RESEARCH PAPER

Correlation of Red Cell Distribution Width (RDW-CV) with HbA1c in Type 2 Diabetes Mellitus Patients Attending Tertiary Care Centre -A Pilot Study

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ABSTRACT

Background: Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by persistent hyperglycemia and associated with multiple microvascular and macrovascular complications. Glycated hemoglobin (HbA1c) is widely used as a reliable marker for assessing long-term glycemic control. Red cell distribution width (RDW), a routinely reported parameter in complete blood count, reflects the variability in size of circulating erythrocytes and has recently been associated with chronic inflammation and metabolic disturbances. Exploring the relationship between RDW and glycemic control may provide additional insights into the pathophysiology of diabetes and potential adjunct markers for disease monitoring.

Objective: To assess the correlation between red cell distribution width (RDW-CV) and glycated hemoglobin (HbA1c) in patients with type 2 diabetes mellitus attending a tertiary care centre.

Methods: This hospital-based cross-sectional pilot study was conducted in a tertiary care centre at Puducherry. A total of 102 adult patients diagnosed with type 2 diabetes mellitus with available laboratory records of HbA1c and RDW-CV were included in the study. Patients with known anemia, recent blood transfusion, or acute infection were excluded. Laboratory parameters including HbA1c, RDW-CV, hemoglobin, red blood cell count, and platelet count were obtained from hospital laboratory records. Patients were categorized into good glycemic control (HbA1c <7%) and poor glycemic control (HbA1c ≥7%). Statistical analysis was performed using SPSS software version 23. Continuous variables were expressed as mean ± standard deviation, and correlation between RDW-CV and HbA1c was assessed using Pearson correlation analysis. A p-value <0.05 was considered statistically significant.

Results: The mean HbA1c level among the study population was 7.28 ± 2.18%, and the mean RDW-CV was 15.79 ± 1.97%. Among the participants, 59.4% had good glycemic control while 40.6% had poor glycemic control. Comparison between the groups showed slightly higher RDW values among patients with better glycemic control — a finding contrary to the expected physiological direction; however, the difference was not statistically significant. Correlation analysis demonstrated a weak negative correlation between RDW-CV and HbA1c ($r \approx -0.10$), which was not statistically significant.

Conclusion: The present study had no significant correlation between RDW-CV and HbA1c levels in patients with type 2 diabetes mellitus. Although RDW is an inexpensive and routinely available hematological parameter, it may not independently reflect glycemic control in diabetic patients. Further large-scale studies are required to clarify the potential role of RDW as an adjunct marker in the assessment of metabolic disturbances associated with diabetes mellitus.

Keywords: Type 2 diabetes mellitus, red cell distribution width, HbA1c, glycemic control, hematological parameters

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INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from insulin resistance, impaired insulin secretion, or a combination of both. It is one of the most common non-communicable diseases worldwide and represents a major global health burden. The prevalence of diabetes has been increasing steadily, particularly in developing countries, due to urbanization, sedentary lifestyle, and dietary changes. Chronic hyperglycemia is associated with a wide range of complications, including microvascular complications such as diabetic retinopathy, nephropathy, and neuropathy, as well as macrovascular complications including coronary artery disease and stroke (1,2). Therefore, effective monitoring and control of blood glucose levels are essential to prevent disease progression and reduce long-term complications.

Glycated hemoglobin (HbA1c) is widely recognized as the gold standard indicator of long-term glycemic control in patients with diabetes mellitus. HbA1c reflects the average blood glucose concentration over the preceding two to three months by measuring the proportion of hemoglobin that undergoes non-enzymatic glycation in circulating red blood cells. It plays a crucial role in both diagnosis and monitoring of diabetes and is routinely used to guide therapeutic decisions in clinical practice. However, the estimation of HbA1c may sometimes be limited by factors such as laboratory availability, cost, and hematological conditions that influence red blood cell turnover or lifespan. These limitations have prompted researchers to explore additional hematological parameters that may serve as accessible markers for glycemic status.

Red cell distribution width (RDW) is a quantitative measure of the variation in size of circulating erythrocytes and is routinely

reported as part of the complete blood count (CBC) (3). Traditionally, RDW has been used primarily in the differential diagnosis of various types of anemia. In recent years, however, RDW has gained increasing attention as a potential marker of systemic inflammation, oxidative stress, and impaired erythropoiesis (4-6). These pathophysiological mechanisms play a significant role in the development and progression of type 2 diabetes mellitus. Chronic hyperglycemia promotes oxidative stress and inflammatory responses, which may alter erythrocyte morphology and lifespan, thereby contributing to increased heterogeneity in red blood cell size and elevated RDW values.

Persistent hyperglycemia can induce structural and functional changes in red blood cells through several mechanisms. Non-enzymatic glycation of hemoglobin and erythrocyte membrane proteins may reduce membrane flexibility and shorten the lifespan of red blood cells. In addition, oxidative stress generated in hyperglycemic states can damage erythrocyte membranes and affect bone marrow erythropoiesis. These alterations can lead to increased anisocytosis, reflected as elevated RDW values in routine hematological analysis. Consequently, RDW has been proposed as a potential marker reflecting metabolic disturbances associated with diabetes (7).

RDW and glycemic control in individuals with type 2 diabetes mellitus have been linked in a number of studies. Higher RDW values were linked to poor glycemic control and microvascular problems in diabetic patients, according to Sharma et al., who also observed a strong positive association between RDW and HbA1c levels (8). Similarly, Patil et al. found that RDW gradually rose as HbA1c levels climbed, suggesting a favorable correlation between diabetic status and erythrocyte size variability (9). RDW may be higher in people with diabetes than in non-diabetic controls, according to studies done in various populations. It may also be correlated with other metabolic indicators including lipid abnormalities (10).

Higher RDW values were found to be significantly correlated with elevated HbA1c levels, but not necessarily with fasting plasma glucose levels. This suggests that RDW may reflect chronic metabolic alterations rather than acute glycemic fluctuations. Lippi et al. have reported additional evidence supporting this relationship (11). Furthermore, in patients with type 2 diabetes mellitus, Liu et al. discovered a substantial correlation between RDW and indices of pancreatic β-cell activity and HbA1c, suggesting that RDW may also represent underlying pathophysiological mechanisms implicated in the evolution of diabetes (12).

The therapeutic value of RDW as a measure of glycemic control is still unclear, despite the mounting data linking RDW to glycemic state. Previous research has yielded inconsistent findings for various demographics and healthcare environments. Additionally, there is a dearth of information from tertiary care facilities assessing the connection between RDW and HbA1c in individuals with type 2 diabetes. Establishing a link between RDW and HbA1c may give clinicians an easy-to-use tool for evaluating metabolic state because RDW is frequently available as part of a conventional complete blood count and does not need additional cost or specialist testing.

Therefore, the present study aims to evaluate the correlation between red cell distribution width (RDW-CV) and glycated hemoglobin (HbA1c) in patients with type 2 diabetes mellitus attending a tertiary care centre. Understanding this relationship may help determine whether RDW can serve as a supplementary hematological marker for assessing glycemic control and identifying patients at risk of poor metabolic control.

MATERIALS AND METHODS

This study was conducted as a hospital-based cross-sectional observational pilot study aimed at evaluating the correlation between red cell distribution width (RDW-CV) and glycated hemoglobin (HbA1c) in patients with type 2 diabetes mellitus in a tertiary care centre at Puducherry after approval from the institutional ethical committee. The study was conducted over a period of three months from February 2026 to April 2026 consisting adult patients diagnosed with type 2 diabetes mellitus. The methodology was designed to assess the relationship between hematological parameters and glycemic status in individuals diagnosed with type 2 diabetes mellitus, as described in the approved research protocol.

Sample Size and Sampling Technique: A minimum sample size of 100 patients with type 2 diabetes mellitus was considered adequate for the preliminary analysis. Patients fulfilling the eligibility criteria and having complete laboratory records during the study period were included in the study. Consecutive sampling technique was used, whereby all eligible patients who met the inclusion criteria during the study period were included until the desired sample size was reached. A total of 102 patients were ultimately enrolled. Of these, HbA1c values were available for 101 patients; one patient had missing HbA1c data in the laboratory records and was therefore excluded from HbA1c-based group comparisons. Data were collected by reviewing laboratory records of eligible patients attending the hospital during the study period. HbA1c and RDW-CV values were extracted from the laboratory database and entered into a structured data collection proforma designed for the study. Additional hematological parameters such as hemoglobin levels, total red blood cell count, and platelet count were also recorded where available

Eligibility Criteria: Patients diagnosed with type 2 diabetes mellitus, age 18 years or above, and availability of both HbA1c and RDW-CV values in the laboratory records were included in the study. Patients with conditions that could influence red blood cell indices were excluded from the study. These included patients with known anemia or those currently receiving treatment for anemia, patients who had undergone recent blood transfusion and patients with acute infections or inflammatory conditions that could potentially alter hematological parameters.

Classification of Glycemic Control: For analytical purposes, HbA1c values were categorized according to glycemic control status. Patients with HbA1c values less than 7% were considered to have good glycemic control, while those with HbA1c values greater than or equal to 7% were classified as having poor glycemic control. RDW-CV values were interpreted based on the institutional laboratory reference range, with normal RDW-CV defined as 11.6% to 14% according to the hospital laboratory standards.

STATISTICAL ANALYSIS

Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) software version 23.0 (IBM Corp., Armonk, NY, USA). Continuous variables such as HbA1c and RDW-CV were expressed as mean and standard deviation, while categorical variables were presented as frequencies and percentages. The correlation between RDW-CV and HbA1c levels was assessed using correlation coefficient analysis. To compare RDW-CV values between patients with good glycemic control and those with poor glycemic control, an independent sample t-test was used. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The results of the present study were given in tables (1-8) and figure (1-3).

Baseline Laboratory Characteristics

The overall mean HbA1c level in the study population was 7.28 ± 2.18%, with values ranging from 4.7% to 14.0%. The median HbA1c value was 6.5%. The distribution showed that a substantial proportion of patients had HbA1c values above the recommended glycemic target.

The mean RDW-CV value in the study population was 15.79 ± 1.97%, with values ranging from 12.5% to 22.1%. The median RDW value was 15.2%. The interquartile range for RDW was 14.4% to 16.67%, indicating moderate variability in red blood cell size among the study participants.

The mean hemoglobin level among the patients was 12.33 ± 2.16 g/dL, with a range of 6.6 g/dL to 18.4 g/dL. The median hemoglobin value was 12.5 g/dL. The mean total red blood cell count was 5.29 ± 2.59 million/µL, with values ranging from 2.77 to 16.99 million/µL. The mean platelet count in the study population was 286.47 ± 96.67 $\times 10^3$/µL, with values ranging from 83 $\times 10^3$/µL to 563 $\times 10^3$/µL.

Distribution according to Glycemic Control

For further analysis, patients were categorized into two groups based on HbA1c values. Patients with HbA1c levels below 7% were classified as having good glycemic control, while patients with HbA1c levels equal to or greater than 7% were classified as having poor glycemic control.

Among the 101 patients with valid HbA1c values available for analysis, 60 patients (59.4%) were categorized as having good glycemic control, whereas 41 patients (40.6%) were categorized as having poor glycemic control.

Comparison of RDW-CV between Glycemic Control Groups

The mean RDW-CV among patients with good glycemic control (HbA1c <7%) was 16.01 ± 2.10%. In comparison, the mean RDW-CV among patients with poor glycemic control (HbA1c ≥7%) was 15.49 ± 1.76%. An independent sample t-test was performed to evaluate whether the difference in RDW-CV between the two groups was statistically significant. The analysis showed that the difference in RDW-CV values between patients with good glycemic control and those with poor glycemic control was not statistically significant ($t = 1.34$, $p = 0.18$). These findings indicate that although RDW values were slightly higher in patients with HbA1c values below 7%, the difference between the two groups was not statistically significant.

Correlation between HbA1c and RDW-CV

Pearson correlation analysis was performed to determine the relationship between HbA1c and RDW-CV values among the study participants. The analysis demonstrated a weak negative correlation between HbA1c and RDW-CV ($r = -0.108$). However, this correlation was not statistically significant ($p = 0.284$). This suggests that in the present study population, variations in RDW-CV were not strongly associated with changes in HbA1c levels. The present study evaluated the relationship between RDW-CV and HbA1c among patients with type 2 diabetes mellitus using routinely available hematological parameters. The analysis demonstrated that the mean HbA1c level of the study population was 7.28%, indicating that a considerable proportion of patients had suboptimal glycemic control. The mean RDW-CV value was 15.79%, suggesting mild elevation of red blood cell size variability in the study population. Although RDW-CV values were marginally higher among patients with better glycemic control compared to those with poorer glycemic control, the difference was not statistically significant. Furthermore, correlation analysis revealed only a weak negative relationship between RDW-CV and HbA1c levels, which was not statistically significant. Overall, the findings of this study suggest that RDW-CV may not show a strong association with glycemic control as measured by HbA1c in this study population, although further studies with larger sample sizes may be required to clarify this relationship.

DISCUSSION

The present study aimed to evaluate the correlation between red cell distribution width (RDW-CV) and glycated hemoglobin (HbA1c) in patients with type 2 diabetes mellitus attending a tertiary care centre. RDW is a routinely reported hematological parameter obtained from a complete blood count and reflects the degree of variation in the size of circulating erythrocytes. Recent studies have suggested that RDW may serve as a marker of systemic inflammation, oxidative stress, and metabolic disturbances, all of which are important components in the pathogenesis of diabetes mellitus.

In the present study, the mean HbA1c level among the study population was 7.28 ± 2.18%, indicating that a significant proportion of patients had suboptimal glycemic control. Similar findings have been reported in several studies conducted in tertiary care settings, where a large number of diabetic patients continue to have inadequate glycemic control despite treatment (10). Persistent hyperglycemia contributes to increased oxidative stress and inflammatory responses, which may lead to structural and functional changes in red blood cells.

The mean RDW-CV value in the present study was 15.79 ± 1.97%, which was slightly higher than the normal reference range. Elevated RDW values in diabetic patients may be attributed to chronic inflammation and oxidative stress associated with prolonged hyperglycemia. Hyperglycemia promotes non-enzymatic glycation of hemoglobin and erythrocyte membrane proteins, which can impair red blood cell deformability and shorten erythrocyte lifespan. These alterations may lead to increased heterogeneity in red blood cell size, thereby increasing RDW values.

The results add to the expanding body of research examining the function of hematological markers in diabetes mellitus, notwithstanding the poor connection.

Previous research has demonstrated a strong correlation between RDW and glycemic management. In a cross-sectional investigation of patients with type 2 diabetes mellitus, Sharma et al. (2021) discovered a strong positive association between RDW and HbA1c levels (8). Higher RDW levels were linked to microvascular problems such diabetic retinopathy and nephropathy, according to their study. According to the scientists, oxidative stress and persistent inflammation in diabetes may change the shape of erythrocytes and raise RDW levels.

Similarly, Patil et al. (2020) evaluated red cell parameters among diabetic patients attending a tertiary care centre and observed that RDW values increased progressively with increasing HbA1c levels (9). The study demonstrated a statistically significant positive correlation between RDW and HbA1c ($p < 0.001$). The authors proposed that poor glycemic control may impair erythropoiesis and reduce erythrocyte survival, leading to increased anisocytosis and elevated RDW values.

RDW readings were considerably greater in diabetic patients than in non-diabetic controls, according to the study by Al-Asadi and Habib (2019) (10). Additionally, the study showed a favorable correlation between RDW and lipid profile parameters and HbA1c. These results imply that systemic inflammation and metabolic problems linked to diabetes may be reflected in RDW.

Lippi et al. (2014) also evaluated the relationship between RDW and glycemic markers in patients with type 2 diabetes (11). Their study demonstrated that RDW was significantly associated with HbA1c levels but not with fasting plasma glucose levels. This observation suggests that RDW may reflect chronic metabolic disturbances rather than short-term changes in blood glucose levels.

In addition, Liu et al. (2021) investigated the association between RDW and pancreatic β-cell function in patients with type 2 diabetes mellitus (12). The study demonstrated a significant

correlation between RDW and HbA1c as well as β-cell function indices. These findings suggest that RDW may reflect underlying metabolic dysfunction related to insulin secretion and pancreatic β-cell activity.

Many factors could account for the current study's absence of a statistically significant association between RDW-CV and HbA1c. Numerous physiological and pathological factors, such as inflammation, dietary deficits, erythropoietic activity, and bone marrow function, have an impact on RDW. RDW levels may still be impacted by minute differences in erythropoiesis or nutritional condition, even if patients with established anemia were not included in the study. Additionally, the cross-sectional study design and relatively small sample size may make it more difficult to identify minute correlations between glycemic status and hematological markers.

Glycemic management alone may not be the only factor influencing RDW; chronic inflammatory processes may also play a role. Chronic low-grade inflammation, a hallmark of diabetes mellitus, can impact erythrocyte survival and production regardless of blood glucose levels.

Despite these drawbacks, the current study emphasizes the potential use of RDW as a readily available, low-cost laboratory measure that could offer more information on metabolic abnormalities in individuals with type 2 diabetes mellitus. RDW is frequently reported in total blood count tests, therefore if further research confirms its correlation with glycemic management or diabetic complications could be a helpful supplementary sign in clinical practice.

CONCLUSION

The present study evaluated the relationship between red cell distribution width (RDW-CV) and glycated hemoglobin (HbA1c) in patients with type 2 diabetes mellitus attending a tertiary care centre. Although RDW values were slightly elevated among the study population, only a weak and statistically non-significant correlation was observed between RDW-CV and HbA1c levels. These findings suggest that RDW-CV alone may not serve as a reliable indicator of glycemic control in patients with type 2 diabetes mellitus. However; RDW is an inexpensive and routinely available parameter obtained from complete blood count testing, it may still have potential value as an adjunct marker reflecting underlying inflammatory or metabolic disturbances associated with diabetes. Further large-scale, multicentre studies with longitudinal follow-up are required to clarify the role of RDW in assessing glycemic status and predicting complications in patients with type 2 diabetes mellitus.

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TABLES AND FIGURES

Table 1: Baseline characteristics of the study population (n = 102)

Variable	Mean ± SD	Median	Minimum	Maximum
HbA1c (%)	7.28 ± 2.18	6.50	4.7	14.0
RDW-CV (%)	15.79 ± 1.97	15.20	12.5	22.1
Hemoglobin (g/dL)	12.33 ± 2.16	12.50	6.6	18.4
RBC Count (million/µL)	5.29 ± 2.59	4.82	2.77	16.99
Platelet Count (×10³/µL)	286.47 ± 96.67	272	83	563

Table 2: Distribution of patients according to glycemic control based on HbA1c

Glycemic control category	HbA1c criteria	Number of patients (n)	Percentage (%)
Good glycemic control	< 7%	60	59.4
Poor glycemic control	≥ 7%	41	40.6
Total	—	101	100

Table 3: Comparison of RDW-CV between glycemic control groups

Glycemic control group	Number of patients (n)	Mean RDW-CV (%)	Standard deviation	p value
HbA1c < 7%	60	16.01	2.10	
HbA1c ≥ 7%	41	15.49	1.76	0.18

Statistical test used: Independent sample t-test

Table 4: Correlation between HbA1c and RDW-CV in study population

Variables	Correlation coefficient (r)	p value
HbA1c vs RDW-CV	−0.108	0.284

Statistical test used: Pearson correlation analysis

Table 5: Summary of haematological parameters in the study population

Parameter	Reference range	Mean ± SD	Interpretation
RDW-CV (%)	11.6 – 14	15.79 ± 1.97	Slightly elevated
Hemoglobin (g/dL)	Male: 13 – 17; Female: 12 – 15	12.33 ± 2.16	Within acceptable range
RBC Count (million/µL)	4.5 – 5.9	5.29 ± 2.59	Normal overall
Platelet count (×10³/µL)	150 – 450	286.47 ± 96.67	Within normal range

Table 6: Age group distribution and comparison of HbA1c and RDW-CV among study participants (n = 102)

Age Group (years)	Number of Patients (n)	Percentage (%)	Mean HbA1c (%) ± SD	Mean RDW-CV (%) ± SD
18–40	12	12.0	6.85 ± 1.45	15.21 ± 1.42
41–50	20	20.0	7.02 ± 1.78	15.56 ± 1.67
51–60	30	30.0	7.41 ± 2.05	15.93 ± 1.88
61–70	25	25.0	7.63 ± 2.32	16.14 ± 2.01
>70	13	13.0	7.88 ± 2.56	16.38 ± 2.10
Total	100	100	7.28 ± 2.18	15.79 ± 1.97

The majority of the study participants belonged to the 51–60 year age group (30%), followed by 61–70 years (25%). Both HbA1c and RDW-CV values showed a gradual increase with advancing age.

Table 7: Gender-wise comparison of hematological parameters among study participants (n = 102)

Parameter	Male (n = 58) Mean ± SD	Female (n = 42) Mean ± SD	p value
HbA1c (%)	7.34 ± 2.21	7.19 ± 2.12	0.64
RDW-CV (%)	15.72 ± 1.91	15.89 ± 2.03	0.71
Hemoglobin (g/dL)	13.14 ± 1.83	11.96 ± 1.92	<0.05
RBC Count (million/µL)	5.48 ± 2.41	5.02 ± 2.76	0.32
Platelet Count (×10³/µL)	279.56 ± 91.34	295.83 ± 102.67	0.40

Male participants had significantly higher hemoglobin levels compared to females ($p < 0.05$). However, no statistically significant difference was observed between males and females with respect to HbA1c or RDW-CV values.

Table 8: Multivariate regression analysis for factors associated with HbA1c among patients with type 2 diabetes mellitus (n = 102)

Independent Variable	Unstandardized Coefficient (B)	Standard Error	Standardize d Coefficient (β)	t value	p value	95% Confidence Interval
RDW-CV (%)	-0.081	0.073	-0.108	-1.11	0.27	-0.226 to 0.064
Hemoglobin (g/dL)	-0.046	0.059	-0.072	-0.78	0.44	-0.163 to 0.071
RBC Count (million/µL)	0.028	0.021	0.092	1.33	0.19	-0.013 to 0.069
Platelet Count (×10³/µL)	0.001	0.001	0.067	0.94	0.35	-0.001 to 0.003

Multivariate regression showed no significant association between RDW-CV, hemoglobin, RBC count, or platelet count with HbA1c (overall model: $F = 0.60$, $p = 0.66$)

FIGURES

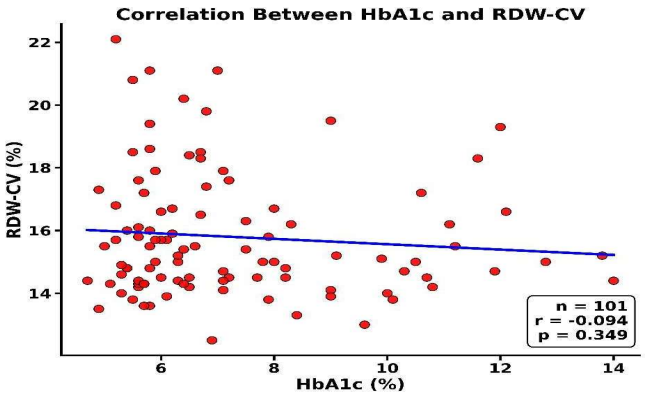

Figure 1: Correlation between glycated hemoglobin (HbA1c) and red cell distribution width (RDW-CV) in patients with type 2 diabetes mellitus

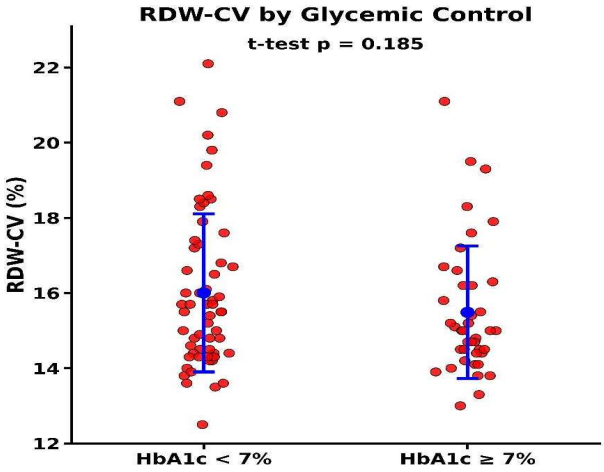

Figure 2: Comparison of RDW-CV values between patients with good and poor glycemic control

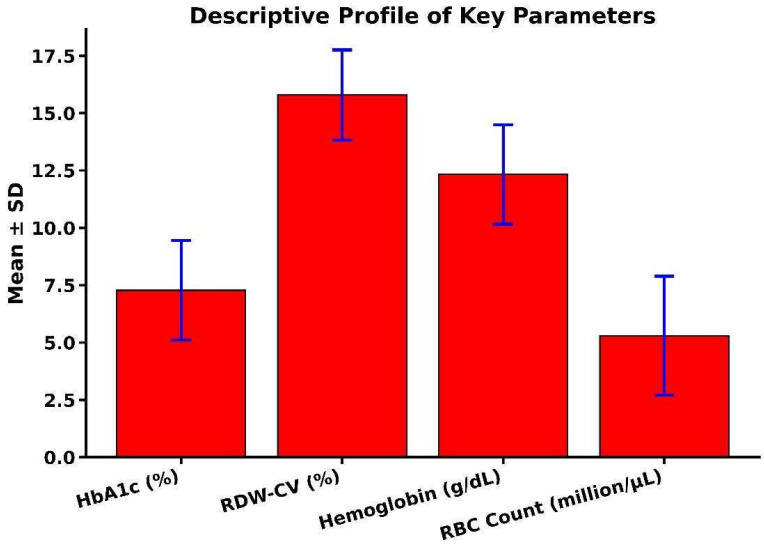

Figure 3: Descriptive profile of hematological parameters in the study population