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COMPARATIVE ANALYSIS OF COMPLETE BLOOD COUNT PARAMETERS IN INSULIN-DEPENDENT AND NON-INSULIN-DEPENDENT DIABETIC PATIENTS

Original Research

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ABSTRACT

Background: Diabetes mellitus is a chronic metabolic disorder that affects multiple organ systems, including the hematopoietic system. Hematological alterations are increasingly recognized as indicators of disease progression and potential complications in diabetes. Complete blood count (CBC) parameters, particularly differences between insulin-dependent and non-insulin-dependent patients, may provide clinically valuable insights for monitoring disease activity and guiding individualized management strategies.

Objective: The objective of this study was to compare CBC parameters among insulin-dependent, non-insulin-dependent, and non-diabetic control groups to determine significant differences with potential clinical implications.

Methods: This descriptive cross-sectional study was conducted at District Headquarters Hospital, Buner, Khyber Pakhtunkhwa, from April to August 2024. A total of 159 participants were enrolled, comprising 53 insulin-dependent diabetics, 53 non-insulin-dependent diabetics, and 53 age-matched healthy controls. Inclusion criteria required patients aged over 40 years with a confirmed diagnosis of type 2 diabetes mellitus of at least three years. Blood samples were collected following overnight fasting and analyzed using an automated hematology analyzer. Statistical analysis was performed in SPSS version 26, employing one-way ANOVA and regression tests, with p-values <0.05 considered significant.

Results: The study population had a mean age of 61.27 ± 12.86 years, with 56% males and 44% females. Insulin-dependent patients demonstrated the longest mean diabetes duration (85.43 ± 62.69 months) compared to non-insulin-dependent patients (49.55 ± 48.24 months; $p < 0.001$). Systolic blood pressure was higher in diabetic groups (133.26 ± 21.65 mmHg insulin-dependent; 133.02 ± 19.66 mmHg non-insulin-dependent) than in controls (124.19 ± 22.73 mmHg; $p = 0.048$), while diastolic pressure showed no significant difference ($p = 0.681$). Total WBC counts were significantly greater in insulin-dependent patients (11.75 ± 5.91 × 10^9/L) than in non-insulin-dependent (10.07 ± 4.22 × 10^9/L) and controls (9.42 ± 3.41 × 10^9/L; $p = 0.030$). Neutrophil counts were also higher in the insulin-dependent group (8.87 ± 5.44 × 10^9/L; $p = 0.054$), whereas hemoglobin, RBC, and platelet counts did not differ significantly ($p > 0.05$).

Conclusion: The findings highlight that insulin-dependent diabetics exhibit elevated WBC and neutrophil counts compared to non-insulin-dependent and control groups, indicating a heightened inflammatory response. Although other hematological indices remained comparable, the results suggest that disease duration and treatment modality may influence hematological profiles, underscoring the need for tailored monitoring and personalized diabetes care.

Keywords: Blood Cell Count; Diabetes Mellitus, Type 2; Hematology; Inflammation; Insulin; Leukocytes; Pakistan.

INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disorder marked by persistent hyperglycemia resulting from inadequate insulin secretion, impaired insulin action, or a combination of both (1). It encompasses a heterogeneous group of conditions that disrupt the regulation of carbohydrate, lipid, and protein metabolism, leading to characteristic features such as glycosuria, hyperlipidemia, and negative nitrogen balance. Prolonged uncontrolled hyperglycemia is particularly detrimental, as it can damage multiple organs and precipitate complications including cardiovascular disease, neuropathy, nephropathy, retinopathy, and, in severe cases, blindness or limb amputation (2,3). Diabetes is generally classified into four main types. Type 1 diabetes mellitus (T1DM) is characterized by autoimmune destruction of pancreatic beta cells, resulting in complete insulin deficiency, while type 2 diabetes mellitus (T2DM) arises from progressive beta-cell dysfunction commonly associated with insulin resistance. In addition, other specific forms of diabetes may result from monogenic syndromes, pancreatic disorders, or drug-induced etiologies. Gestational diabetes mellitus presents during the second or third trimester of pregnancy without prior evidence of diabetes. Both T1DM and T2DM can cause extensive systemic complications, as sustained hyperglycemia interferes with lipid metabolism, vascular homeostasis, immune regulation, and hematological processes (4-6). Diabetes is widely recognized as a leading risk factor for cardiovascular disease, with additional contributors such as obesity, hypertension, environmental exposures, and genetic predispositions compounding its impact. The metabolic disturbances of diabetes, including dyslipidemia, insulin resistance, oxidative stress, endothelial dysfunction, and pro-thrombotic states, further heighten cardiovascular risk (7,8). Importantly, hematological alterations are increasingly acknowledged in diabetes, particularly in T2DM, where abnormalities in red blood cells (RBCs), white blood cells (WBCs), and platelet indices are common. Anemia is frequently observed in diabetic patients, and its prevalence is particularly high in those with nephropathy (9,10).

The World Health Organization defines anemia as hemoglobin concentrations below 12.0 g/dl in women and 13.0 g/dl in men, though reference values vary with sex, ethnicity, and physiological status. Chronic hyperglycemia promotes the generation of reactive oxygen species (ROS) and advanced glycation end products (AGEs), which impair endothelial function and contribute to hematological changes (11,12). Oxidative stress disrupts erythrocyte integrity, induces platelet hyperactivation, and enhances inflammatory responses, all of which accelerate vascular damage in T2DM (13). Moreover, insulin resistance has been linked to increased inflammatory markers, higher leukocyte counts, and platelet dysfunction, underscoring the multifactorial role of hematological changes in the pathogenesis of diabetic complications (14). Despite their clinical importance, hematological parameters are often underexplored in the context of diabetes, particularly in low-resource settings where laboratory monitoring may be limited. Few studies have systematically evaluated complete blood count (CBC) variations in diabetic patients, and evidence remains sparse in populations from developing countries such as Ethiopia (11,14). Addressing this gap is crucial, as identifying hematological alterations could provide valuable insights into disease progression, complication risk, and potential management strategies. The objective of this study is therefore to compare hematological parameters, specifically complete blood count indices, between insulin-dependent and non-insulin-dependent diabetic patients and to evaluate their potential clinical significance in the broader context of diabetes management.

METHODS

The present study was designed as a descriptive cross-sectional investigation and was conducted at the District Headquarters (DHQ) Hospital, Buner, Khyber Pakhtunkhwa, Pakistan, between April 2024 and August 2024. The geographic location of Buner lies between latitudes 34°-9′ N and 34°-43′ N, and longitudes 72°-10′ E and 72°-47′ E, with altitudes ranging from 1,200 to 9,550 feet above sea level. Ethical approval for the study was obtained from the Board of Advanced Project and Research Committee at Nur International University, Lahore (dated January 29, 2024), and subsequently from the hospital's review board (Letter No. 203-06/F, dated March 25, 2024). Additional clearance was granted by the heads of the medical and surgical departments. Written informed consent was obtained from all participants in English, Urdu, or Pashto to ensure comprehension by the local population. The sample size was calculated using G*Power software version 3.1.9.4, based on a prior study, with a two-tailed alpha error of 0.05, a statistical power of 0.80, an allocation ratio of 1.36, and an effect size of 0.5. A minimum of 159 participants was required to provide adequate power. Accordingly, 159 individuals were enrolled and evenly distributed across three groups: 53 patients with insulin-dependent type 2 diabetes mellitus (T2DM), 53 with non-insulin-dependent T2DM, and 53 age-matched healthy controls. This distribution allowed for a robust comparison

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of complete blood count (CBC) parameters across the groups. The study population included patients diagnosed with T2DM admitted to the medical or surgical wards of DHQ Hospital, Buner. Eligibility criteria required patients to be older than 40 years, to have a confirmed diagnosis of T2DM for more than three years, and to be on a consistent treatment regimen for at least six months, whether insulin therapy or oral hypoglycemic agents. Exclusion criteria included individuals with known hematological disorders, malignancies, other endocrinological or systemic illnesses, congenital heart disease, degenerative neurological conditions, or a prior history of cardiac surgery (7,8). Participants receiving inotropic or mechanical support, those with implantable cardiac devices, or those scheduled for off-pump or beating-heart surgeries were excluded, as such conditions could serve as confounding factors.

Data collection was carried out at the same hospital. Patients attending for regular check-ups and medication refills were approached, and those meeting the inclusion criteria were enrolled. Blood samples were drawn by trained phlebotomists using standard venipuncture techniques in the morning following an overnight fast, thereby minimizing variability due to recent dietary intake. Samples were collected in EDTA tubes to preserve cellular integrity and were promptly transported to the hospital's laboratory for analysis. An automated hematology analyzer was employed to measure CBC parameters, including red blood cell (RBC) count, white blood cell (WBC) count, hemoglobin concentration, hematocrit, mean corpuscular volume (MCV), platelet count, and differential leukocyte counts. The laboratory staff ensured quality control procedures, and all data were anonymized prior to statistical processing to maintain confidentiality. The data were entered into SPSS software version 26.0 for analysis. Descriptive statistics, including means and standard deviations, were calculated for continuous variables, while categorical variables such as gender and treatment group were summarized as frequencies and percentages. A one-way Analysis of Variance (ANOVA) was performed to compare mean hematological parameters among the three groups (insulin-dependent T2DM, non-insulin-dependent T2DM, and healthy controls). Post-hoc tests were planned where necessary to identify specific intergroup differences. In addition, linear regression analysis was applied to assess correlations between continuous hematological variables and clinical parameters, enabling an understanding of the potential influence of treatment modalities on blood indices. Results were graphically illustrated using charts and plots for clarity of interpretation.

RESULTS

The study included 159 participants, with a slight male predominance (56%) compared to females (44%). Educational attainment was low, with 67.3% of participants unable to read or write, while 15.7% had completed primary education, 14.5% secondary, and only 2.5% higher education. The majority of respondents were unemployed (71.7%), and 74.8% reported engaging in regular physical activity. Skin color changes or bruising were observed in 36.5% of individuals, while smoking was infrequent (10.1%). Symptoms of unusual fatigue, weakness, or dizziness were present in 64.2%, and visual disturbances were reported in 56.6%. A family history of diabetes was identified in 48.4% of participants. When comparing groups, distinct demographic and clinical patterns emerged. Males were more prevalent in the insulin-dependent cohort (62.3%) compared with the non-insulin-dependent group (50.9%) and controls (54.7%). Illiteracy was highest among non-insulin-dependent participants (73.6%), while unemployment was uniformly high across all groups. Regular physical activity was reported most frequently among controls (88.7%) compared with insulin-dependent participants (58.5%). Skin color alterations or bruising were strikingly more common in the insulin-dependent group (66%) than in controls (1.9%). Smoking prevalence was marginally higher among insulin-dependent participants (17%). A family history of diabetes was most common among insulin-dependent participants (71.7%), followed by non-insulin-dependent (54.7%), and least among controls (18.9%). Insulin-dependent subjects also reported the highest rates of atypical fatigue or dizziness (81.1%) and visual disturbances (77.4%). Hematological comparisons revealed significant differences among groups. The insulin-dependent group demonstrated the highest total WBC count (11.75 ± 5.91 $\times 10^3/\mu L$), followed by non-insulin-dependent (10.07 ± 4.22 $\times 10^3/\mu L$) and controls (9.42 ± 3.41 $\times 10^3/\mu L$). Neutrophil counts followed the same pattern, being highest in insulin-dependent participants (8.87 ± 5.44 $\times 10^3/\mu L$) and lowest in controls (6.73 ± 3.61 $\times 10^3/\mu L$). Lymphocyte and monocyte counts showed little variation across groups, while eosinophil and basophil counts were lowest in insulin-dependent participants and slightly elevated among controls. Neutrophil percentages were also highest in insulin-dependent participants (73.88 ± 13.39%), while controls exhibited the highest lymphocyte percentages (24.28 ± 14.02%). Hemoglobin concentrations were lowest in the insulin-dependent group (12.28 ± 2.38 g/dL), compared with 12.95 ± 2.15 g/dL in non-insulin-dependent and 12.96 ± 1.9 g/dL in controls. Hematocrit values followed a similar trend, being lowest in insulin-dependent patients (37.74 ± 8.04%) and highest among controls (38.8 ± 6.67%).

Clinical variables also showed variation. Systolic blood pressure was significantly higher in both diabetic groups (133.26 ± 21.65 mmHg for insulin-dependent, 133.02 ± 19.66 mmHg for non-insulin-dependent) compared with controls (124.19 ± 22.73 mmHg, $p = 0.048$). Diastolic blood pressure did not differ significantly across groups. Body mass index was comparable, with a non-significant trend

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towards higher values in non-insulin-dependent participants (24.38 ± 3.73) compared with insulin-dependent (23.35 ± 3.6) and controls (24.11 ± 3.74). The mean duration of diabetes was longest in insulin-dependent participants (85.43 ± 62.69 months) compared with non-insulin-dependent participants (49.55 ± 48.24 months), as expected, while negligible in controls. Post-hoc analysis confirmed that total WBC counts were significantly higher in insulin-dependent participants compared with controls ($p = 0.028$), though differences between insulin-dependent and non-insulin-dependent groups did not reach statistical significance. Neutrophil percentages were significantly higher in insulin-dependent patients than controls (mean difference 2.14, $p = 0.042$). Conversely, eosinophil and basophil percentages were significantly lower in insulin-dependent participants compared with controls ($p = 0.042$ and $p = 0.007$, respectively). Non-insulin-dependent participants also exhibited lower basophil percentages compared with controls ($p = 0.008$). These findings highlighted clear alterations in white blood cell subtypes associated with insulin dependence.

Table 1: Demographic Variables Among Respondents

Category	Frequency	Percent
Gender of the Participant		
Male	89	56
Female	70	44
Total	159	100
Educational Status		
Not read and write	107	67.3
Primary	25	15.7
Secondary	23	14.5
Higher education	4	2.5
Total	159	100
Occupational Status		
Non-employed worker	114	71.7
Employed worker	25	15.7
Other	20	12.6
Total	159	100
Regular Physical Activity		
Yes	119	74.8
No	40	25.5
Total	159	100
Skin Color or Bruising		
Yes	58	36.5
No	101	63.5
Total	159	100
Smoking History		
Yes	16	10.1
No	143	89.9

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Category	Frequency	Percent
Total	159	100
Unusual Fatigue, Weakness, Dizziness		
Yes	102	64.2
No	57	35.8
Total	159	100
Visual Disturbance		
Yes	90	56.6
No	69	43.4
Total	159	100
Treatment Regimen		
Insulin-dependent	53	33.3
Non-insulin-dependent/Oral	53	33.3
Control	53	33.3
Total	159	100
Family History of Diabetes		
Yes	77	48.4
No	82	51.6
Total	159	100

Table 2: Demographic Distribution Among Different Groups

Parameter	Insulin Dependent (n=53)		Non-Insulin Dependent (n=53)		Control (n=53)	
	(n)	%	(n)	%	(n)	%
Gender						
Male	33	62.30%	27	50.90%	29	54.70%
Female	20	37.70%	26	49.10%	24	45.30%
Education Status						
Not able to read and write	31	58.50%	39	73.60%	37	69.80%
Primary	9	17.00%	7	13.20%	9	17.00%
Secondary	13	24.50%	6	11.30%	4	7.50%
Higher Education	0	0.00%	1	1.90%	3	5.70%
Occupation Status						
Unemployed	39	73.60%	36	67.90%	39	73.60%
Employed	7	13.20%	8	15.10%	10	18.90%
Other	7	13.20%	9	17.00%	4	7.50%
Physical Activity						

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Parameter	Insulin Dependent (n=53)		Non-Insulin Dependent (n=53)		Control (n=53)	
Yes	31	58.50%	41	77.40%	47	88.70%
No	22	41.50%	12	22.60%	6	11.30%
Skin Color or Bruising						
Yes	35	66.00%	22	41.50%	1	1.90%
No	18	34.00%	31	58.50%	52	98.10%
Smoking History						
Yes	9	17.00%	6	11.30%	1	1.90%
No	44	83.00%	47	88.70%	52	98.10%
Other Medications/Supplement						
Yes	37	69.80%	35	66.00%	34	64.20%
No	16	30.20%	18	34.00%	19	35.80%
Family History of Diabetes						
Yes	38	71.70%	29	54.70%	10	18.90%
No	15	28.30%	24	45.30%	43	81.10%
Unusual Fatigue, Weakness, or Dizziness						
Yes	43	81.10%	41	77.40%	18	34.00%
No	10	18.90%	12	22.60%	35	66.00%
Visual Disturbance						
Yes	41	77.40%	35	66.00%	14	26.40%
No	12	22.60%	18	34.00%	39	73.60%

Table 3: Hematological Parameters Among Different Groups

Parameter	Insulin Dependent (n=53)		Non-Insulin Dependent (n=53)		Control (n=53)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Total WBC Count (10^3/µL)	11.75	5.91	10.07	4.22	9.42	3.41
Neutrophil Count (10^3/µL)	8.87	5.44	7.85	4.33	6.73	3.61
Lymphocyte Count (10^3/µL)	2.08	1.16	2.39	2.41	2.41	2.2
Monocyte Count (10^3/µL)	0.51	0.47	0.52	0.65	0.47	0.6
Eosinophil Count (10^3/µL)	0.23	0.89	0.29	0.48	0.26	0.37
Basophil Count (10^3/µL)	0.01	0.03	0.03	0.1	0.05	0.09
Neutrophil %	73.88	13.39	73.28	13.73	69.45	15.57
Lymphocyte %	20.22	12.15	21.14	12.4	24.28	14.02
Monocyte %	3.87	3.06	4.01	2.95	3.69	2.92
Eosinophil %	1.19	1.67	1.6	1.8	2.01	1.73
Basophil %	0.11	0.3	0.12	0.29	0.32	0.43

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Parameter	Insulin Dependent (n=53)		Non-Insulin Dependent (n=53)		Control (n=53)	
RBC Count (10^6/µL)	4.68	0.9	4.68	0.78	4.72	0.76
Hemoglobin (g/dL)	12.28	2.38	12.95	2.15	12.96	1.9
Hematocrit %	37.74	8.04	38.18	6.98	38.8	6.67

Table 4: Comparison of Demographic Parameters Among Insulin-Dependent, Non-Insulin-Dependent, And Control Groups

Parameter	Group	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	P-value
						Lower Bound	
Systolic Blood Pressure	Insulin-dependent	53	133.26	21.65	2.97	127.3	0.048
	Non-insulin-dependent/Oral	53	133.02	19.66	2.7	127.6	
	Control	53	124.19	22.73	3.12	117.92	
	Total	159	130.16	21.67	1.72	126.76	
Diastolic Blood Pressure	Insulin-dependent	53	80.34	10.74	1.47	77.38	0.681
	Non-insulin-dependent/Oral	53	81.49	10.66	1.46	78.55	
	Control	53	79.58	12.29	1.69	76.2	
	Total	159	80.47	11.21	0.89	78.72	
Body Mass Index (BMI)	Insulin-dependent	53	23.35	3.6	0.49	22.36	0.335
	Non-insulin-dependent/Oral	53	24.38	3.73	0.51	23.35	
	Control	53	24.11	3.74	0.51	23.08	
	Total	159	23.95	3.69	0.29	23.37	
Duration of Disease (Months)	Insulin-dependent	53	85.43	62.69	8.61	68.15	0
	Non-insulin-dependent/Oral	53	49.55	48.24	6.63	36.25	
	Control	53	0.03	0.16	0.03	-0.03	
	Total	159	49.34	58.29	4.84	39.78	

Table 5: Multiple Comparisons of Total White Blood Cell Count Among Insulin-Dependent, Non-Insulin-Dependent, and Control Groups Using Tukey HSD Test

Dependent Variable: Total WBC Count (10⁹/L)						
Treatment Regimen	(I) Treatment Regimen	(J) Treatment Regimen	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval
						Lower Bound
Insulin-dependent	Non-Insulin-Dependent/Oral	1.67868	0.89979	0.152	-0.4505	3.8079

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	Control	2.33226*	0.89979	0.028*	0.2031	4.4614
Non-Insulin-Dependent/Oral	Insulin-dependent	-1.67868	0.89979	0.152	-3.8079	0.4505
	Control	0.65358	0.89979	0.748	-1.4756	2.7828
Control	Insulin-dependent	-2.33226*	0.89979	0.028*	-4.4614	-0.2031
	Non-Insulin-Dependent/Oral	-0.65358	0.89979	0.748	-2.7828	1.4756

Table 6: Multiple Comparisons of White Blood Cell Parameters Among Insulin-Dependent, Non-Insulin-Dependent, and Control Groups Using Tukey HSD Test

Dependent Variable	Comparison (I-J)	Mean Difference	Std. Error	P-value	95% Confidence Interval
					Lower Bound - Upper Bound
Total WBC Count (10^3)	Insulin-dependent vs. Control	2.33*	0.9	0.028	0.20 - 4.46
	Control vs. Insulin-dependent	-2.33*	0.9	0.028	-4.26
Neutrophil Count (%)	Insulin-dependent vs. Control	2.14*	0.88	0.042	0.07 - 4.22
	Control vs. Insulin-dependent	-2.14*	0.88	0.042	-4.15
Eosinophil Count (%)	Insulin-dependent vs. Control	-0.82*	0.34	0.042	-1.6
	Control vs. Insulin-dependent	0.82*	0.34	0.042	0.02 - 1.62
Basophil Count (%)	Insulin-dependent vs. Control	-0.21*	0.07	0.007	-0.32
	Non-Insulin-dependent vs. Control	-0.20*	0.07	0.008	-0.32
	Control vs. Insulin-dependent	0.21*	0.07	0.007	0.05 - 0.37
	Control vs. Non-Insulin-dependent	0.20*	0.07	0.008	0.04 - 0.36

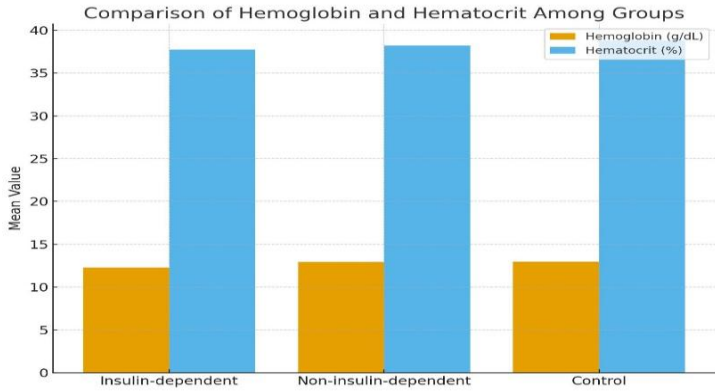

Figure 1 Comparison of Hemoglobin and Hematocrit Among Groups

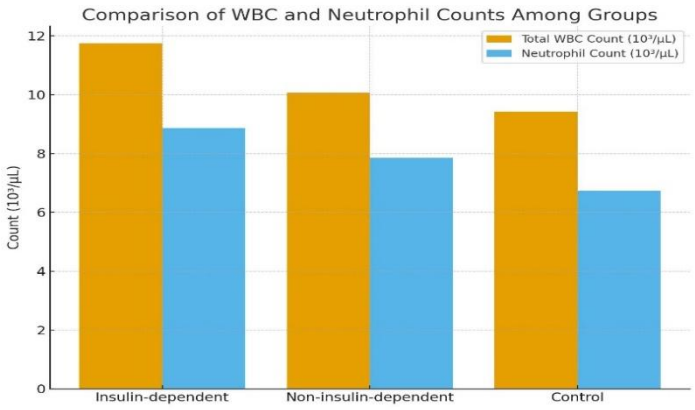

Figure 2 Comparison of WBC and Neutrophil Counts Among Groups

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DISCUSSION

The present findings reinforced that, hematological alterations were common in type 2 diabetes mellitus and constituted a clinically meaningful but often under-recognized burden. Total leukocyte counts and absolute neutrophil, lymphocyte, eosinophil, and basophil counts were significantly higher in individuals with T2DM than in non-diabetic controls, accompanied by lower hemoglobin, altered red cell distribution width (RDW), larger mean platelet volume (MPV), and higher platelet counts, whereas mean red cell counts were marginally lower but not statistically different from controls (5,6). This profile aligned with reports from India, Libya, Sudan, and Addis Ababa, Ethiopia, which similarly described depressed erythrocyte indices in diabetes, plausibly driven by chronic hyperglycemia, oxidative stress, and nonenzymatic glycation that together reduce erythrocyte deformability, increase aggregation, and accelerate senescence, thereby impairing microcirculatory flow and predisposing to microangiopathy (7,8). In contrast, evidence from Pakistan and northwest Ethiopia documented higher RBC counts and hemoglobin in T2DM, a divergence that likely reflected differences in case mix, altitude, hydration, iron status, renal function, and the proportion of insulin-resistant phenotypes with relative erythropoietin stimulation, underscoring biological heterogeneity across populations and settings. The consistently elevated RDW in T2DM supported the concept of ineffective erythropoiesis and shortened erythrocyte survival in an inflammatory, oxidative milieu, mirroring observations from Pakistan, Saudi Arabia, Addis Ababa, and Gondar (9-11). Increased heterogeneity in red cell size provided a simple hematological surrogate for ongoing metabolic and inflammatory stress, and its association with lower hemoglobin strengthened the argument for routine anemia surveillance in diabetes care, particularly in resource-limited settings where comprehensive iron studies may not be readily available (12,13). The observed reduction in hemoglobin with a modest population-level prevalence of anemia within the World Health Organization “mild public health problem” range was compatible with prior estimates from Saudi Arabia, Australia, and Sudan, while remaining lower than several reports from India, Nigeria, and northeast Ethiopia; such variability was credibly explained by differences in demographic composition, sex proportions, renal disease burden, glycemic control, and study size (14-16).

Duration of diabetes demonstrated a robust association with anemia, with markedly higher odds beyond seven years of disease, aligning with evidence that cumulative metabolic injury, low-grade inflammation, and rising interleukin-6 activity progressively blunt erythropoietin responsiveness and erythroid proliferation (16,17). The association between habitual milk intake and anemia further highlighted a modifiable nutritional determinant; the inhibitory effects of calcium and casein on non-heme iron absorption, coupled with the low intrinsic iron and folate content of milk, offered a biologically coherent pathway that justified dietary counseling within comprehensive diabetes management (17,18). Leukocyte perturbations observed here—higher total and differential counts—were directionally consistent with studies from Turkey, Bangladesh, Libya, and Gondar and supported the paradigm that T2DM represented a chronic inflammatory state in which hyperglycemia, advanced glycation end products, and oxidative stress sustain leukocyte activation and endothelial injury (19). Although subgroup analyses in some cohorts have shown lower eosinophil or basophil proportions among insulin-treated patients, the present analysis, which emphasized absolute counts at the group level, indicated higher eosinophil and basophil counts overall in T2DM than in controls, a pattern also reported in Saudi and Bangladeshi populations and one that may reflect differences in treatment stage, comorbid allergic disease, or parasitic exposure (20). Neutrophils and monocytes remained plausible biomarkers of the inflammatory load in diabetes and tracked with vascular risk, reinforcing their potential utility in risk stratification and monitoring (21). These results carried practical implications. First, routine complete blood count profiling—beyond glucose and lipid monitoring—may identify patients at risk for anemia, heightened inflammatory activity, or pro-thrombotic shifts reflected by platelet indices, enabling earlier dietary interventions, iron evaluation, renal assessment, and optimization of glycemic control. Second, simple metrics such as RDW and MPV, obtainable in basic laboratories, may serve as accessible adjuncts for risk stratification where advanced inflammatory markers are unavailable. Third, recognizing dietary contributors to anemia, including high calcium loads around iron-containing meals, offers a low-cost target for counseling and public-health messaging.

The study possessed several strengths: standardized fasting sampling, use of an automated analyzer for CBC indices, and inclusion of a contemporaneous control group enhanced internal validity. The analysis also evaluated both absolute and proportional leukocyte measures, capturing different dimensions of inflammatory change. However, important limitations tempered inference. The cross-sectional design precluded causal attribution, and single-center, hospital-based recruitment limited generalizability to community settings. The absence of iron studies, vitamin B12 and folate levels, reticulocyte counts, erythropoietin measurements, and renal function indices constrained mechanistic interpretation of anemia. Glycemic control markers (e.g., HbA1c), inflammatory biomarkers (e.g., IL-6, CRP), and detailed comorbidity profiling were not incorporated, potentially confounding hematological differences across groups. Morphological blood film assessment and coagulation parameters were not evaluated, despite their relevance to microangiopathy and thrombotic risk. Future work would benefit from prospective cohort designs linking longitudinal changes in CBC indices with

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trajectories of glycemic control, renal function, and incident vascular outcomes. Inclusion of iron panel testing, micronutrient assessment, erythropoietin levels, and inflammatory cytokines would clarify causal pathways to anemia and define actionable thresholds for intervention. Interventional studies testing integrated packages—dietary iron optimization, timing of calcium-rich foods, renoprotective therapy, and intensified glycemic management—could quantify hematologic and clinical benefits. Stratification by treatment modality, diabetes duration, and complication burden would refine the clinical utility of CBC-derived markers across heterogeneous patient groups. Taken together, the hematological signature observed in T2DM—elevated leukocyte counts and subtypes, increased RDW and MPV, higher platelets, and lower hemoglobin with nonsignificant differences in mean RBC counts—was biologically plausible, consistent with a chronic inflammatory and oxidative milieu, and operationally useful for routine risk assessment in resource-constrained care pathways.

CONCLUSION

This study concluded that notable hematological differences exist between insulin-dependent and non-insulin-dependent diabetic patients, reflecting the distinct impact of treatment modalities and disease progression on blood profiles. Insulin-dependent patients demonstrated clearer signs of inflammatory changes, highlighting their heightened vulnerability to complications and the need for vigilant monitoring. These findings emphasize the importance of integrating routine hematological assessments into diabetes management to guide personalized treatment strategies, improve long-term outcomes, and reduce the burden of diabetes-related complications.

AUTHOR CONTRIBUTION

Author	Contribution
Mukhtair Ahmad*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Mati Ullah	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Ihsan Ali	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
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