



## Red Blood Cell Parameters and Their Correlation with Glycemic Control Among Type 2 Diabetics

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### Declaration

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All authors equally contributed to the study and approved the final manuscript.

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### ABSTRACT

**Objective:** "To determine the correlation of red blood cell parameters with glycemic control among type 2 diabetics". **Study design:** Cross-Sectional Study. **Study place and duration:** Department of Medicine, Ghurki Trust Teaching Hospital, Lahore for a duration of 3 months from 17 January 2025 to 20 April 2025. **Methodology:** Patients were recruited from medical OPD and blood sample was taken for assessment of RBC parameters and fasting blood glucose level. Reports were assessed and levels were recorded. All this information was recorded in proforma and analyzed in SPSSv.25. Spearman's correlation coefficient was calculated to measure correlation between glycemic control and hematological parameters. **Results:** In this study, the mean age of diabetics was  $49.95 \pm 12.28$  years. There were 148 (53.2%) male diabetics and 130 (46.8%) female diabetics. Hematological parameters were observed as mean fasting blood glucose level of diabetics was  $153.24 \pm 25.31$  mg/dl, mean red blood cell count was  $5.32 \pm 0.56$  cells/ $\mu$ L, mean hematocrit level was  $39.02 \pm 10.47\%$  and mean hemoglobin level was  $14.08 \pm 4.06$  g/dl. Out of 278 diabetics, 145 (52.16%) had good glycemic control while 133 (47.84%) had poor glycemic control. It has been observed that the glycemic control had negative weak relationship with red blood cell count i.e.  $r = -0.343$  (p-value  $<0.05$ ). Similarly, glycemic control had negative weak relationship with hematocrit level i.e.  $r = -0.484$  (p-value  $<0.05$ ). But the relationship between glycemic control and hemoglobin level was very weak, although positive i.e.  $r = 0.065$  (p-value  $>0.05$ ). **Conclusion:** It is concluded that hematological parameters have negative relationship with glycemic control. As the glycemic level will increase, hematological parameters will decrease, leading to deterioration of health of diabetic patient.

### INTRODUCTION

A group of metabolic disorders known as diabetes mellitus are characterized by anomalies in the metabolism of proteins, fats, and carbohydrates as well as consistently elevated blood sugar levels. These disorders are caused by defects in the action, synthesis, or both of insulin.<sup>1</sup> From 108 million cases in 1980 to 463 million cases and 4.2 million deaths in 2019, the number of adults worldwide suffering from diabetes has increased significantly. Over three-quarters of the world's diabetes cases occur in low- and middle-income nations, and 700 million people are predicted to have the disease globally by 2045.<sup>2</sup>

Because the body either cannot produce enough insulin or cannot effectively use the insulin it does produce, diabetes mellitus is a chronic condition characterized by increased blood glucose levels. Individuals with poorly managed diabetes have notable changes in a number of parameters, such as cellular, immunological, hematological, and metabolic abnormalities that result in vascular problems.<sup>3,4</sup>

Patients with diabetes mellitus have notable abnormalities in a number of hematological parameters, including those that impact red blood cells (RBCs). Any of the RBC indicators are impacted by all of these derangements.<sup>1,5</sup> It has been demonstrated that DM is directly linked to a number of hematological alterations that impact the RBCs. The osmotic disruption, cytoplasmic viscosity inside each cell, and the persistent increase in glycosylated Hgb in hyperglycemia is associated with both structural and functional changes in the Hgb molecule. The RBC count, Hct, MCV, mean cell hemoglobin (MCH), MCHC, and red cell distribution width are examples of RBC indices, might be significantly impacted by any of these modifications.<sup>6,7</sup> According to recent research, hematological indicators play a part in diabetes patients' vascular damage.<sup>8,9</sup> The variability in red blood cell size is reflected in the red cell distribution width (RDW). Few research, meanwhile, looked at the potential relationship between RDW and glucose metabolism indicators.<sup>10</sup>

Rationale of this study was to determine the correlation of red blood cell parameters with glycemic control among type 2 diabetics. Though literature, it has been observed that diabetes mellitus effects the RBC parameters. But limited studies have been done before. Therefore, there is a need to conduct a study to get evidence for local setting and implement screening and diagnosing protocol for early detection of changes in RBC parameters among diabetics to prevent hematological complications that may lead to cardiovascular and cerebrovascular incidents. This will help us to get updated evidence and in future, we will implement findings of this study in local setting.

## METHODOLOGY

After approval from ethical review board, this Cross-Sectional Study was carried out in the Department of Medicine, Ghurki Trust Teaching Hospital, Lahore for a duration of three months from 17 January 2025 to 20 April 2025. Using WHO calculator, sample size of 278 cases is calculated with 5% type I error, 10% type II error and value of correlation i.e.  $r = -0.193$  between HB and glycemic control.<sup>11</sup> Patients were enrolled by applying Non-probability, consecutive sampling technique, who fulfilled following selection criteria.

### Inclusion Criteria

Patients of age 30-70 years, either gender, diagnosed with type II diabetes. Diabetes was defined as presence of HbA1c >5.5% for >1 year and patient has been prescribed with anti-glycemic medicines.

### Exclusion Criteria

Patients with coronary artery disease, congestive cardiac failure, chronic obstructive pulmonary disease, hepatic dysfunction and renal dysfunction, HIV, Hepatitis, Syphilis, and malaria were excluded.

Patients were recruited from medical OPD and informed consent and demographics were noted. Patients were asked to present in next OPD with 10-12 hours fast. On presentation, blood sample was taken in a 5cc disposable syringe and was sent to the laboratory of the hospital for assessment of RBC parameters and fasting blood glucose level. Reports were assessed and levels were recorded. Glycemic control was noted as good if fasting blood sugar level <152 mg/dl and poor if fasting blood sugar level  $\geq 152$  mg/dl. RBC parameters were assessed in terms of RBC count ( $10^6/\mu\text{L}$ ), Hgb (g/dl), and Hct (%) in blood at time of presentation. All this information was recorded in proforma.

All the collected data was entered and analyzed into SPSS version 25. Spearman's correlation coefficient was calculated to measure correlation between glycemic control and RBC parameters. P-value  $\leq 0.05$  was kept significant.

## RESULTS

In this study, the mean age of diabetics was  $49.95 \pm 12.28$  years. There were 148 (53.2%) male diabetics and 130 (46.8%) female diabetics. The mean BMI of patients was  $26.39 \pm 3.62$  kg/m<sup>2</sup>. Diabetics were diagnosed with type 2 diabetes mellitus from mean duration of  $8.04 \pm 4.31$  years.

At the time of presentation, the mean HbA1c of diabetics was  $10.20 \pm 2.27\%$ . Out of 278 diabetics, 59 (21.2%) diabetics were businessman, 114 (41.0%) were housewives, 83 (29.9%) were doing job, 13 (4.7%) were shopkeepers and 9 (3.2%) were technicians or professionals. About 145 (52.2%) diabetics had active lifestyle while 133 (47.8%) diabetics had sedentary lifestyle. Dyslipidemia was noted in 131 (47.1%) diabetics, smoking in 70 (25.2%), hypertension in 150 (54.0%) and anemia in 131 (47.1%) diabetics. Out of 278 diabetics, 93 (33.5%) were taking Insulin only, while 93 (33.5%) were on oral anti-glycemic medication only, while 92 (33.1%) were taking both insulin and oral anti-glycemic medication. About 90 (32.4%) diabetics had good compliance to treatment, while 83 (29.9%) had average compliance, but more patients had poor compliance to treatment [105 (37.8%)]. Hematological parameters were observed as mean fasting blood glucose level of diabetics was  $153.24 \pm 25.31$  mg/dl, mean red blood cell count was  $5.32 \pm 0.56$  cells/ $\mu\text{L}$ , mean hematocrit level was  $39.02 \pm 10.47\%$  and mean hemoglobin level was  $14.08 \pm 4.06$  g/dl. Table I

Out of 278 diabetics, 145 (52.16%) had good glycemic control while 133 (47.84%) had poor glycemic control. Fig I

It has been observed that the glycemic control had negative weak relationship with red blood cell count i.e.  $r = -0.343$  (p-value <0.05). Similarly, glycemic control had negative weak relationship with hematocrit level i.e.  $r = -0.484$  (p-value <0.05). But the relationship between glycemic control and hemoglobin level was very weak, although positive i.e.  $r = 0.065$  (p-value >0.05). Table II

**Table I**

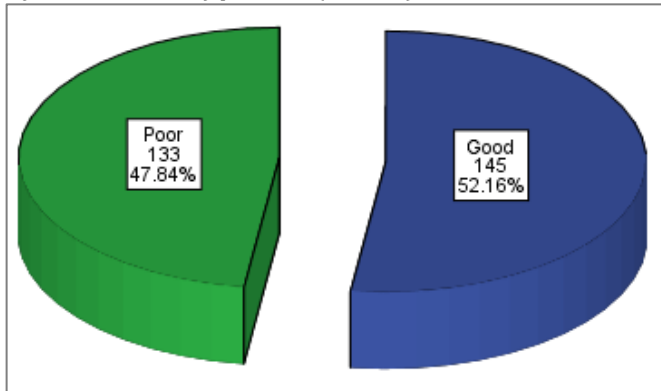
*Baseline demographics of enrolled patients (n = 278)*

	Mean $\pm$ SD, F (%)
<b>n</b>	
Age (years)	49.95 $\pm$ 12.28
Gender	
Male	148 (53.2%)
Female	130 (46.8%)
BMI	26.39 $\pm$ 3.62
Duration of diabetes	8.04 $\pm$ 4.31
HbA1c	10.20 $\pm$ 2.27
Occupation	
Business	59 (21.2%)
Housewife	114 (41.0%)
Job	83 (29.9%)
Shopkeeper	13 (4.7%)
Technician	9 (3.2%)
Lifestyle	
Active	145 (52.2%)
Sedentary	133 (47.8%)
Exercise / gym	Nil
History of:	
Dyslipidemia	131 (47.1%)
Smoking	70 (25.2%)
Hypertension	150 (54.0%)
Anemia	131 (47.1%)
Treatment	
Insulin	93 (33.5%)
Oral anti-glycemic	93 (33.5%)
Both	92 (33.1%)
Compliance of treatment	
Good	90 (32.4%)
Average	83 (29.9%)
Poor	105 (37.8%)
Hematological parameters	
Fasting blood sugar (mg/dl)	153.24 $\pm$ 25.31

Red Blood Count (cell/ $\mu$ L)	5.32 $\pm$ 0.56
Hematocrit level (%)	39.02 $\pm$ 10.47
Hemoglobin (g/dl)	14.08 $\pm$ 4.06

**Figure I**

Glycemic control of patients (n = 278)



**Table II**

Correlation between glycemic control and hematological parameters

Spearman's rho		Glycemic control
Red blood count (cell/ $\mu$ L)	Correlation Coefficient	-0.343
	P-value	0.000
Hematocrit level (%)	Correlation Coefficient	-0.484
	P-value	0.000
Hemoglobin (g/dl)	Correlation Coefficient	0.065
	P-value	0.281

**DISCUSSION**

In this study, we observed that the mean fasting blood glucose level of diabetics was 153.24  $\pm$  25.31 mg/dl, mean red blood cell count was 5.32  $\pm$  0.56 cells/ $\mu$ L, mean hematocrit level was 39.02  $\pm$  10.47% and mean hemoglobin level was 14.08  $\pm$  4.06 g/dl. Out of 278 diabetics, 145 (52.16%) had good glycemic control while 133 (47.84%) had poor glycemic control. It has been observed that the glycemic control had negative weak relationship with red blood cell count i.e.  $r = -0.343$  (p-value  $<0.05$ ). Similarly, glycemic control had negative weak relationship with hematocrit level i.e.  $r = -0.484$  (p-value  $<0.05$ ). But the relationship between glycemic control and hemoglobin level was very weak, although positive i.e.  $r = 0.065$  (p-value  $>0.05$ ). Arkew et al., conducted a cross sectional study in 2022 and found that RBC count ( $r = -0.239$ ,  $p = 0.012$ ), Hgb ( $r = -0.193$ ,  $p = 0.044$ ) and Hct ( $r = -0.265$ ,  $p = 0.005$ ), showed a statistically significant negative correlation with glycemic control.<sup>11</sup>

Aarushi et al., conducted another study in India and reported that the relationship between fasting blood glucose level and red blood cell count was positive although very weak ( $r = 0.153$ , p-value = 0.103), while the relationship between fasting blood glucose level and hematocrit level could not be calculated ( $r = 0.000$ , p-value = 0.999).<sup>12</sup>

Ahmed conducted a study on 125 diabetic individuals and noted that correlation between fasting blood sugar level and red blood cells was very weak but negative ( $r = -0.180$ , p-value = 0.045), with hemoglobin level was also

negative, although very weak ( $r = -0.120$ , p-value = 0.184) and with hematocrit was also negative, but some less weak than hemoglobin and red blood cell count ( $r = -0.248$ , p-value = 0.005).<sup>13</sup> This discovered an inverse relationship between fasting blood glucose and red blood cell and hematocrit. This supports the findings of a previous Ethiopian study that discovered an inverse connection between fasting blood glucose and hematocrit and red blood cell count in diabetics.<sup>3</sup> It is crucial to remember that this conclusion runs counter to the findings of a Japanese study that found a favorable correlation between fasting blood glucose and red blood cell count in diabetics.<sup>14</sup>

In another study, conducted by Arkew et al., a Between diabetics and non-diabetics, a statistically significant difference was found in the glycemic index and red blood cell characteristics. Patients with diabetes had considerably lower mean hemoglobin, hematocrit, and red blood cell counts than those without the disease.<sup>15</sup> The formation of free oxygen radicals and irreversible glycation of hemoglobin and red blood cell membrane proteins may be the cause of the relative decline in hemoglobin level, hematocrit, and red blood cell count caused by chronic hyperglycemia. Together, these actions cause red blood cells to age, become less deformable, aggregate more readily, and have a lower chance of surviving.<sup>16, 17</sup> Red blood cell aggregation and decreased deformability negatively impact blood viscosity, which impacts microcirculation and causes microangiopathy, which in turn leads to increased death of red blood cells.<sup>18</sup> However, research from Ethiopia and Pakistan contradicted our findings, indicating that people with type 2 diabetes had higher hemoglobin levels and red blood cell counts than those without the disease.<sup>19, 20</sup>

In diabetes, oxidative stress brought on by an imbalance between the body's antioxidant defense mechanisms and free radicals may be the cause of the negative connection between RBC, Hct, and Hgb and glycemic control. Research demonstrated that diabetics were more vulnerable to oxidative stress, and that elevated blood glucose levels were linked to lipid peroxidation mediated by free radicals, which decreased red blood cell survival. The main cause of glucose autoxidation, hemoglobin and membrane protein glycation, and polyol pathway activation with elevated oxidative stress is chronic hyperglycemia.<sup>21</sup> A major target of oxidative stress, the red blood cell produces a lot of H2O2 both internally and externally due to hemoglobin autoxidation, glycooxidation, and lipoxidation.<sup>22, 23</sup> Moreover, diabetic nephropathy, one of the effects of diabetes, can be brought on by changes in metabolic and hemodynamic pathways, such as hyperglycemia, oxidative stress, glomerular hyperfiltration, and glomerular and tubular epithelial hypertrophy.<sup>24</sup> Anemia is caused by erythropoietin insufficiency and low Hgb when the kidney undergoes structural and functional changes, such as injury to the peritubular fibroblasts.<sup>25, 26</sup>

**CONCLUSION**

It is concluded that hematological parameters have negative relationship with glycemic control. As the glycemic level will increase, hematological parameters will

decrease, leading to deterioration of health of diabetic patient. Therefore, there it is important to screen and diagnose promptly the changes in RBC parameters among

diabetic diabetics to prevent hematological complications that may lead to cardiovascular and cerebrovascular incidents.

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