calcium	9.15 ± 0.81	9.41 ± 0.47	<0.0001

As presented in Table 3, TSH levels were significantly elevated in diabetic individuals compared to non-diabetics (4.37 ± 2.52 vs. 2.54 ± 1.16 mIU/L; $p < 0.0001$). However, no statistically significant difference was observed in Free T4 levels between the two groups (1.33 ± 0.40 vs. 1.29 ± 0.24 ng/dL; $p = 0.132$).

Table 3. Comparison of Thyroid Function Parameters Between Diabetic and Non-Diabetic Participants

Thyroid	Diabatic	Non diabatic	P value
TSH	4.37 ± 2.52	2.54 ± 1.16	<0.0001
Free T4	1.33 ± 0.40	1.29 ± 0.24	0.132

Table 4 shows that diabetic patients had significantly higher creatinine levels (1.55 ± 0.53 vs. 0.90 ± 0.18 mg/dL; $t = 18.40$, $p < 0.001$) and ferritin levels (261.89 ± 136.39 vs. 151.58 ± 80.39 ng/mL; $t = 11.02$, $p < 0.001$). Lipid profile analysis revealed significantly elevated LDL (137.6 ± 40.73 vs. 97.38 ± 15.2 mg/dL; $p < 0.001$), total cholesterol (209.23 ± 40.47 vs. 185.11 ± 19.77 mg/dL; $p < 0.001$), and triglycerides (250.74 ± 95.67 vs. 109.57 ± 23.11 mg/dL; $p < 0.001$) in the diabetic group. Conversely, HDL levels were significantly lower in diabetics (46.54 ± 10.95 vs. 53.57 ± 7.19 mg/dL; $p < 0.001$).

Table 4. Comparison of Renal Function, Iron Status, and Lipid Profile Between Study Groups

Thyroid	Diabatic	Non-diabatic	t-value	P value
Creatinine	1.55 ± 0.53	0.9 ± 0.18	18.40	2.20E-51
Ferritin	261.89 ± 136.39	151.58 ± 80.39	11.02	7.46E-25
HDL	46.54 ±10.95	53.57 ±7.19	-8.48702	3.47E-16
LDL	137.6 ±40.73	97.38 ±15.2	14.63075	2.13E-37
Total Cholesterol	209.23 ±40.47	185.11 ±19.77	8.47	6.31E-16
Triglyceride	250.74 ±95.67	109.57 ± 23.11	22.68	3.53E-65

As shown in Table 5, HbA1c demonstrated significant positive correlations with creatinine ($r = 0.52$, $p < 0.0001$), LDL ($r = 0.42$, $p < 0.0001$), ferritin ($r = 0.35$, $p < 0.0001$), TSH ($r = 0.30$, $p < 0.0001$), and total cholesterol ($r = 0.27$, $p < 0.0001$). Significant negative correlations were observed with HDL ($r = -0.28$, $p < 0.0001$), sodium ($r = -0.21$, $p < 0.0001$), and calcium ($r = -0.14$, $p = 0.002$). Chloride showed a weak positive correlation ($r = 0.099$, $p = 0.027$), while potassium ($r = 0.078$, $p = 0.080$) and Free T4 ($r = 0.06$, $p = 0.184$) were not significantly associated.

Table 5. Correlation of Biochemical Parameters with Glycemic Control (HbA1c%)

Parameter	Correlation coefficient r	p-value	P value significant
TSH	0.3****	8.86E-12	<0.0001
Sodium	-0.21****	3.56E-06	<0.0001
Potassium	0.078	0.0801	0.0801
Chloride	0.099*	0.0275	0.0275
Calcium	-0.14**	0.00208	0.00208
Total Cholesterol	0.27****	8.12E-10	<0.0001
Free T4	0.06	0.184	0.184
LDL	0.42****	2.90E-23	<0.0001
Creatinine	0.52****	1.39E-36	<0.0001
Ferritin	0.35****	2.75E-16	<0.0001
HDL	-0.28****	2.58E-10	<0.0001

r = Spearman's rank correlation coefficient. Significance levels < 0.05, {**}p < 0.01, {***}p < 0.001, {****} p<0.0001*

Table 6 indicates that ferritin levels were significantly positively correlated with HbA1c (r = 0.35, p < 0.0001), LDL (r = 0.24, p < 0.0001), creatinine (r = 0.24, p < 0.0001), and total cholesterol (r = 0.14, p = 0.001). Negative correlations were observed with HDL (r = -0.13, p = 0.00499) and calcium (r = -0.10, p = 0.024). Sodium also showed a weak negative correlation (r = -0.12, p = 0.0098). No significant associations were found with potassium, chloride, or Free T4.

Table 6. Correlation of Biochemical Parameters with Serum Ferritin Levels

Parameter	Correlation coefficient r	p-value	P value significant
HbA1c	0.35****	2.75E-16	<0.0001
TSH	0.11	0.0102	0.0102
Sodium	-0.12	0.0098	0.0098
Potassium	0.047	0.295	0.295
Chloride	0.058	0.196	0.196
Calcium	-0.1	0.024	0.024
Total Cholesterol	0.14	0.002	0.001
T4	0.038	0.401	0.401
LDL	0.24	4.42E-08	<0.0001****
Creatinine	0.24	3.47E-08	<0.0001****
HDL	-0.13	0.00499	0.00499**

r = Spearman's rank correlation coefficient. Significance levels < 0.05, {**}p < 0.01, {***}p < 0.001, {****} p<0.0001*

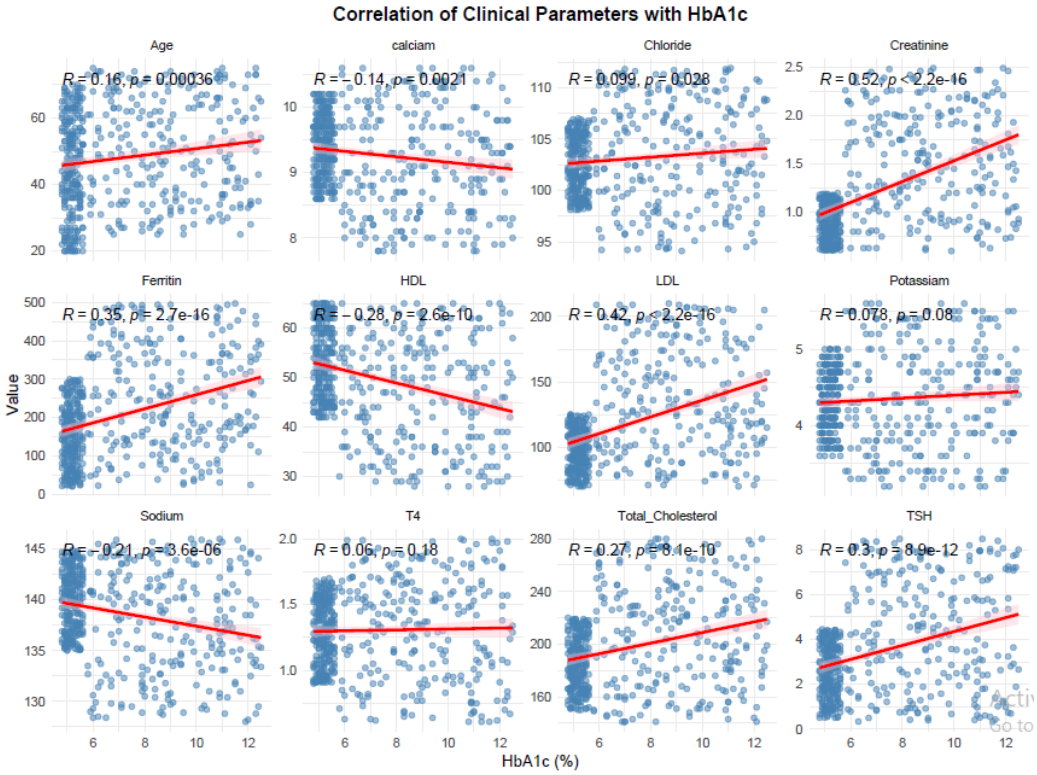

Figure 1. Correlation of biochemical and clinical parameters with glycemic control (HbA1c%). The faceted scatter plots illustrate the relationship between HbA1c (%) and variables including age, electrolytes (Sodium, Potassium, Chloride, Calcium), renal function (Creatinine), thyroid profile (TSH, fT4), iron stores (Ferritin), and lipid profile (Total Cholesterol, HDL, LDL). Red lines represent the linear regression fit with 95% confidence intervals (shaded areas). Spearman's correlation coefficients (R) and p-values are indicated within each panel.

Correlation analysis revealed significant associations between several clinical parameters and HbA1c levels (Figure 1).Positive Correlations: Strong significant positive correlations were observed between HbA1c and Creatinine ($R = 0.52$, $p < 0.001$), LDL ($R = 0.42$, $p < 0.001$), Ferritin ($R = 0.35$, $p < 0.001$), TSH ($R = 0.3$, $p < 0.001$), and Total Cholesterol ($R = 0.27$, $p < 0.001$).Negative Correlations: Significant negative correlations were found for HDL ($R = -0.28$, $p < 0.001$), Sodium ($R = -0.21$, $p < 0.001$), and Calcium ($R = -0.14$, $p = 0.0021$). Non-Significant Findings: No significant correlation was observed between HbA1c and Potassium ($R = 0.078$, $p = 0.08$) or fT4 ($R = 0.06$, $p = 0.18$) (Figure-1).

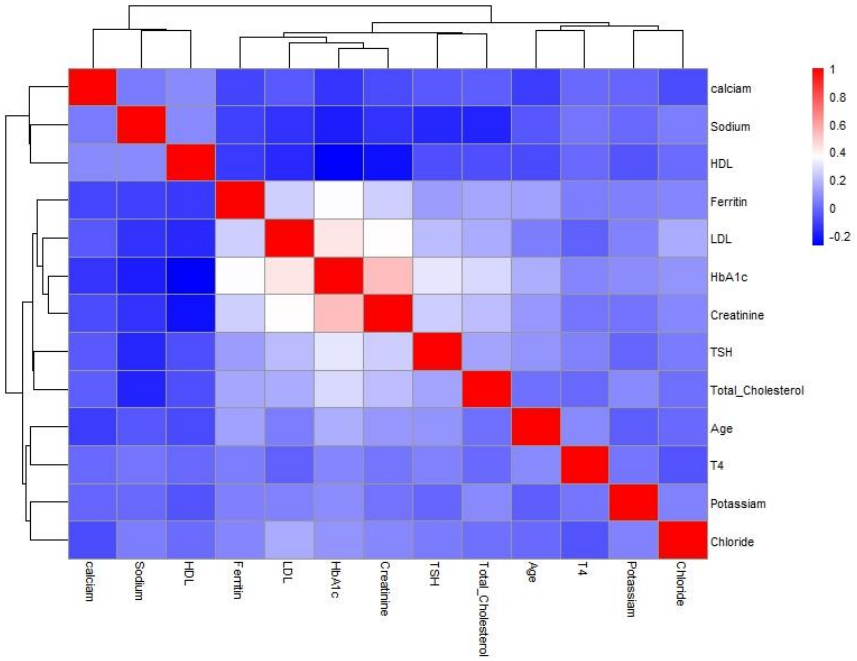

Figure 2. Hierarchical cluster correlation heatmap showing relationships among biochemical parameters with HbA1c (%). Color intensity represents correlation strength (red = strong positive correlation; blue = weak or negative correlation Dendrograms indicate clustering based on similarity patterns.

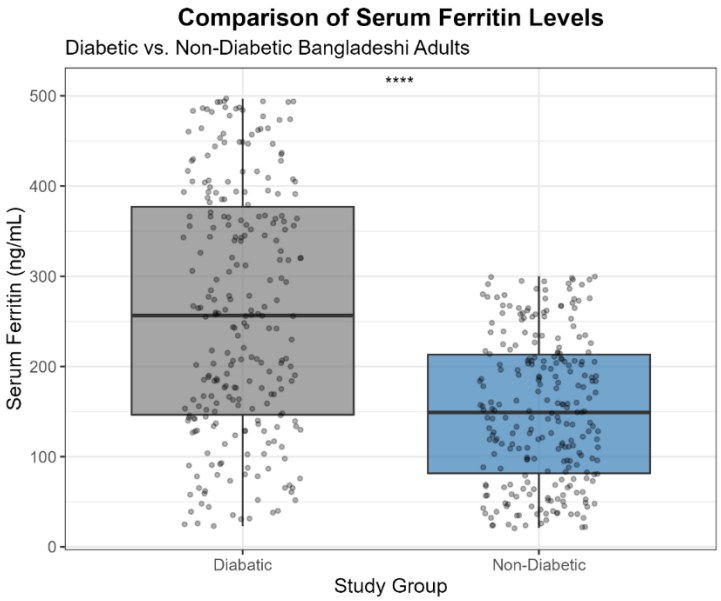

Figure 3. Comparative distribution of serum ferritin levels between diabetic and non-diabetic groups. The box-and-whisker plots illustrate the median and interquartile ranges, with individual data points overlaid as a jitter plot to show the full distribution. The four asterisks (****) denote a highly significant difference between groups ($p < 0.0001$).

Serum ferritin levels were significantly elevated in the diabetic group compared to the non-diabetic controls ($p < 0.0001$). As shown figure 3, the diabetic group exhibited a much wider distribution of ferritin values, with a significantly higher median compared to the healthy population.

A multiple linear regression model was constructed to identify the independent predictors of HbA1c levels among Bangladeshi adults. The overall model was highly significant ($F(14, 485) = 42.88$, $p < 0.001$) and explained approximately 54% of the variance in HbA1c (Adjusted $R^2 = 0.540$). The strongest independent predictors were FBS ($\beta = 0.304$, $p < 0.001$) and RBS ($\beta = 0.224$, $p < 0.001$). Among the metabolic and renal markers, Triglycerides ($\beta = 0.135$, $p = 0.001$), Creatinine ($\beta = 0.101$, $p = 0.009$), and Total Cholesterol ($\beta = 0.072$, $p = 0.027$) showed significant positive associations with HbA1c. Conversely, HDL $\beta = -0.075$, $p = 0.021$) was a significant negative predictor. Parameters such as Age, Sodium, and T4 did not emerge as significant independent predictors in this model ($p > 0.05$) (Table 8).

Table 8. Multiple linear regression analysis identifying independent predictors of HbA1c%.

Predictor	Unstandardized β	Standardized β	Std. Error	T-value	p-value
Intercept	6.63	NA	3.33	1.992	0.04688 *
Age	0.0035760	0.0228057	0.0049026	0.729	0.46610
FBS	0.2514984	0.3037837	0.0369268	6.811	2.88e-11 ***
RBS	0.1222486	0.2239972	0.0239611	5.102	4.83e-07 ***
Sodium	-0.0282137	-0.0523185	0.0173844	-1.623	0.10525
Potassium	-0.0085951	-0.0020588	0.1296212	-0.066	0.94716
Chloride	0.0005955	0.0010447	0.0178206	0.033	0.97336
calcium	-0.0515928	-0.0147140	0.1097542	-0.470	0.63851
T4	0.0146283	0.0020308	0.2204577	0.066	0.94712
Ferritin	.0008447	0.0444887	0.0006448	1.310	0.19083
Total Cholesterol	0.0050174	0.0721005	0.0022620	2.218	0.02701 *
Triglyceride	0.0032204	0.1348018	0.0009942	3.239	0.00128 **
HDL	-0.0179248	-0.0749430	0.0077481	-2.313	0.02112 *
Creatinine	0.4652657	0.1008723	0.1765008	2.636	0.00866 **
LDL	0.0018033	0.0279611	0.0023565	0.765	0.44449

*$R^2 = 0.553$; Adjusted $R^2 = 0.540$; F-statistic = 42.88 ($p < 0.001$). Significance: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$*

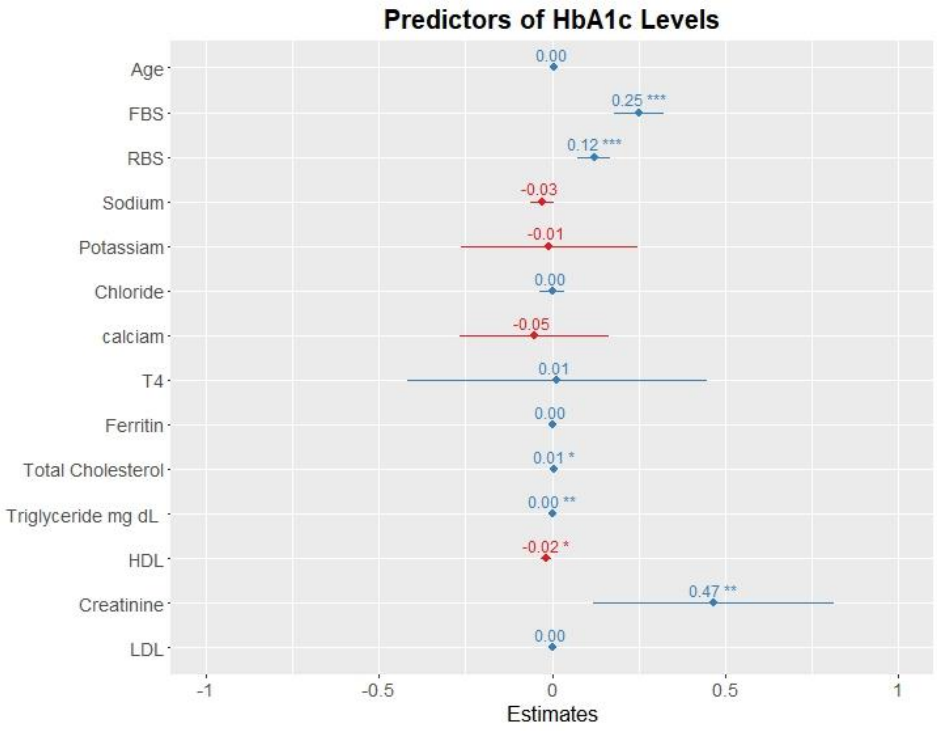

Figure 4. Multiple linear regression coefficients for predictors of HbA1c%. The plot displays the standardized regression coefficients β for each clinical parameter. Horizontal bars represent the 95% confidence intervals. Predictors with intervals not crossing the zero vertical line are statistically significant independent predictors of glycemic control ($p < 0.05$). The model adjusted for age and gender, explaining 54% of the total variance ($R^2 = 0.54$).

4. Discussion

The present study demonstrated markedly elevated glycemic indices in diabetic individuals compared to non-diabetic controls. FBS levels were nearly 92.7% higher in diabetics (9.52 vs. 4.94 mmol/L), while RBS showed an increase of approximately 103% (13.34 vs. 6.56 mmol/L). Similarly, HbA1c levels were elevated by about 74% (9.04% vs. 5.19%). These substantial differences confirm persistent hyperglycemia and poor long-term glycemic control in diabetic patients. The strong statistical significance ($p < 0.001$ for all parameters) further reinforces the robustness of these findings. Additionally, the higher mean age in the diabetic group (50.80 vs. 45.19 years) suggests a progressive deterioration of glucose metabolism with age, consistent with the natural history of type 2 diabetes.

Electrolyte disturbances observed in this study further highlight the systemic effects of hyperglycemia. Serum sodium levels were reduced by approximately 1.7% in diabetic individuals (137.51 vs. 139.90 mmol/L), while calcium levels decreased by around 2.8% (9.15 vs. 9.41 mg/dL). Although these percentage changes appear modest, their statistical significance ($p < 0.0001$) indicates clinically relevant alterations in electrolyte homeostasis. In contrast, potassium and chloride levels showed slight increases of 0.9% and 1.1%, respectively. Importantly, sodium and calcium demonstrated significant negative correlations with HbA1c ($r = -0.21$ and $r = -0.14$), suggesting that worsening glycemic control is directly associated with declining electrolyte balance. These findings support the role of osmotic diuresis, renal dysfunction, and altered cellular ion transport in diabetic patients[15].

Thyroid function analysis revealed a notable endocrine association with glycemic status. TSH levels were approximately 72% higher in diabetic individuals (4.37 vs. 2.54 mIU/L), indicating a higher prevalence of hypothyroid tendencies. The moderate positive correlation between TSH and HbA1c ($r = 0.30$, $p < 0.0001$)

suggests that thyroid dysfunction may contribute to poor glycemic control, possibly through increased insulin resistance and reduced metabolic rate. In contrast, Free T4 levels showed only a minimal difference (~3%) and no significant association ($p = 0.132$), indicating that TSH may be a more sensitive marker for detecting subtle thyroid abnormalities in this population[16].

Iron metabolism findings were particularly striking. Serum ferritin levels were elevated by approximately 73% in diabetic patients (261.89 vs. 151.58 ng/mL), reflecting increased iron stores and inflammatory activity. The moderate positive correlation between ferritin and HbA1c ($r = 0.35$, $p < 0.0001$) suggests that iron overload and oxidative stress play a significant role in worsening glycemic control. Furthermore, ferritin also showed positive correlations with LDL ($r = 0.24$) and creatinine ($r = 0.24$), indicating its involvement in both cardiovascular risk and renal dysfunction. The wide distribution of ferritin values among diabetics further highlights variability in inflammatory and metabolic status within this group[17].

Renal function, as assessed by serum creatinine, showed a substantial increase of approximately 72% in diabetic individuals (1.55 vs. 0.90 mg/dL). This finding reflects early renal impairment and supports the well-established link between chronic hyperglycemia and diabetic nephropathy. Notably, creatinine exhibited the strongest positive correlation with HbA1c ($r = 0.52$), indicating that worsening glycemic control is strongly associated with declining kidney function. This emphasizes the importance of early detection and monitoring of renal markers in diabetic patients[18].

Dyslipidemia was prominently observed, with diabetic individuals exhibiting a clearly atherogenic lipid profile. LDL levels were increased by approximately 41% (137.6 vs. 97.38 mg/dL), triglycerides by 129% (250.74 vs. 109.57 mg/dL), and total cholesterol by 13% (209.23 vs. 185.11 mg/dL). In contrast, HDL levels were reduced by approximately 13% (46.54 vs. 53.57 mg/dL). These findings indicate significant lipid abnormalities associated with diabetes. The correlation analysis further supports this relationship, with HbA1c showing strong positive associations with LDL ($r = 0.42$) and total cholesterol ($r = 0.27$), and a negative association with HDL ($r = -0.28$). This pattern highlights the direct contribution of poor glycemic control to dyslipidemia and increased cardiovascular risk[19].

The overall correlation analysis demonstrated that HbA1c is significantly associated with multiple biochemical parameters, including creatinine, LDL, ferritin, TSH, and total cholesterol. Among these, creatinine showed the strongest association, followed by LDL and ferritin. These findings suggest that glycemic control is not an isolated metabolic parameter but rather a central component influencing renal, lipid, inflammatory, and endocrine pathways. Conversely, negative correlations with HDL, sodium, and calcium indicate potential protective roles that are compromised in diabetic states[20].

Ferritin-centered analysis further revealed its strong association with metabolic dysregulation. Ferritin showed a significant positive correlation with HbA1c ($r = 0.35$), LDL ($r = 0.24$), and creatinine ($r = 0.24$), while demonstrating a negative relationship with HDL ($r = -0.13$). These findings reinforce the role of ferritin as both an inflammatory marker and a contributor to metabolic imbalance, suggesting its potential utility as a biomarker for identifying high-risk individuals[21,22].

The multiple linear regression analysis provided important insights into independent predictors of glycemic control. The model explained approximately 54% of the variance (Adjusted $R^2 = 0.540$), indicating strong predictive capability. FBS ($\beta = 0.304$) and RBS ($\beta = 0.224$) emerged as the strongest predictors, as expected. However, triglycerides ($\beta = 0.135$), creatinine ($\beta = 0.101$), and total cholesterol ($\beta = 0.072$) were also significant independent predictors, demonstrating that metabolic and renal factors contribute significantly to HbA1c levels. HDL showed a negative association ($\beta = -0.075$), confirming its protective role. The lack of

significance for variables such as age, sodium, and Free T4 suggests that their effects may be indirect or mediated through other metabolic pathways[23,24].

Overall, the findings of this study demonstrate that diabetes is a complex, multisystem disorder characterized by significant alterations in metabolic, electrolyte, endocrine, and inflammatory parameters. The magnitude of differences observed across multiple variables, along with strong correlations and predictive relationships, highlights the interconnected nature of these physiological systems[25].

From a clinical perspective, these results emphasize that effective diabetes management requires a comprehensive and multidimensional approach. Monitoring glycemic indices alone may not adequately capture the full extent of metabolic dysfunction. Instead, integrated assessment of electrolytes, thyroid function, iron status, renal markers, and lipid profile is essential for early detection of complications and improved patient outcomes.

5. Conclusion

This study demonstrates that poor glycemic control is strongly associated with significant alterations in electrolyte balance, thyroid function, iron status, renal markers, and lipid profile among Bangladeshi adults. HbA1c showed strong positive associations with creatinine, LDL, ferritin, TSH, and total cholesterol, and negative associations with HDL, sodium, and calcium, highlighting the multisystem impact of diabetes. These findings emphasize the need for a comprehensive, multi-parameter approach in the clinical evaluation and management of diabetic patients to improve outcomes and reduce complications.

6. Limitations

This study has several limitations. The cross-sectional design restricts the ability to establish causal relationships. Data were collected from a single tertiary care hospital, which may limit generalizability to the broader population. Potential confounding factors such as diet, medication use, lifestyle, and duration of diabetes were not controlled. Additionally, reliance on retrospective laboratory data may introduce selection bias.

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