Data-Driven Analysis of Hematological and Biochemical Changes in Non-Insulin-Dependent Diabetes Patients

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Abstract: Non-insulin-dependent diabetes mellitus (NIDDM) is associated with metabolic and hematological changes that may lead to complications. To study the physiological and biochemical blood parameters in male NIDDM patients in Najaf, Iraq. 40 male patients with NIDDM, aged 38–70 years, were examined over a three-month period after confirmation of NIDDM. Physiological parameters included hemoglobin concentration, total and differential white blood cell count, and erythrocyte sedimentation rate (ESR). Biochemical parameters included serum glucose and total cholesterol. We compared them with 40 healthy males. Data are presented as mean ± standard error, and significance was tested at $p<0.05$**.** Patients showed a significant increase ($p<0.01$) in total white blood cell count and erythrocyte sedimentation rate compared to the control group. Serum glucose and total cholesterol levels also increased significantly ($p<0.01$). No significant changes were observed in hemoglobin concentration and some white blood cell subsets. Differential counts revealed neutrophilia and a relative decrease in lymphocytes in the patients. The Iraqi patients who have non-type 2 diabetes show significant changes in biochemical parameters, and hematological, particularly hyperglycemia, dyslipidemia, and inflammation.

1 INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disease that can be recognized by persistently elevated blood glucose levels, due to insulin resistance, impaired insulin secretion, or both. There are different types of diabetes, type 2 diabetes mellitus (T2DM), also called non-insulin-dependent diabetes mellitus (NIDDM). This type of diabetes represents more than 90% of diabetes cases worldwide, and it has become a major public health concern [1]. Recently, the reports of the WOH show in Iraq, the prevalence of type 2 diabetes continues to rise, this increase refers to the lifestyle changes, evolving dietary habits, and increased urbanization [2].

Diabetes can lead to systemic changes that affect hematological and biochemical parameters. In addition to elevated blood glucose levels, several changes in hemoglobin, white blood cell (WBC), erythrocyte sedimentation rate (ESR), and erythrocyte sedimentation rate (ESR) levels are typically associated with chronic inflammation and oxidative stress [3], [4]. Such as, Dyslipidemia, particularly hypercholesterolemia, is a well-known metabolic disorder in type 2 diabetes and significantly contributes to the risk of cardiovascular disease [5]. Despite the many studies on diabetes, data on the physiological and biochemical manifestations of type 2 diabetes in Iraqi patients are limited.

This work proposed a method to examine selected blood parameters in Iraqi male patients who have type 2 diabetes, to provide localized insights into the hematological and biochemical changes of this disease. Diabetes is a heterogeneous condition, with chronic hyperglycemia resulting from either impaired insulin production, insulin resistance, or both. Type 2 diabetes, formerly known as non-insulin-dependent diabetes mellitus (NIDDM), affects more than 537 million adults worldwide and is projected to reach 783 million by 2045, with the greatest increase anticipated in low- and middle-income countries [1]. In Iraq, the steady rise in type 2 diabetes is attributed to urbanization, sedentary lifestyle, changing dietary patterns, and genetic predisposition [2]. It is worth noting that diabetes is not simply a disorder of glucose metabolism; it also has far-reaching effects on the hematological and biochemical systems. Changes in hemoglobin (Hb), white blood cell count (total and differential), and erythrocyte sedimentation

rate (ESR) indicate a persistent inflammatory process in diabetic patients. Research has increasingly highlighted the role of immune dysfunction and chronic low-grade inflammation in the development of insulin resistance and related vascular problems [6], [7].

Concerning dyslipidemia, biochemical abnormalities, characterized by elevated total cholesterol, low-density lipoprotein cholesterol, and triglycerides, along with low high-density lipoprotein cholesterol, have been identified as a major contributor to cardiovascular disease in diabetic patients [5].

Although extensive international efforts have been made, few studies have comprehensively examined these biochemical abnormalities and physiological aspects in Iraqi diabetic patients. Given the country's unique dietary habits, genetic background, and healthcare infrastructure, such population-specific research is essential to improve clinical management.

Several studies have included the Iraqi population suffering from diabetes in general and type 2 diabetes in particular, such as [8]-[15].

This study aimed to evaluate a set of hematological (hemoglobin, erythrocyte sedimentation rate, total and differential white blood cell count) and biochemical (serum glucose, cholesterol) parameters in heterosexual male diabetic patients in Najaf, Iraq, and compare them with a healthy control group. The results are expected to provide new insights into the pathophysiological impact of diabetes in the Iraqi population and support more evidence-based monitoring strategies.

2 MATERIALS AND METHODS

According to the ADA Standards of Medical Care in Diabetes, diagnosis is confirmed [12]. This cross-sectional study was conducted at Al-Sadr Teaching Hospital, Najaf, Iraq, from January to March. The study included 80 male participants, including 40 patients clinically diagnosed with non-insulin-dependent diabetes mellitus (NIDDM) (aged 38–70 years, according to American Diabetes Association criteria), and 40 age-matched healthy males. Participants with type 1 diabetes, chronic infections, hematological disorders, renal failure, or malignancies were excluded from the study. The proposed method shows in Figure 1 and it includes six steps.

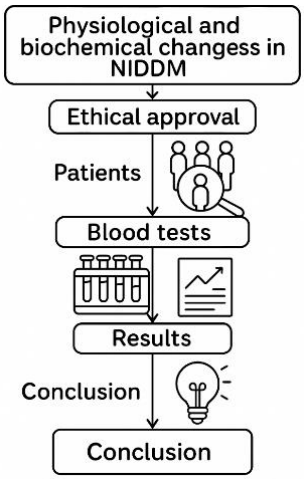

Figure 1: Flowchart of proposed method.

2.1 Study Population

Conducted at a public hospital in Najaf, Iraq (Jan–Mar 2025). 80 male patients, ages 38–70, clinically diagnosed with NIDDM. Exclusion criteria: Insulin-dependent diabetes, chronic infections, hematological disorders, or recent major illness.

2.2 Ethical Considerations

The study was approved by the hospital's Ethics Committee and Scientific Ethics Committee at the university of Kufa.

2.3 Sample Collection

Each participant provided 5 ml of venous blood after an overnight fast (10–12 hours). Blood samples were divided into two parts: EDTA tubes were used for blood tests, and regular tubes were centrifuged at 3,000 rpm for 10 minutes to extract serum for biochemical tests.

2.4 Physiological Parameters

Hemoglobin (Hb) was measured using the cyanomethemoglobin method. Erythrocyte sedimentation rate (ESR) was determined using the Westergren method. Total and differential white blood cell (WBC) counts were assessed using an automated hematology analyzer (Sysmex KX-21, Japan) and confirmed by microscopic examination of Giemsa-stained smears.

2.5 Biochemical Parameters

Serum glucose was assessed using the glucose oxidase-peroxidase enzymatic method. Serum total cholesterol was measured using an enzyme-linked colorimetric assay using the CHOD-PAP method.

2.6 Statistical Analysis

Data were expressed as mean ± standard deviation (SD). The normality of the data set was verified using the Shapiro-Wilk test. The Student's t-test was used to compare means between patients and controls. All statistical analyses were performed using SPSS version 26.0 (IBM Corporation, USA), with a p-value < 0.05 considered statistically significant.

3 RESULTS AND DISCUSSION

As mentioned previously, this study was conducted in the Najaf city- Iraq. This study found that male patients with non-insulin-dependent diabetes mellitus (NIDDM) in Al-Sadr Teaching Hospital, Najaf, Iraq, exhibited significant hematological and biochemical changes compared to healthy controls. Specifically, their total white blood cell (WBC) count and erythrocyte sedimentation rate (ESR) were significantly elevated, highlighting a state of chronic low-grade inflammation, a well-documented factor contributing to diabetes-related complications. These findings are consistent with the broader understanding that oxidative stress resulting from hyperglycemia promotes immune dysregulation.

Interestingly, hemoglobin levels remained statistically stable between patients and controls, suggesting that diabetes-related anemia was not common in this group, despite its reported prevalence in other diabetic populations. This stability may reflect early disease progression or the presence of adequate compensatory mechanisms in red blood cell production.

Differential white blood cell analysis revealed a marked increase in neutrophils and a decrease in lymphocytes, suggesting a shift toward innate immune activation and a weakened adaptive immune response. This imbalance between neutrophils and lymphocytes not only reflects underlying inflammation but may also represent a simple and cost-effective diagnostic indicator for assessing diabetes progression and associated risks.

At the biochemical level, serum glucose and total cholesterol levels were significantly higher in the patient group. These abnormalities reflect poor glycemic control and diabetic dyslipidemia, both of which significantly increase the risk of cardiovascular disease. The combination of hyperglycemia and hyperlipidemia underscores the systemic nature of type 2 diabetes and the need for integrated metabolic monitoring.

These findings are consistent with international research but provide novel and local insights into the Iraqi population, where lifestyle factors - such as high carbohydrate intake and physical inactivity - may exacerbate the effects of metabolic diseases.

Table 1: Physiological blood parameters in NIDDM patients and controls.

Parameter	Patients (Mean ± SE)	Controls (Mean ± SE)	p-value
Total WBC (×10^9/L)	8.769 ± 0.124	5.691 ± 0.137	<0.01 ↑
Hemoglobin (g/dL)	14.24 ± 0.317	14.36 ± 0.251	NS
ESR (mm/hr)	19.39 ± 0.32	3.97 ± 0.11	<0.01 ↑

Table 1 shows Physiological blood parameters in NIDDM patients and controls. The significant increase in total white blood cell (WBC) counts in diabetic patients compared to the control group highlights the role of systemic inflammation in non-insulin-dependent diabetes mellitus (NIDDM). Elevated WBC levels are often associated with chronic hyperglycemia and are thought to reflect persistent oxidative stress and the release of pro-inflammatory cytokines. The concomitant elevation in erythrocyte sedimentation rate (ESR) supports a pro-inflammatory state, which may increase the risk of diabetes-related complications [16], [17].

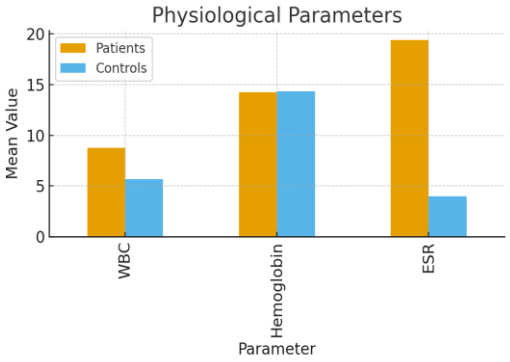

Figure 2: Physiological blood parameters.

Figure 2 illustrates physiological blood parameters. It is important to note that hemoglobin levels remained stable between patients and the

control group. This suggests that anemia associated with chronic disease was not a common feature in this group, despite its reported occurrence in other categories of diabetic patients.

Taken together, these findings underscore the importance of monitoring inflammatory markers, as they may represent early indicators of complications and help guide proactive management of diabetic patients.

Table 2: Differential WBC counts in NIDDM patients and controls.

Subtype (%)	Patients (Mean ± SE)	Controls (Mean ± SE)	p-value
Neutrophils	69.31 ± 0.51	65.23 ± 0.56	<0.05 ↑
Lymphocytes	28.22 ± 2.1	32.27 ± 3.2	<0.05 ↓
Monocytes	1.30 ± 0.71	1.77 ± 0.29	NS
Eosinophils	0.80 ± 0.31	0.50 ± 0.44	NS
Basophils	0.37 ± 0.56	0.23 ± 0.66	NS

Table 2 suggests differential white blood cell (WBC) counts in NIDDM patients and controls. Differential analysis of WBCs revealed a significantly increased neutrophil count in patients, suggesting innate immune activation [15], [18]. Lymphocyte ratios were significantly decreased, reflecting impaired adaptive immunity and susceptibility to infection. Monocytes, eosinophils, and basophils did not differ significantly. This suggests that the inflammatory imbalance in NIDDM is primarily caused by neutrophil-lymphocyte shifts. The neutrophil-lymphocyte ratio may serve as a simple diagnostic indicator in diabetes.

Table 3: Biochemical parameters in NIDDM patients and controls.

Parameter	Patients (Mean ± SE)	Controls (Mean ± SE)	p-value
Serum Glucose (mg/dL)	192.79 ± 3.29	148.32 ± 3.01	<0.001 ↑
Total Cholesterol (mg/dL)	192.79 ± 3.29	148.32 ± 3.01	<0.01 ↑

Table 3 suggests biochemical parameters in patients with non-type 2 diabetes mellitus (NIDDM) and controls. Differential analysis of white blood cells revealed a significantly increased neutrophil count in patients compared to controls. This increase in neutrophils is consistent with the inflammatory state of diabetes and may indicate activation of innate immune responses. In contrast, lymphocyte ratios were significantly decreased, reflecting impaired adaptive immunity and susceptibility to infection. No significant differences were found in monocytes, eosinophils, or basophils. This suggests that the inflammatory imbalance in NIDDM is primarily driven by neutrophil-to-lymphocyte conversion. The neutrophil-to-lymphocyte ratio (NLR), derived from these values, could constitute a diagnostic index of inflammation in diabetes.

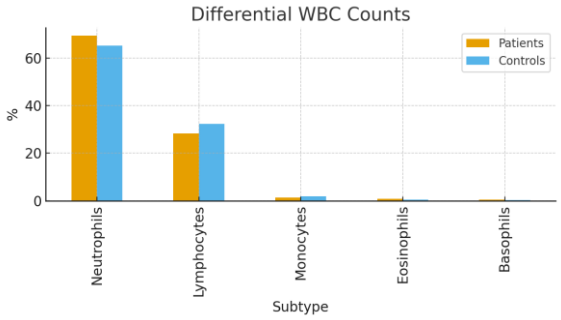

Figure 3: Differential WBC counts.

Figure 3 shows the differential white blood cell count. Serum glucose concentrations were significantly elevated in patients, consistent with the American Diabetes Association (ADA) diagnostic criteria and known diabetic dyslipidemia pathways [5], [9], [19], as well as poor glycemic control and non-type 2 diabetes mellitus (NIDDM) diagnostic criteria. Chronic hyperglycemia promotes oxidative stress, endothelial dysfunction, and protein aggregation, which contribute to many diabetic complications. Total cholesterol levels were also significantly elevated in patients, indicating diabetic dyslipidemia and an increased risk of cardiovascular disease. The coexistence of hyperglycemia and hypercholesterolemia underscores the importance of integrated metabolic monitoring in diabetes management. Uncontrolled glucose levels exacerbate lipid abnormalities and accelerate atherosclerosis. These findings are consistent with reports from other populations but provide new data or Iraqi patients.

Figure 4 shows hematological parameters. This study identified significant hematological and biochemical changes in Iraqi males with non-insulin-dependent diabetes mellitus (NIDDM). Elevated serum glucose and cholesterol were expected findings, consistent with diabetic dyslipidemia and poor glycemic control [15].

Physiological markers showed decreased hemoglobin levels, which may indicate anemia of chronic disease or erythrocyte changes associated with glycosylation. Elevated erythrocyte sedimentation rate and leukocytosis suggest chronic

low-grade inflammation, a hallmark of diabetes-induced immune dysfunction [16], [17].

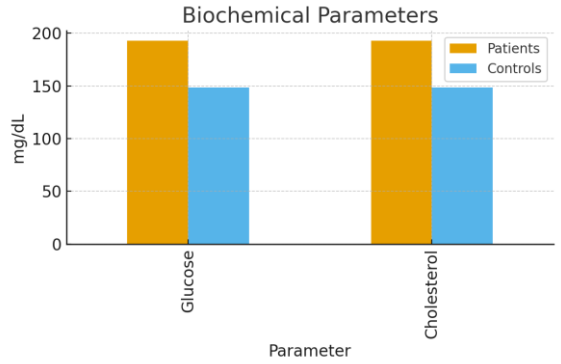

Figure 4: Blood parameters.

These findings are consistent with international findings [1], [4], but provide new insights specific to Iraq, where genetic and lifestyle factors (such as a high-carbohydrate diet and physical inactivity) may exacerbate metabolic complications [2].

Limitations: Small sample size (80 patients), study of only a male cohort, and lack of a control group (comparisons were made using reference values). Future studies should include larger cohorts, female participants, and advanced biomarkers such as glycated hemoglobin (HbA1c), lipids, C-reactive protein, and interleukins.

Finally, patients with non-insulin-dependent diabetes mellitus (NIDDM) often develop minor and major complications because of prolonged hyperglycemia and metabolic imbalance. The most common of these complications is damage to small and large blood vessels, while chronic hyperglycemia can damage peripheral nerves, leading to loss of sensation, pain, and tingling, particularly in the feet and hands. Progressive kidney damage resulting from glomerular thrombosis leads to proteinuria, hypertension, and ultimately to chronic kidney disease [19]-[22].

4 CONCLUSIONS

As a conclusion, this study was conducted at Al-Sadr Teaching Hospital, Najaf, Iraq, from January to March 2025. The study included 80 male participants, including 40 patients clinically diagnosed with non-insulin-dependent diabetes mellitus (NIDDM) (aged 38–70 years, according to American Diabetes Association criteria). Patients with non-type 2 diabetes in Al-Sadr Teaching Hospital, Najaf, Iraq, show there are marked changes in biochemical and hematological parameters, such as widespread metabolic and inflammatory disturbances. Also, white blood cell (WBC) levels, cholesterol, glucose, and erythrocyte sedimentation rate (ESR), along with alterations in immune cell patterns. One of the important points suggested by this study is that the key features of non-type 2 diabetes are systemic inflammation and immune dysfunction. Another important finding that can be summarized here is that the hemoglobin levels remained steady; the presence of neutropenia and lymphopenia reflects a weakened immune response, potentially increasing susceptibility to infections and complications. These results show the importance of routine observation of metabolic parameters and inflammation, especially in resource-limited healthcare settings, to guide early intervention and reduce complication rates. Finally, future work, this research can be extended by including larger and more diverse cohorts, including female participants, and examining additional parameters such as C-reactive protein, glycated hemoglobin (HbA1c), lipid subfractions, and interleukins to improve risk stratification and patient care strategies. Also, for the near future work, the findings of this work can be compared with different countries using the same disease and parameters for fair comparison.

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