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Research Article

# Assessment of the differences of hematological variables and their correlation with glycemic control among type 2 diabetes mellitus patients in Iraq: Comparative cross-sectional study

**Osamah Awad Ahmed**[1*], **Luay Awad Ahmed**[2]

[1]Middle Technical University, Technical Institute of Anbar, Department of Community Health, Iraq
[2]Fallujah Teaching Hospital, Director of Anbar, Iraq

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**Abstract:** This research aimed to assess the hematological traits of male adults diagnosed with diabetes and investigate the relationship between blood sugar levels with hematological factors among patients. A cross-sectional comparison study was conducted at Fallujah Teaching Hospital from April 1 to July 30, 2023. The research comprised 185 volunteers, including 125 individuals with type 2 diabetes mellitus (65 with well blood sugar levels and 60 with poorly-regulated blood sugar levels) and 60 healthy individuals serving as controls. The evaluation of hematological parameters was conducted using Swelab-Alfa. An independent T-test was used for assessment. The patients exhibited substantially decreased mean absolute lymphocyte count, Hct, MCHC, and PLT values compared to the control group. The diabetic group had significantly higher mean values for total neutrophil count, absolute basophil counts, RDWSD, RDWCV, PDW, PLCR, and MPV than the control group. Patients with poor glycemic control had substantially elevated levels of Mon, Eos, Bas, MCHC, PLT, MPV, PLCR, and PCT. In contrast, individuals with poor glycemic control had substantially lower levels of Neu, RBC count, and PDW. The findings demonstrated a statistically significant positive connection between neutrophil count, MCV, MCH, MCHC, PDW, MPV, PLCR, and PCT with FBG. Lym, RBC count, and Hct exhibited a statistically significant inverse connection with FBG in individuals with type 2 diabetes mellitus (T2DM). This research demonstrated a notable impact of diabetes mellitus, poor glycemic control, and fasting blood glucose levels on some hematological markers.

## 1. INTRODUCTION

Diabetes mellitus (DM) is a rapidly worsening worldwide medical issue and one of the top non-communicable illnesses that leaders around the globe are focusing on addressing, it has been placed ninth among diseases that cause mortality (World Health Organization, 2016). Diabetes, a metabolic disorder, has been identified as two cardinal kinds, 1 and 2 diabetes. Type 2 diabetes (T2DM), which constitutes a significant proportion of DM cases, accounting for 90-95% of

*CONTACT: Osamah Awad Ahmed ✉ osamahahmed@mtu.edu.iq Middle Technical University, Technical Institute of Anbar, Department of Community Health, Iraq



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them, is typified by the presence of peripheral insulin resistance or decreased insulin production (American Diabetes Association, 2014).

In 2021, there was a substantial rise in the number of persons diagnosed with diabetes mellitus (DM), reaching 537 million. Diabetes is more common in low- and middle-income countries, constituting over 75% of the global prevalence. Moreover, experts predict that the worldwide diabetes population will reach 783 million by 2045 (International Diabetes Federation, 2021). The prevalence of diabetes has been steadily rising across the countries of the Middle East and northern Africa. A recent global study indicates that the Middle East and North Africa region has a diabetes prevalence rate of 16.2%, impacting around 73 million individuals. In Iraq, the prevalence of diabetes among adults is particularly estimated to be about 9.4%, affecting roughly 2.0114 million persons (International Diabetes Federation, 2021). Diabetes mellitus is characterized by a multitude of pathological alterations, encompassing derangements in metabolism, cellular processes, and blood constituents that lead to vascular consequences (Agu, 2018).

The Hematological indices have been shown to alter in T2DM patients, including changes to platelet counts, platelet indices, white blood cell (WBC), and red blood cell (RBC) shape, function, and metabolism (Antwi-Baffour *et al*., 2018). According to the study's findings, chronic hyperglycemia in diabetes lead to increase production of reactive oxygen species (ROS) and glycation processes which result changes in hematological parameters. Moreover, increased ROS generation and glycation processes in diabetes patients cause oxidative stress linked to tissue damage and hematological alterations, including erythrocyte dysregulation, Activated WBCs, boosted WBC count, and PLT hyperactivity, (Çakırca *et al*., 2019; Shin *et al*., 2020).

Inflammation and endothelial cell dysfunction have been indicated by some hematological parameters among diabetic patients such as white blood cell count, red blood cell distribution width (RDW), mean platelet volume (MPV), platelet distribution width, and platelet count (Asmah *et al*., 2015; Kaur *et al*., 2018). Besides, glucose level in T2DM might regulate by Monitoring patients tests may prevent diabetes complication (American Diabetes Association, 2014; Agu, 2018; Çakırca et al., 2019).

The alterations of hematological indices among patient with T2DM were clarified by various researchers in different regions, but the results were inconsistent. Some studies show no significant variation in RBC indices, WBC count, and platelet count between diabetic patients and healthy controls (Alhadas et al., 2016; Kizilgul et al., 2018; Osman & Mansour, 2013). However, other research has revealed that diabetic patients exhibit significantly higher RBC, WBC, and PLT indices than control subjects (Jabeen et al., 2013). Besides, some investigations have communicated that RBC indices, except RDW, are significantly lower in the diabetic group compared to the control group, while WBC and PLT indices are substantially higher in the diabetic group (Biadgo et al., 2016; Shehri, 2017). These conflicting results indicate that more research is needed to investigate hematological abnormalities in diabetic patients, and the effect of other variables such as age, gender, and glycemic control on blood parameters in diabetic patients should be considered. Also, The Differences in cultural differences and study design, physiological conditions, obesity, smoking, alcoholism and sample features could impact hematology markers such as hemoglobin levels, RBC, WBC, and Platelet indices. In addition, Hemoglobin (Hgb) values below 13.0 g/dL for men are considered anemia (Cappellini & Motta, 2015). Most investigations in previous studies do not exclude smokers, alcoholism and abnormal body mass index. Therefore, this study looks at hematological variables in adult males between diabetic and healthy, as well as comparing controlling and uncontrolled diabetes, and also the relationship between fasting glucose level and hematological variables among patients.

## 2. MATERIAL and METHODS

### 2.1. Study Population and Participants

The study was a cross-sectional investigation that was carried out from 1st April to 30th July of 2023.The research was carried out at the Fallujah Teaching Hospital, Fallujah, Iraq. The study consisted of a sample of 165 male subjects who had type 2 Diabetes, as well as a control group of 60 healthy males. The diabetic patients had been living with the disease between 5 and 10 years. All participants were male and the ages (40 – 50), with normal body mass index. The control group appeared healthy with no signs of diabetes and were not suffering from any other chronic diseases. Individuals who had any chronic ailments, such as liver diseases, smokers, alcoholics, abnormal body mass index, women, or prediabetics were exclusion criteria.

The patient group was segregated into two distinct groups based on their fasting blood glucose (FBS) as good glycemic control is comprised of individuals whose FBS levels were under 152 mg/dL and poor glycemic control had FBS levels exceeding 152 mg/dL (American Diabetes Association, 2019). The data collection protocol utilized in this study was based on a systematic questionnaire comprising a set of well-constructed inquiries. The questionnaire sought data on the participant's age, gender, name, diabetes status, and consumption of lipid-lowering drugs and haematinics

### 2.2. Sampling Procedure

Blood samples were acquired from study volunteers in both groups in a supervised and sterilization. In evaluating haematology indices, the first 3 millilitres (ml) from blood samples were immediately placed in a red test tube (containing K2EDTA), an anticoagulant. All blood samples were thoroughly checked for hemolysis and clots before analysis. The samples were then appropriately blended. After that, 50 microliters of each sample were examined in under an hour utilizing the Swelab-Alfa automated haematology analyzer for the instrumental analysis. We meticulously documented and archived these data for future statistical studies.

The glucose level was estimated via chemical analysis by applying a small amount of blood onto the ACCU-CHEK Glucose meter strip. The glucose level was determined using this procedure.

### 2.3. Data Analysis

Data was gathered through notebooks and subsequently transferred to a computer, which was kept secure and confidential. Statistical Package for Social Sciences (SPSS, Version 25) was used to compare the data between groups. The study conducted a statistical analysis to compare the haematological parameters of participants with and without diabetes. They used an independent sample t-test for this purpose. Similarly, the analysis compared diabetic patients with good glycemic control to those with poor glycemic control. The findings regarding the mean value ± standard deviation (*SD*) were reported. Pearson’s correlation was utilized to determine the relationship between the obtained haematological indices and fasting glucose. Statistical significance was considered to be a p-value below 0.05.

## 3. RESULTS

### 3.1. Comparison of Hematology Parameters Between Groups

The current study employed an independent t-test to scrutinize any dissimilarity between the patients and control groups in the average of the haematological variables (Table 1). WBC, lymphocyte count, and basophil count were notably elevated in diabetic patients, while lymphocyte count was significantly low in the diabetes group. However, the difference was insignificant in eosinophil count and monocyte count. Interestingly, the patients' RBC, Hct, and MCHC significantly decreased. At the same time, the RDWSD and RDWCV were elevated considerably among the patients. Furthermore, the means of PDW, MPV, PLCR, and glucose were markedly increased in the diabetes group, but the PLT counts were significantly lowered in the diabetic group.

**Table 1.** Comparison of hematology Variables between case study and controls at Fallujah hospital, Iraq, from 1st April to 30th July 2023 (n = 185).

| Variables | Control n = (60) | Case n = (125) | *p*-value |
|---|---|---|---|
| Red blood cell indices | | | |
| RBC ($10^6$/µL) Mean ± *SD* | 4.726 (0.81176) | 4.485 (0.74144) | 0.264 |
| Hct (%) Mean ± *SD* | 39.28 (3.12447) | 37.3696 (5.22982) | 0.045 |
| Hgb (g/dL) Mean ± *SD* | 13.07 (1.09642) | 12.0184 (1.65653) | 0.129 |
| MCV (fL) Mean ± *SD* | 83.78 (9.70837) | 83.9488(6.62536) | 0.143 |
| MCH (Pg) Mean ± *SD* | 27.93 (3.66052) | 27.028 (2.37023) | 0.064 |
| MCHC (g/dL) Mean ± *SD* | 33.33 (0.85337) | 32.1744 (1.16196) | 0.002 |
| RDWSD (fL) Mean ± *SD* | 39.63 (2.93248) | 43.2984 (6.53715) | 0.000 |
| RDWCV (%) Mean ± *SD* | 13.21 (1.88470) | 14.2224 (2.10984) | 0.025 |
| White blood cell indices | | | |
| WBC ($10^3$/µL) Mean ± *SD* | 7.5760 (1.86997) | 8.8781 (3.04349) | 0.001 |
| Lym ($10^3$/µL) Mean ± *SD* | 2.2020 (0.51891) | 2.0742 (0.83454) | 0.001 |
| Neu ($10^3$/µL) Mean ± *SD* | 4.2970 (1.85443) | 5.9990 (3.75224) | 0.000 |
| Mon ($10^3$/µL) Mean ± *SD* | 0.5570 (0.16230) | 0.5925 (0.19423) | 0.485 |
| Eos ($10^3$/µL) Mean ± *SD* | 0.2640 (0.13953) | 0.2088 (0.17925) | 0.590 |
| Bas ($10^3$/µL) Mean ± *SD* | 0.0890 (0.017211) | 0.0252 (0.01484) | 0.000 |
| Platelet indices | | | |
| PLT ($10^3$/µL) Mean ± *SD* | 294.1 (61.29360) | 292.488 (83.07882) | 0.027 |
| PDW (fL) Mean ± *SD* | 11.7 (2.13970) | 12.684 (2.67679) | 0.009 |
| MPV (fL) Mean ± *SD* | 10.206 (.91669) | 10.468 (1.18632) | 0.021 |
| PLC-R (%)Mean ± *SD* | 26.1 (7.36202) | 28.7616 (9.43224) | 0.005 |
| PCT (%) Mean ± *SD* | 0.2890 (0.06650) | 0.2943 (0.08240) | 0.923 |

Abbreviations: RBC; red blood cells, Hgb; hemoglobin, Hct; hematocrit, MCV; mean corpuscular volume, MCH; mean corpuscular hemoglobin, MCHC; mean corpuscular hemoglobin concentration, RDW- *SD*; red cell distribution width standard deviation, RDW-CV; red cell distribution width coefficient of variation, Lym; lymphocyte, Nue; neutrophils , Mon; monocytes, Eos; eosinophil, Bas; basophil , PDW; platelet distribution width, PLC-R; platelet large cell ratio, FBG; fasting blood glucose, *SD*; standard deviation

### 3.2. Comparison of Hematology Variables Between Groups In Patients

The research has shown notable variations in haematological parameters across groups (Table 2). The research shows that the average levels of Mon, Eos, Bas, MCHC, PLT, MPV, PLCR, PCT, and FBG were notably elevated in individuals with poor glycemic control. In contrast, the average values of Neu, RBC count, and PDW were lower in individuals with poor glycemic control. However, the two groups observed no statistically significant changes in other haematological parameters.

**Table 2.** Comparison of hematology Variables between good glycemic control and poor glycemic control in case study at Fallujah Hospital, Iraq, from 1st April to 30th July 2023 ($n$ = 125).

| Parameters | Glycemic control | | *p*-value |
|---|---|---|---|
| | Good ($n$ = 65) Mean ± (*SD*) | Poor ($n$= 60) Mean ± (*SD*) | |
| White blood cell indices | | | |
| WBC ($10^3$/µL) | 8.8191 (3.42811) | 8.942 (2.59072) | 0.074 |
| Neu ($10^3$/µL) | 6.0294 (4.51587) | 5.966 (2.73258) | 0.003 |
| Lym ($10^3$/µL) | 2.0745 (0.92139) | 2.074 (0.73678) | 0.173 |
| Mon ($10^3$/µL) | 0.5255 (0.12305) | 0.665 (0.22931) | 0.001 |
| Eos ($10^3$/µL) | 0.1689 (0.09584) | 0.252 (0.023220) | 0.000 |
| Bas ($10^3$/µL) | 0.0208 (0.00692) | 0.03 (0.01913) | 0.000 |
| Red blood cell indices | | | |
| RBC ($10^6$/µL) | 4.5211 (0.80951) | 4.4460 (0.66449) | 0.002 |
| Hgb (g/dL) | 11.7585 (1.64904) | 12.30 (1.63168) | 0.582 |
| Hct (%) | 37.0277 (4.75695) | 37.74 (5.71567) | 0.492 |
| MCV (fL) | 82.7938 (5.34491) | 85.2 (7.62916) | 0.092 |
| MCH (Pg) | 26.2692 (2.06003) | 27.85 (2.42540) | 0.187 |
| MCHC (g/dL) | 31.7169 (1.18580) | 32.67 (0.91212) | 0.003 |
| RDWSD (fL) | 43.4446 (5.71929) | 43.14 (7.36771) | 0.422 |
| RDWCV (%) | 14.2985 (1.89296) | 14.14 (2.33566) | 0.536 |
| Platelet indices | | | |
| PLT ($10^3$/µL) | 273.7385 (82.08385) | 312.8 (79.94040) | 0.045 |
| PDW (fL) | 12.9369 (3.49118) | 12.41 (1.30042) | 0.000 |
| MPV (fL) | 10.3185 (1.52417) | 10.63 (0.62173) | 0.000 |
| PLCR (%) | 27.5538 (12.00644) | 30.07 (5.22135) | 0.000 |
| PCT (%) | 0.2568 (0.04247) | 0.335 (0.09527) | 0.002 |
| FBG (mg/dL) | 135.0769 (10.73445) | 186.3 (40.62908) | 0.000 |

### 3.3. Correlation of Hematological Parameters and FBG in Patients with T2D

The current investigation employed the Pearson correlation examination to explore the correlation between fasting blood glucose and hematological indices in diabetics group (Table 3). The results revealed that neutrophil count, MCV, MCH, MCHC, PDW, MPV, PLCR, and PCT exhibited a statistically significant positive correlation with FBG. In contrast, Lym, RBC count, and Hct demonstrated a statistically significant negative correlation with FBG in T2DM.

**Table 3.** Correlation of hematological indices and FBG in diabetics group in a hospital in Fallujah, Iraq, from 1st April to 30th July 2023 (*n*=125).

| Variables | FBG Correlation coefficient (r) | *p*-value |
|---|---|---|
| RBC ($10^6$/μL) | -0.180* | 0.045 |
| Hgb (g/dL) | -0.120 | 0.184 |
| Hct (%) | -0.248** | 0.005 |
| MCV (fL) | 0.527** | 0.000 |
| MCH (Pg) | 0.469** | 0.000 |
| MCHC (g/dL) | 0.207* | 0.021 |
| RDWSD (fL) | 0.016 | 0.856 |
| RDWCV (%) | -0.154 | 0.086 |
| WBC ($10^3$/μL) | 0.140 | 0.120 |
| Neu ($10^3$/μL) | 0.181* | 0.043 |
| Lym ($10^3$/μL) | -0.264** | 0.003 |
| Mon ($10^3$/μL) | 0.062 | 0.494 |
| Eos ($10^3$/μL) | 0.021 | 0.814 |
| Bas ($10^3$/μL) | 0.128 | 0.154 |
| PLT ($10^3$/μL) | -0.121 | 0.179 |
| PDW (fL) | 0.202* | 0.024 |
| MPV (fL) | 0.358** | 0.000 |
| PLCR (%) | 0.283** | 0.001 |
| PCT (%) | 0.427** | 0.000 |

**. Correlation has significant at 0.01
*. Correlation has significant at 0.05

## 4. DISCUSSION and CONCLUSION

In this study, it has been recorded that individuals who are diagnosed with diabetes have marked abnormalities in numerous hematological variables. The current study observed significant differences in both the mean and standard deviation of various blood parameters, including WBC, neutrophil count, lymphocyte count, basophil counts, Hct, MCHC, RDWSD, RDWCV, PLT, PDW, MPV, PLCR, and glucose levels, in a group of cases compared to a control population.

The current investigation achieved a significantly higher overall leukocyte count and absolute neutrophil count in diabetics. Similarly, papers reported in Bangladesh, northeastern Ethiopia, Libya, Turkey and northeastern Ethiopia among diabetics (Alam *et al*., 2015; Biadgo *et al*., 2016; Al Salhen & Mahmoud, 2017; Kizilgul *et al*., 2018; Arkew *et al*., 2021). The lymphocyte count and the basophil count were decreased a significant among diabetics. The previous researches confirm decreasing absolute basophil count in Bangladesh and Saudi Arabia in T2DM (Alam *et al*., 2015; Shehri, 2017). However, the absolute count of lymphocytes contradicts our findings, as surveys were conducted in Libya, India, and Nigeria (Al Salhen & Mahmoud, 2017; Harish *et al*., 2017; Awofisoye *et al*., 2019) reported mixed results.

The present study has revealed findings demonstrating a significant increase in both RDWSD and RDWCV. This study has yielded analogous with researchers in countries such as Saudi Arabia and Ethiopia (Shehri, 2017; Arkew *et al*., 2021). The elevated red RDW serves as a reliable indicator of the presence of a diverse population of RBC circulating throughout the body, which is often associated with impaired erythropoiesis and erythrocytic dissociation (Salvagno *et al.*, 2014) .Another explanation by Sherif *et al*., 2013, it is well known that chronic inflammation and high levels of oxidative stress, which are often seen in diabetes patients, may drastically impair the lifetime of RBC, which in turn can contribute to considerable variations in RBC volume.

Low MCHC and hematocrit levels were found in diabetics in the present study. Whereas MCHC and hematocrit were significantly low in diabetic patients, this finding is in line with what has been documented in India, Brazil, University of Gondar in Ethiopia, Northeast Ethiopia and (Farooqui *et al*., 2019; Knychala *et al*., 2021; Adane *et al*., 2021; Ebrahim *et al*., 2022). The current study found that the average PLT counts were lower in the cases group, whereas the average PDW, MPV, and PLCR were considerably higher. This report in harmony with other researchers such as Harish *et al*., 2017; Kizilgul *et al*., 2018; Ebrahim *et al.*, 2022. This might be due to persistent hyperglycemia, which is directly related to enzymatic glycosylation and increased expression of pro-inflammatory cytokines in the bloodstream (Barbieri *et al*., 2015; Bekele *et al*., 2019; Bhatt *et al*., 2020).

In this study, the mean Mon, Eos, Bas, MCHC, PLT, MPV, PLC-R, and PCT were a significant increasing in uncontrolled diabetes. Correspondingly, a plethora of congruous findings were documented in Southwest Ethiopia, Northeast Ethiopia, where the MPV and P-LC-R evinced a noteworthy escalation in patients with diabetes whose inadequate glycemic management (Asmamaw *et al*., 2021; Ebrahim *et al*., 2022).

On the contrary, it can be observed that there exists a significant decrease in the count of absolute neutrophils, red blood cells, and platelet distribution width among individuals with inadequate glycemic management. However, it is significant to mention that certain inconsistent results have been documented in India, wherein platelet distribution width exhibited a significant increase in patients with diabetes who had inadequate glycemic management (Farooqui *et al*., 2019). This finding is corroborated by further relevant studies conducted in India, Southwest, and Eastern Ethiopia, which reported a significant increase in red blood cell count among diabetes patients with inadequate glycemic control (Farooqui *et al*., 2019; Asmamaw *et al*., 2021; Arkew *et al*., 2022).

The current analysis, FBG has found a correlation with neutrophil count, MCV, MCH, MCHC, PDW, MPV, PLCR, and plateletcrit in individuals diagnosed with T2DM. This finding has confirmed by a paper was done in Ethiopia, demonstrating that levels of FBG rise in proportion to incremental increases in PDW, MPV, PLC-R, and plateletcrit (Ebrahim *et al*., 2022). Nevertheless, it is crucial to acknowledge that India has reported contradictory results, as MPV and MCV have shown an inverse relationship with FBG in individuals with diabetes (Joshi & Jaison, 2019). This study of type 2 diabetics discovered an inverse relationship between FBG and lymphocyte count, RBC, and Hct. This confirms the results of an earlier Ethiopian research that found the same thing among diabetics, there is an inverse relationship between FBG and RBC count and Hct (Ebrahim *et al*., 2022). However, it is important to note that this outcome contradicts the results of a study carried out in Japan, where RBC count was observed to be positively correlated with FBG in individuals with diabetes (Jaman *et al*., 2018).

This study showed a statistically significant effect of type 2 diabetes mellitus patients on some hematological parameters such as WBC, Hct, and MPV. Also, glycemic management has a significant correlation with hematological parameters such as RBC in patients with type 2 diabetes mellitus. Fasting blood glucose, it effects on hematological parameters among diabetics.

### Declaration of Conflicting Interests and Ethics

The authors declare no conflict of interest. This research study complies with research and publishing ethics. The scientific and legal responsibility for manuscripts published in IJSM belongs to the authors. **Ethics Committee Number**: The present study was approved at 28/march/2023. Community Health/ Anbar Technical Institute/ Middle Technical University, Iraq, 00045.

### Authorship Contribution Statement

**Osamah Awad Ahmed**: Supervision, Investigation, Resources, Visualization, Software, Formal Analysis, and Writing -original draft. **Luay Awad Ahmed**: Methodology and Formal Analysis.

### Orcid

Osamah Awad Ahmed https://orcid.org/0000-0003-3546-2136
Luay Awad Ahmed https://orcid.org/0000-0001-8325-2374

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