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Original article

Tracking the Burden of Type 2 Diabetes Mellitus Among Libyan Patients in Three Populated Districts of Tripoli, Libya

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Abstract
The rising global incidence of Type 2 Diabetes Mellitus (T2DM) is a major contributor to increased morbidity and mortality. Research consistently links type 2 diabetes mellitus (T2DM) with various hematological and lipid abnormalities. However, studies in Libya that examine the relationship between these factors in T2DM patients and correlate them with geographical distribution are scarce. This study aims to evaluate the variations in hematological and lipid profiles among Libyan individuals with type 2 diabetes mellitus (T2DM) and to investigate potential correlations between these parameters. Additionally, it seeks to conduct T2DM surveillance in densely populated regions. A cross-sectional study was conducted at laboratories located in three different districts of Tripoli: Ghout Al Shaal Specialized Hospital, Abu Salim Hospital, and Al Sarai Laboratory in Hay Al Andalus. A total of 261 Libyan participants were divided into 170 patients with type 2 diabetes and 91 non-diabetic (controls), aged 50-85 years. Anthropometric data (weight, height, and body mass index (BMI)) were measured using standard protocols. Complete blood count (CBC) and lipid profile analysis were measured using the Sysmex XP-300 automated hematology analyzer and the Roche Cobas Integra 400 Plus system, respectively. Data were analyzed statistically using GraphPad Prism and SPSS version 27. A p-value of <0.05 was considered statistically significant. -value of <0.05 was considered statistically significant. T2DM subjects exhibited a higher body mass index (BMI) across study groups, genders, and districts (p<0.001) and demonstrated a statistically significant increase in red blood cell (RBC) counts (p=0.018) when compared to controls. Gender analysis indicated that diabetic women had a slightly higher RBC count (p=0.02), while men showed elevated neutrophil percentages (p=0.046). District-specific analyses revealed distinct trends. In Abu Salim, both hemoglobin (Hb) concentrations and RBC counts were high (p=0.036 and p=0.012, respectively). In Hay Al Andalus, mean cell volume (MCV) was significantly lower, and white blood cell (WBC) counts were higher (p=0.031 and p=0.022, respectively). In Ghout Al Shaal, significantly higher neutrophil percentages (p<0.001) and lower lymphocyte percentages (p=0.005) were found among diabetics. Additionally, the diabetic group exhibited substantially high levels of HbA1c, fasting blood sugar (FBS), and triglycerides (TG) (p<0.001). While diabetic women aligned with these trends, the male subgroup displayed similar glycaemic levels but exhibited less pronounced lipid differences. Notably, lipid variances were only observed in Hay Al Andalus; diabetic participants had lower high-density lipoprotein cholesterol (HDL-C) and higher TG (p=0.02 and p=0.001, respectively). T2DM Libyan patients suffer from increased adiposity and poor glycemic control. Distinct lipid abnormalities were also observed among patients, but these are commonly seen in women. Patients in the Hay Al Andalus region had the most devastating dyslipidaemia compared to other districts. Moreover, the observed variations in blood indices may be attributed to chronic inflammation, disease severity, and potential hypoxia, influenced by gender and geographic factors. Our findings may offer valuable guidance for prevention and clinical management strategies for T2DM patients in Tripoli.

Keywords: *Lipid Profile, Haematological Parameters, Type 2 Diabetes Mellitus, Dyslipidemia, Districts*

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Introduction

Diabetes mellitus (DM) is a chronic metabolic disorder characterised by improper regulation of blood glucose levels, resulting in persistently high blood sugar due to deficient insulin production or a lack of insulin response [1]. Previously, the international diabetes federation (IDF) announced that diabetes mellitus impacts over 415 million people with a prevalence rate of 9% in adults around the globe, and about 90% of total diabetes cases are type 2 diabetes [2]. Nowadays, IDF reports that 589 million adults (20-79 years) are living with diabetes, and this number is expected to increase to 853 million by 2050 [3]. Unfortunately, a previous publication conducted by A. Eltobgi (2009) has examined around 4000 Libyan cases and found that around 73% of these individuals were encountering type II diabetes, suggesting that Libya has the highest prevalence of type II diabetes in North Africa and in the Arab world as well [4]. IDF supports this notion, as postulated in 2024, that the prevalence of type II diabetic mellitus (T2DM) among

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Libyan adults only is approaching 16% of the total adult population [5]. The prevalence of type 2 diabetes among Libyan adults is estimated to range between 15% and 20%, with a rising trend observed over the past two decades [6]. In this study, we focused on T2DM as it is believed to be one of the main causes of major health expenditure here in Libya.

There are three main types of diabetes mellitus: type 1 diabetes mellitus (T1DM), T2DM and gestational diabetes mellitus (GDM). T1DM is a condition in which the immune system destroys insulin-making cells in the pancreas [7]. In contrast, T2DM begins when the cells become unable to utilise the amount of insulin produced by the pancreas, resulting in hyperglycemia. GDM is happening during pregnancy in women, and can end after birth or develop into type II [8]. Particularly, T2DM is not only associated with impaired glucose metabolism but also with significant lipid abnormalities (impaired lipid metabolism (dyslipidemia)) [9]. Diabetic dyslipidemia patients are typically characterized by elevated triglycerides (TG), small dense atherogenic low-density lipoprotein cholesterol (LDL-C), and reduced high-density lipoprotein cholesterol (HDL-C) [10]. Such alterations contribute significantly to the development of macro-vascular and micro-vascular complications leading to cardiovascular diseases (CVD), which are the leading cause of morbidity and mortality in diabetic patients [11]. Early detection and monitoring of these parameters play an important role in managing the disease and preventing its progression [12].

In addition to the lipid abnormalities, patients with T2DM also show a significant perturbation in various haematological parameters and coagulation factors [13-15]. Altered levels of red blood cells (RBCs), white blood cells (WBCs), and platelets (PLTs) are mostly common [16]. Several epidemiological studies have indicated a linkage between the WBC count and components of metabolic syndrome, such as obesity, high blood pressure, high TG levels, and LDL-C [16-18]. These abnormalities have been shown to markedly increase blood viscosity, triggering microangiopathy [19]. It was assumed that T2DM patients with a higher WBC count (one of the main components of the inflammatory process) are more prone to develop atherosclerotic progression and CVD [20]. Haematological indices are therefore crucial indicators in the evaluation of variations in size, number, and maturity of different blood cells, and for the assessment and management of patients with T2DM [16, 21].

According to the study conducted by Abual Hasan et al. 2022, high levels of glucose in the bloodstream were significantly associated with dyslipidemia [22]. More recently, dyslipidemia was shown to be closely associated with poorer glycemic control, greater obesity level, CVD, and chronic kidney disease [23]. Perhaps, numerous studies have provided strong evidence for the implication of abnormal lipid profiles in the development of CVD in patients with T2DM [23-25]. This makes lipid profile assessment crucial for the diagnosis of chronic diseases such as CVD and DM. Essentially, the relationship between dyslipidemia and vascular complications in T2DM has long been of interest because both tend to come with greater frequency in DM than in the general population, taking into account the obesity factor [26]. In fact, when a comparison was made between overweight subjects and their respective thinner counterparts, the probability of having a high total cholesterol (TC), LDL-C, TG, and blood pressure was 2.4 to 7.1 times higher, indicating that obesity is solely related to insulin resistance syndrome and a leading cause of CVD [27].

Although several comprehensive studies have described a relationship between T2DM and either haematological indices or lipid profiles worldwide, very few studies have been established so far in Libya to examine these profiles together in diabetic patients. In Libya, the current burden of T2DM and linking it with heavily populated conurbations is still obscure. Exploring these associations and combining them with geographical distribution may offer valuable insights into the disease burden and guide the development of evidence-based clinical strategies tailored to the local population. The aim of this study is therefore to evaluate haematological and lipid profiles in Libyan patients with T2DM and unravel a possible correlation between these parameters. A second aim would be to conduct T2DM surveillance in densely populated districts, thus identifying high-risk groups, thereby carrying out focused interventions, like lifestyle modification programs.

Methods

Study subject and classification

This cross-sectional study included a total of 261 participants aged 50-85 years recruited from three different districts named Hay Al-Andalus, Abu Salim, and Ghout Al-Shaal, which belong to Tripoli city, Libya. The study period was from June 2025 to September 2025. The samples were randomly collected from three different biochemistry laboratories scattered at the above-mentioned places.

The study subjects were divided into two groups: the first group was T2DM patients (n=170), and the second group was healthy individuals (n=91). The inclusion criteria for diabetes include confirmed T2DM subjects who used oral hypoglycemic drugs and had no acute illness in the past six months. Only samples from Libyan subjects with

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confirmed district residential were included. T2DM subjects on lipid-lowering therapy and had CVD and hypertension, or were suffering from renal and liver diseases, were excluded. Non-diabetic controls consisted of apparently healthy adults with no history of diabetes or hypertension and free from serious illness in the past six months.

Sample Collection, blood tests, and measurements

The study commenced with the collection of basic information from all participants. Body weight was measured using a digital scale, and height was measured using a stadiometer, after which body mass index (BMI) was calculated for each participant to assess their baseline physical status. Following confirmation of participants, understanding, and obtaining informed consent, venous blood samples (5-7ml) were collected under aseptic conditions after a minimum fasting period of 8 hours to ensure the accuracy of biochemical tests. Blood samples were divided into two types of tubes: EDTA tubes for complete blood count (CBC) analysis, and Plain tubes for biochemical assays. Hematological parameters were measured using the Sysmex XP-300 automated hematology analyzer, including: hemoglobin (Hb), red blood cell indices, WBCs, and PLTs. Biochemical tests, including fasting blood sugar (FBS), lipid profile, TC, TG, LDL-C, HDL-C, and HbA1c, were analyzed using the Roche Cobas Integra 400 Plus system to ensure accuracy and reliability of measurements. All samples were processed within two hours of collection to maintain data integrity, reliability, and accuracy.

For the serum lipid reference level, the National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) guideline was referred to. According to the NCEP-ATPIII guideline, hypercholesterolemia is defined as TC >200 mg/dl, high LDL-C when value >100 mg/dl, hypertriglyceridemia as TG >150 mg/dl, and low HDL when value <40 mg/dl. Dyslipidemia was defined by the presence of one or more abnormal serum lipid concentrations. Diabetes was defined as ≥ 6.5% for HbA1c and ≥ 126 mg/dl for FBS according to American Diabetes Association (ADA) criteria.

Data analysis

Statistical analysis was performed using GraphPad Prism and SPSS version 27. Descriptive statistics were applied to summarize the data, with categorical variables presented as percentages and continuous variables summarized as mean ± standard deviation (SD). Pearson correlation was used to examine associations between variables, such as age and LDL, while an independent t-test was applied to compare means of continuous variables (FBS, HBA1C, TG, and TC) between two independent groups, assuming normal distribution of the data. Variability is expressed as mean ± SD, and a p-value < 0.05 was considered statistically significant.

Results

This study was conducted across three areas in Tripoli: Abu Salim, Hay Al-Andalus, and Ghout Al Shaal. Among the 261 enrolled subjects, 91 samples (34.9%) were normal healthy individuals (controls) and 170 cases (65.1%) were patients with T2DM (Fig. 1). A percentage of 60.5% were females, while 39.5% were males (Fig. 2). Baseline assessments included demographic (age, BMI), hematological, and lipid/glycemic profiles. In fact, the gender distribution differed between study sites. Abu Salim contributed 80 (30.7%) participants (50 diabetic, 30 controls), Hay Al Andalus contributed 91 (34.9%) participants (60 diabetic, 31 controls) and Ghout Al Shaal contributed 90 (34.5%) participants (60 diabetic, 30 controls) (Fig. 3). The balanced representation across gender and districts enhances the quality of the findings.

Table 1 depicts the age and BMI characteristics within the study population. Age distributions were similar between groups. The mean age of the diabetic cohort was 62.28 ± 10.94 years, compared with 60.41 ± 12.16 years in the control group ($p = 0.207$), which was statistically insignificant (Table 1). By contrast, BMI exhibited a significant difference. Individuals with diabetes had a higher mean BMI (29.37 ± 4.17 kg/m²) than controls (25.73 ± 2.74 kg/m²; $p < 0.001$) (Table 1). This pattern had clearly persisted across gender and across all three districts. For example, diabetic women had a mean BMI of 29.81 ± 4.32 kg/m² compared with 25.53 ± 3.22 kg/m² in nondiabetic women, and diabetic men had a mean BMI of 28.72 ± 3.88 kg/m² compared with 26.04 ± 1.71 kg/m² in nondiabetic men (Table 2). At the district level, diabetic subjects from Abu Salim, Hay Al-Andalus, and Ghout Al Shaal showed statistically higher BMI compared to non-diabetic controls (Table 3).

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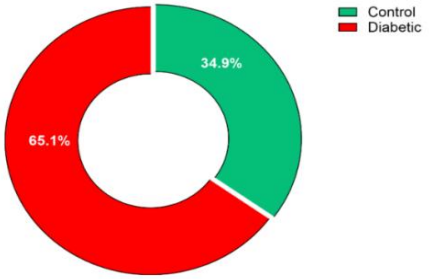

Figure 1. Distribution of study

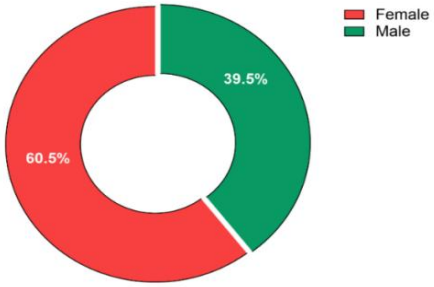

Figure 2. Gender distribution

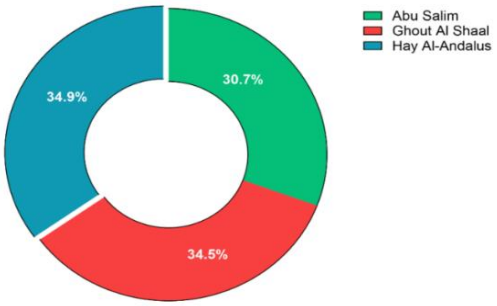

Figure 3. Participant distribution by study area

Table 1. Comparison of age and BMI in control and diabetic groups.

Parameters	Non-Diabetic (n=91)	Diabetic (n=170)	t-test (p-value)
Age (years)	60.41 ± 12.16	62.28 ± 10.94	0.207
Body mass index (kg/m ²)	25.73 ± 2.74	29.37 ± 4.17	**0.001***

** Significantly different compared to the non-diabetic control p-<0.05*

Table 2. Comparison of age and BMI in control and diabetic groups, stratified by gender

Parameter	*Male*		*Female*	
	Non-Diabetic (n=35)	Diabetic (n=68)	Non-Diabetic (n=56)	Diabetic (n=102)
Age (years)	59.37 ± 12.90	61.68 ± 11.34	61.05 ± 11.74	62.68 ± 10.69
BMI (kg/m²)	26.04 ± 1.71	28.72 ± 3.88	25.53 ± 3.22	29.81 ± 4.32

Table 3. Comparison of Age and BMI between Diabetic and Control Groups across Three Study Locations in Tripoli

Location	Parameter	Non-Diabetic Group (n)	Diabetic Group (n)	p-value
Abu Salim	Age (years)	58.63 ± 13.83 (30)	57.80 ± 10.43 (50)	0.761
	BMI (kg/m ²)	24.76 ± 2.81 (30)	30.14 ± 3.65 (50)	**0.001***
Hay Al-Andalus	Age (years)	63.68 ± 9.80 (31)	67.43 ± 9.80 (60)	0.087
	BMI (kg/m ²)	24.81 ± 2.51 (31)	27.24 ± 3.06 (60)	**0.001***
Ghout Al Shaal	Age (years)	58.80 ± 12.28 (30)	60.85 ± 10.49 (60)	0.412
	BMI (kg/m ²)	27.64 ± 1.78 (30)	30.87 ± 4.70 (60)	**0.001***

** Significantly different compared to the non-diabetic control p-<0.05*

To evaluate the disease progression and monitor any abnormalities in haematological indices that are attributed to diabetes mellitus, we first compared the haematological variables in both sampled study groups (diabetic and control groups). Red blood cell (RBC) count showed a modest but statistically significant increase in the diabetic group ($4.64 \pm 0.53 \times 10^{12}$/L) compared with controls ($4.47 \pm 0.56 \times 10^{12}$/L; $p = 0.018$). Despite Hb and haematocrit (HCT) values being found slightly higher in the diabetic group, they did not reach conventional statistical significance. No significant differences were observed in the mean values of the remaining haematological indices between the study groups (Table 4).

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To compare these values more precisely, sex specific analyses revealed subtle haematological differences. Among women, RBC counts were slightly higher in diabetics (4.47 ± 0.49 × 10^{12}/L) than in controls (4.31 ± 0.35 × 10^{12}/L; p = 0.020), while other indices showed no significant variation. Among men, neutrophil percentages were higher in diabetic participants (59.88 ± 10.18 % vs 55.54 ± 10.62 %; p = 0.046) (Table 5).

Table 4. Hematological Profile of the Study Population

Parameter	Non-diabetic (n=91)	Diabetic (n=170)	t-test (p-value)
RBC (x10^{12}/L)	4.47 ± 0.56	4.64 ± 0.53	**0.018***
Hemoglobin (g/dL)	13.01 ± 1.59	13.29 ± 1.63	0.181
Hematocrit / PCV (%)	39.08 ± 4.78	40.15 ± 4.46	0.073
Mean Cell Hemoglobin (pg)	29.13 ± 2.08	29.13 ± 5.42	0.998
Mean Cell Volume (fL)	87.54 ± 5.79	86.23 ± 8.12	0.173
Mean Cell Hemoglobin Concentration (g/dL)	34.00 ± 6.90	32.99 ± 1.37	0.064
White Blood Cell Count (x10^{9}/L)	7.04 ± 2.50	7.63 ± 2.48	0.071
Neutrophil (%)	55.48 ± 10.88	56.74 ± 10.76	0.367
Lymphocytes (%)	34.03 ± 8.85	32.62 ± 9.00	0.228
Platelets (x10^{9}/L)	235.57 ± 79.94	245.11 ± 78.04	0.352

** Significantly different compared to the non-diabetic control p-<0.05*

Table 5. Gender variations of hematological indices between the Control and Diabetic Groups

Hematological Parameters	Female			Male		
	Non-diabetic (n=56)	**Diabetic (n=102)**	**p-value**	**Non-diabetic (n=35)**	**Diabetic (n=68)**	**p-value**
NEUT (%)	55.43 ± 11.13	54.65 ± 10.67	0.666	55.54 ± 10.62	59.88 ± 10.18	**0.046***
LYM (%)	45.80 ± 62.97	34.43 ± 9.40	0.184	44.31 ± 62.84	29.67 ± 8.29	0.179
Platelets (10^{9}/L)	248.30 ± 83.55	258.73 ± 84.66	0.458	206.83 ± 74.03	224.69 ± 62.06	0.198
MCHC (g/dL)	34.27 ± 8.77	32.76 ± 1.32	0.204	33.58 ± 1.15	33.34 ± 1.39	0.377
MCH (pg)	33.21 ± 32.55	31.88 ± 28.99	0.792	29.61 ± 2.19	33.24 ± 33.30	0.523
Hct (%)	38.63 ± 8.31	38.95 ± 5.95	0.779	41.34 ± 5.57	48.00 ± 44.42	0.380
MCV (fL)	87.17 ± 5.87	85.15 ± 9.17	0.139	88.13 ± 5.69	87.84 ± 5.93	0.814
HB (g/dL)	12.47 ± 1.20	12.65 ± 1.30	0.384	13.87 ± 1.77	14.24 ± 1.63	0.283
RBC (10^{12}/L)	4.31 ± 0.35	4.47 ± 0.49	**0.020***	4.71 ± 0.73	4.88 ± 0.51	0.182
WBC (10^{9}/L)	6.95 ± 2.37	7.31 ± 2.12	0.323	7.18 ± 2.72	8.09 ± 2.89	0.126

** Significantly different compared to the non-diabetic control p-<0.05*

On the other hand, to assess glycemic levels among diabetic patients and further explore the effect of T2DM on lipid profile, we next sought to compare the average of blood sugar and glycated Hb variables in both study groups (control and diabetic patients). As expected, glycaemic control was markedly worse among participants with diabetes. HbA1c was 8.40 ± 1.96 %, compared with 5.50 ± 0.37 % in controls (p < 0.001). FBS mirrored this pattern (178.76 ± 69.24 mg/dL vs 104.64 ± 18.93 mg/dL; p < 0.001) (Table 6).

Nevertheless, differences in lipid parameters were less pronounced. LDL-C was slightly higher in the diabetic group (109.25 ± 39.15 mg/dL) than in controls (105.79 ± 37.90 mg/dL; p = 0.492), while HDL-C tended to be lower (46.55 ± 15.00 mg/dL vs 49.69 ± 18.10 mg/dL; p = 0.136), although neither difference was significant. TC was similar between groups. TG were substantially elevated in the diabetic cohort (162.45 ± 125.68 mg/dL vs 121.47 ± 53.35 mg/dL; p < 0.001) (Table 6).

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Table 6. Fasting blood sugar and lipid profile of the study population

Parameter	Non-diabetic (n=91)	Diabetic (n=170)	t-test (p-value)
HbA1C (%)	5.50 ± 0.37	8.40 ± 1.96	**0.001***
LDL (mg/dL)	105.79 ± 37.90	109.25 ± 39.15	0.492
HDL (mg/dL)	49.69 ± 18.10	46.55 ± 15.00	0.136
Total Cholesterol (mg/dL)	168.73 ± 43.38	175.66 ± 46.26	0.240
Triglycerides (mg/dL)	121.47 ± 53.35	162.45 ± 125.68	**0.001***
Fasting Blood Sugar (mg/dL)	104.64 ± 18.93	178.76 ± 69.24	**0.001***

** Significantly different compared to the non-diabetic control p-<0.05*

Gender specific lipid profile analyses showed that diabetic women had significantly higher TG levels (166.28 ± 142.36 mg/dL vs 113.60 ± 54.74 mg/dL; p = 0.009) and higher FBS and HbA1c values. The male subgroup showed similar trends in glycaemic markers but less pronounced lipid differences (Table 7).

To track the escalating trend of T2DM cases among our community, we compared the haematological, glycaemic, and lipid indices separately across three major regions in Tripoli city. Indeed, when haematological parameters were examined by district, distinctive patterns emerged (Table 8). In Abu Salim, diabetic participants exhibited higher Hb concentrations (13.60 ± 1.53 g/dL vs 12.79 ± 1.82 g/dL) and higher RBC counts (4.62 ± 0.52 × 10^{12}/L vs 4.32 ± 0.49 × 10^{12}/L), with p values of 0.036 and 0.012, respectively, suggesting an increase in erythropoietic activity among diabetics in this area. In Hay AlAndalus, mean cell volume (MCV) was modestly lower in the diabetic (87.24 ± 5.83 fL vs 89.92 ± 4.94 fL; p = 0.031), but other indices did not differ significantly.

Table 7. Gender variations of glycemic & lipid profiles between the control and diabetic groups

Glycemic & Lipid Profile	Female			Male		
	Non-diabetic (n=56)	**Diabetic (n=102)**	**p-value**	**Non-diabetic (n=35)**	**Diabetic (n=68)**	**p-value**
LDL (mg/dL)	107.26 ± 37.37	111.24 ± 37.41	0.523	103.45 ± 39.16	106.28 ± 41.74	0.740
HDL (mg/dL)	52.75 ± 19.71	49.62 ± 16.68	0.292	44.79 ± 14.10	41.94 ± 10.62	0.253
TC (mg/dL)	169.00 ± 42.49	180.80 ± 45.81	0.114	168.30 ± 45.40	167.96 ± 46.20	0.971
TG (mg/dL)	113.60 ± 54.74	166.28 ± 142.36	**0.009***	130.63 ± 53.08	156.71 ± 96.10	0.139
FBS (mg/dL)	100.25 ± 13.90	176.74 ± 71.51	**0.001***	111.66 ± 23.53	181.80 ± 66.09	**0.001***
HbA1C (%)	5.46 ± 0.37	8.33 ± 1.78	**0.001***	5.57 ± 0.37	8.50 ± 2.20	**0.001***

** Significantly different compared to the non-diabetic control p-<0.05*

In Ghout Al Shaal, neutrophil percentages were higher (59.60 ± 8.11 % vs 52.31 ± 7.22 %; p < 0.001) and lymphocyte percentages were lower (31.21 ± 8.41 % vs 36.29 ± 6.86 %; p = 0.005) among diabetics (Table 8).

Conversely, glycaemic measures (HbA1c and FBS) were consistently elevated in diabetics across all districts (Table 9). Lipid differences were more selective: in Hay Al-Andalus, diabetic participants had significantly lower HDL cholesterol (44.03 ± 9.25 mg/dL vs 49.55 ± 12.73 mg/dL) and higher TG (191.35 ± 188.69 mg/dL vs 106.19 ± 42.90 mg/dL; p = 0.001). In Abu Salim and Ghout Al Shaal, differences in LDL and TC were small and not consistently significant (Table 9). Finally, Table 10 represents the correlation analyses within the diabetic cohort. Within the diabetic group (n = 170), correlations between haematological indices, glycaemic measures, and lipid parameters were examined to identify potential associations (Table 10). Most correlations were weak. For example, WBC count correlated positively with HbA1c (r = 0.216), suggesting a mild association between systemic inflammation and long-term glycaemic control. Platelet count correlated modestly with HDL (r = 0.204) and TC (r = 0.208). MCV correlated inversely with HDL (r = –0.164) and TG (r = –0.172). Correlations of WBC with LDL (r = 0.065) and of platelet count with TG (r = 0.093) were near zero.

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Table 8. Comparative haematological parameters by location and diabetes status

Parameter	Abu Salim			Hay AlAndalus			Ghout Al Shaal		
	Non-diabetic (n=30)	Diabetic (n=50)	p-value	Non-diabetic (n=31)	Diabetic (n=60)	p-value	Non-diabetic (n=30)	Diabetic (n=60)	p-value
NEUT (%)	55.18 ± 13.95	55.00 ± 12.79	0.954	58.83 ± 9.74	55.34 ± 10.82	0.135	52.31 ± 7.22	59.60 ± 8.11	**0.001***
LYM (%)	67.92 ± 105.89	33.56 ± 10.83	0.087	31.91 ± 9.05	32.97 ± 8.60	0.585	36.29 ± 6.86	31.21 ± 8.41	**0.005***
Platelets (10^9/L)	229.25 ± 90.26	269.04 ± 98.09	0.074	237.61 ± 97.93	230.85 ± 68.14	0.701	230.00 ± 53.17	239.43 ± 63.92	0.488
MCHC (g/dL)	35.66 ± 11.39	33.66 ± 1.33	0.345	33.17 ± 1.23	32.72 ± 1.24	0.103	33.21 ± 3.47	32.70 ± 1.35	0.32
MCH (pg)	37.48 ± 44.35	36.25 ± 39.54	0.898	29.83 ± 2.07	33.30 ± 36.94	0.604	28.23 ± 1.56	28.35 ± 2.48	0.812
Haematocrit / PCV (%)	37.95 ± 4.81	41.08 ± 7.85	0.053	40.27 ± 10.81	45.18 ± 47.72	0.575	40.77 ± 4.90	41.20 ± 4.41	0.672
MCV (fL)	87.14 ± 4.52	84.81 ± 12.17	0.317	89.92 ± 4.94	87.24 ± 5.83	**0.031***	85.47 ± 6.90	86.40 ± 5.41	0.489
Haemoglobin (g/dL)	12.79 ± 1.82	13.60 ± 1.53	**0.036***	12.77 ± 1.47	12.82 ± 1.67	0.901	13.46 ± 1.40	13.50 ± 1.60	0.915
RBC ($x10^{12}$/L)	4.32 ± 0.49	4.62 ± 0.52	**0.012***	4.31 ± 0.48	4.51 ± 0.51	0.076	4.78 ± 0.59	4.78 ± 0.54	0.963
WBC ($x10^9$/L)	7.43 ± 3.11	7.80 ± 2.94	0.588	6.27 ± 1.88	7.25 ± 1.91	**0.022***	7.45 ± 2.25	7.85 ± 2.56	0.466

** Significantly different compared to the non-diabetic control p-<0.05*

Table 9. Comparative glycaemic and lipid profiles by location and diabetes status

Parameter	Abu Salim			Hay AlAndalus			Ghout Al Shaal		
	Non-diabetic (n=30)	Diabetic (n=50)	p-value	Non-diabetic (n=31)	Diabetic (n=60)	p-value	Non-diabetic (n=30)	Diabetic (n=60)	p-value
LDL (mg/dL)	105.36 ± 37.32	112.02 ± 38.04	0.447	113.74 ± 35.19	113.13 ± 37.04	0.94	98.01 ± 40.66	103.07 ± 41.90	0.587
HDL (mg/dL)	55.33 ± 25.71	51.42 ± 19.00	0.438	49.55 ± 12.73	44.03 ± 9.25	**0.02***	44.19 ± 11.15	45.00 ± 15.19	0.795
Total cholesterol (mg/dL)	163.33 ± 44.75	176.02 ± 45.93	0.231	168.13 ± 38.52	175.98 ± 46.25	0.42	174.75 ± 47.29	175.05 ± 47.31	0.978
Triglycerides (mg/dL)	124.76 ± 68.04	157.96 ± 77.98	0.057	106.19 ± 42.90	191.35 ± 188.69	**0.001***	129.97 ± 48.37	137.29 ± 55.50	0.54
Fasting blood sugar (mg/dL)	97.80 ± 12.15	177.28 ± 46.05	**0.001***	103.35 ± 15.45	176.33 ± 75.14	**0.001***	112.80 ± 24.46	182.43 ± 79.39	**0.001***
HbA1C (%)	5.50 ± 0.57	8.65 ± 1.93	**0.001***	5.45 ± 0.27	7.95 ± 1.76	**0.001**	5.55 ± 0.18	8.64 ± 2.11	**0.001***

** Significantly different compared to the non-diabetic control p-<0.05*

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Table 10. Correlation coefficients (r) between haematological, lipid, and glycemic parameters among diabetic subjects

Hematological index (unit)	LDL (mg/dL)	HDL (mg/dL)	TC (mg/dL)	TG (mg/dL)	FBS (mg/dL)	HbA1c (%)
NEUT (%)	−0.087	−0.050	−0.127	−0.110	−0.010	0.139
LYM (%)	0.049	0.015	0.123	0.139	0.053	−0.121
Platelets (×10^9^/L)	0.149	0.204	0.208	0.093	0.018	0.058
MCHC (g/dL)	0.091	−0.063	0.066	0.036	0.084	0.048
MCH (pg)	0.06	−0.066	0.028	0.041	−0.045	−0.098
MCV (fL)	0.007	−0.164	−0.022	−0.172	−0.104	−0.071
Hct (%)	0.11	−0.045	0.078	0.004	−0.055	−0.063
HB (g/dL)	0.12	−0.095	0.117	−0.058	0.042	0.086
RBC (×10^12^/L)	0.045	−0.033	0.06	0.023	0.044	0.049
WBC (×10^9^/L)	0.065	0.068	0.088	−0.003	0.05	0.216

Discussion

This study was conducted to monitor the current haematological parameters and lipid profiles of Libyan individuals with T2DM across three urban districts of Tripoli, to explore the potential association between these values, thereby understanding the prevalence and incidence, as well as controlling mortality. Among study groups, gender, or even across three districts of Tripoli city, excess adiposity tracked tightly with T2DM, which statistically exhibited higher BMI levels compared to controls, while no significant difference was observed in age (Table 1-3). Unfortunately, these findings mirror Libya's rising twin epidemics of obesity and diabetes [28].

To assess the inflammation status and disease progression in T2DM Libyan patients, haematological parameters were analysed. Our results showed a slight but statistically significant increase in RBC count in the diabetic group compared to the control group (p=0.018). Conversely, no significant differences were observed in other indices, such as Hb, HCT, MCV, MCH, MCHC, WBC, and platelet count (Table 4), suggesting no major uniform alteration in these parameters. This is partially aligned with previous studies from Pakistan [29] and Ethiopia [30], but contrary to our findings, reports from India [31], Libya [32], Sudan [33], and Ethiopia.[34]. In fact, when the data were analyzed by gender, additional differences emerged. Among females, RBC count was higher in diabetic patients compared to female controls (p=0.020). In males, neutrophil percentage was significantly higher in diabetics than in male controls (p= 0.046) (Table 5). These patterns may suggest sex specific inflammatory responses in diabetes, in which diabetic male seems to be more prone to encountering chronic inflammation status and developing CVD [35]. High RBC count in a female subject might be due to poor glycemic control and hyperinsulinemia, in which insulin has a role in increasing erythropoiesis [36].

Generally, diabetic patients showed significant impairment in blood sugar regulation, with markedly higher HbA1c (p<0.001) and FBS (p<0.001) compared to controls. These results confirm that both long-term and short-term glycemic control are poorly maintained in diabetic Libyan patients (Table 6). In contrast, lipid profile alterations were less consistent. LDL-C levels were similar between diabetics and non-diabetics (p=0.492), while HDL-C showed a slight, non-significant reduction in diabetics (p=0.136). TC also did not differ significantly. However, TG was significantly higher in diabetics (p<0.001) (Table 6). These results were consistent with a previous observation [37], indicating a possible diabetic dyslipidemia due to insulin resistance, which in turn significantly contributes to the development of CVD [11]. Precisely, gender specific analysis revealed an important scenario between diabetic men and women. Diabetic women exhibited significantly higher TG levels than diabetic men (p=0.009) (Table 7). This potentially puts women at risk of atherogenic dyslipidemia and cardiovascular complications. This result aligns with earlier work by Walden in 1984, who reported that diabetes has a more adverse effect on TG and lipoprotein concentrations in women than in men [38]. The diabetic male showed similar trends in glycaemic markers, but less pronounced lipid differences compared to women (Table 7). These results emphasize the influence of biological sex on metabolic responses in T2DM, consistent with Huxley *et al*., who reported a higher cardiovascular mortality risk in diabetic women than men [39].

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The hematological differences observed in this study were generally modest and appeared to vary according to geographical location. In fact, some district-specific patterns were evident. In Abu Salim, diabetic participants exhibited relatively higher Hb and red blood cell levels. In Hay Al Andalus, there was a slight reduction in MCV and an elevation in WBC, while in Ghout Al Shaal, a significant increase in neutrophil proportion was noted and a significant reduction in lymphocytes (Table 8). These findings indicate that hematological variations among type 2 diabetic patients are heterogeneous and more likely influenced by local environmental and lifestyle exposures rather than representing a consistent or uniform hematological signature of T2DM [40].

The alterations in the lipid profile observed in this study were selective rather than global, meaning that not all lipid fractions were equally affected. Specifically, TG showed a significant elevation, and HDL-C demonstrated a marked reduction in the Hay Al Andalus district in diabetic subjects. In contrast, both LDL-C and TC did not display any significant differences between diabetic patients and the control group (Table 9). Although this agreement with Mooradian 2009, it is worth mentioning here that his study did not examine lipid profile differences across regions [41]. This was not the case in Abu Salim and Ghout Al Shaal districts, in which no differences in lipid profile were observed, suggesting the heterogeneity of dyslipidaemia across neighbourhoods and may reflect environmental, dietary habits, or lifestyle influences.

Indeed, hospital-based cohorts frequently show enrichment for elevated LDL-C. For instance, findings from Tripoli University Hospital indicated that approximately 53% of attending diabetic patients had raised LDL-C levels [28]. In contrast, population-based or door-to-door sampling uncovers a more variable picture, revealing differences between districts. The present study underscores this heterogeneity by identifying the distinct TG↑/HDL↓ lipid signature in Hay Al Andalus. This unique profile may be influenced by localized factors, such as dietary habits, lifestyle patterns, and environmental exposures, which in turn shape lipid metabolism in a manner different from what is typically observed in hospital-attending populations.

When considering the relationship between metabolic and hematological parameters within the diabetic cohort, the associations appeared to be weak. A mild positive correlation was detected between total WBC count and HbA1c ($r \approx 0.22$), which may reflect the presence of low-grade inflammation that frequently accompanies chronic hyperglycemia [39]. Furthermore, MCV demonstrated an inverse correlation with both HDL and TG levels; however, the strength of these correlations was relatively small. These weak associations suggest that, in clinically stable outpatients, hematologic markers rarely serve as strong metabolic surrogates.

Conclusion

In conclusion, the current study emphasizes that type 2 diabetes is strongly associated with increased adiposity, poor glycemic control, and distinct lipid abnormalities. The differences observed in blood indices among individuals with diabetes may be linked to chronic inflammation, disease severity, and even potentially hypoxia, influenced by gender and geographic distribution. Despite the weak correlation between inflammatory markers and lipid alterations, our findings may provide important insights for improving prevention strategies and clinical management of diabetic patients in Tripoli. Further studies with a larger sample size would be required for cautious data interpretation.

Conflict of interest. Nil

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