

# Immune System Cells, Hematological Parameters, and Lifestyle Choices in Diabetics Living in Jeddah, Saudi Arabia

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**Abstract—Purpose:** Type 2 diabetes mellitus (T2DM) is a multifactorial disease influenced by genetic and lifestyle factors, and resulting in chronic hyperglycemia and oxidative stress, which alter cell growth, induce inflammation, and may affect all major blood cell types. No studies have been conducted in Saudi Arabia examining sex-based differences in hematological parameters among individuals with T2DM, regardless of nationality. Therefore, this study aimed to investigate the differences in the hematological and lifestyle characteristics between female and male patients with T2DM residing in Jeddah, Saudi Arabia. **Methods:** A total of 63 patients (30 females and 33 males) with T2DM, aged 39–83 years, were randomly recruited for this cross-sectional study. Subjects signed a consent form and filed a lifestyle questionnaire. Blood samples were collected for the differential complete blood count analysis. **Results:** Most participants were Saudi, overweight or obese, non-smokers, physically inactive, and had a family history of diabetes. Compared to males, females had significantly lower mean red blood cell and monocyte counts, neutrophil-to-lymphocyte ratio, hemoglobin levels, and hematocrit percent, but they had significantly higher mean platelet and lymphocyte counts, lymphocyte-to-monocyte ratio, and red cell distribution width-coefficient of variation percent. No significant differences were observed in other hematological parameters. **Conclusion:** These findings show significant sex-based differences in important hematological parameters, both immunological and non-immunological parameters, between females and males with T2DM. This emphasizes the importance of using sex-specific reference ranges in both clinical practice and research studies and in establishing clinical guidelines and policies.

**Keywords—** Type 2 diabetes mellitus, immune system cells, hematological parameters, differential complete blood count, sex-based differences.

## I. INTRODUCTION

Diabetes mellitus (DM) is not a single disorder, rather it refers to a group of metabolic conditions that lead to high blood sugar that is caused by partial or total insulin deficiency, the body's inability to effectively use insulin that is produced in the body, or a combination of these causes (Egan and Dinneen 2019). The two main types of diabetes are type 1 and type 2 diabetes mellitus (T2DM). According to the Saudi Ministry of Health, Gulf countries are among the highest globally in the prevalence of diabetes. (Ministry of Health 2024). Saudi Arabia is among the top ten countries globally for diabetes prevalence, with an estimated 23.1% of its adult population affected (International Diabetes Federation 2024). The International Diabetes Federation (2025) reported that the global prevalence of diabetes in adults was 589 million in 2024, which is 1 in 9 adults, and it is expected to increase to 853 million by 2050. In addition, type 2 is the much more prevalent type with more than 90% of diabetics being afflicted by it.

T2DM is a multifactorial disease influenced by both genetic predisposition and modifiable lifestyle factors such as diet, physical activity, and smoking. Obesity, often quantified by using body mass index (BMI), is a key contributor to insulin resistance (Zhang et al. 2025). Additionally, in the Saudi population, obesity, physical inactivity, unhealthy dietary habits, and smoking have been specifically identified as major contributors to the rising prevalence of T2DM

(Alneami and Coleman 2015) and higher cardiovascular risk factors (Jatoi et al. 2022).

An important clinical hallmark of both type 1 and type 2 diabetes is elevated blood glucose levels. This leads to negative effects on metabolism of fats, carbohydrates, and proteins. Subsequently, this leads to damage of nerves, blood vessels, kidney, heart, and eyes. In addition, diabetes may lead to increased risk for diseases and conditions, such as cardiovascular diseases and dementia, and increased mortality rates (Institute for Health Metrics and Evaluation. 2024). Additionally, chronic hyperglycemia can disrupt the normal characteristics of blood cells and alter their associated indices (Milosevic and Panin 2019). This disruption is largely due to oxidative stress, which induces glycation of lipids and proteins, inflammation, and changes in cell growth. As a result, various immune and hematological parameters are affected, including the structure, function, and metabolism of red blood cells (RBCs), white blood cells (WBCs), and platelets (Essawi et al. 2023). These changes are often accompanied by changes in lymphocyte and monocyte counts, reflecting the underlying chronic inflammatory state associated with T2DM (Allahyani et al. 2023). Evidence from Saudi Arabia supports a link between changes in hematological indices and the progression of type 2 diabetes mellitus (Alodhayani et al. 2022; Essawi et al. 2023; AlShareef et al. 2024;). While many reports indicate a significant decrease in RBC and hemoglobin indices in T2DM patients (Arkew et al. 2021; Bambo et al. 2024; Nawal et al. 2025) other studies have shown notable increases (Mansoori et

al. 2023; Gomez-Garcia et al. 2025), highlighting inconsistencies in the observed hematological changes. Additionally, it has been shown that both low and high counts of WBC are associated with increased risk for T2DM, suggesting an immune imbalance may play a role in disease development (Du et al. 2009; Kheradmand et al. 2021). Additionally, higher neutrophils and lymphocytes counts have been associated with an increased risk of developing T2DM (Zhang et al. 2017). These findings suggest a potential link between hematologic changes and early metabolic disturbances.

Although there are extensive studies on diabetes and its effects on many health-related indices, cells and organs in the body, no studies have been conducted in Saudi Arabia that specifically examine sex-based differences in hematological parameters in individuals with T2DM, regardless of nationality. Therefore, this study aimed to investigate the differences in hematological and lifestyle characteristics between female and male T2DM patients residing in Jeddah, Saudi Arabia.

## II. MATERIALS AND METHODS

### *Subjects*

For this cross-sectional study, a total of 63 subjects (30 females and 33 males) were randomly recruited from individuals visiting the East Jeddah Hospital and its affiliated primary healthcare centers in Jeddah, Saudi Arabia, for any reason during the morning and early afternoon. The subjects were collected over a period extending from September to October 2024. Inclusion criteria included individuals aged 39–85 years who had a confirmed diagnosis of T2DM at least 3 years ago. Exclusion criteria excluded participants who were experiencing any form of active infection during the time of recruitment. All participants signed an informed consent form and completed a lifestyle questionnaire. In addition, blood samples and anthropometric measurements were obtained on the same day of recruitment.

### *Blood samples*

Venous blood samples were collected in the morning hours from all participants after a fasting period of 10–12 hours. Different types of vacutainer tubes were used depending on the assays performed. For the differential complete blood counts (CBC), samples were collected using ethylenediaminetetraacetic acid (EDTA) vacutainer tubes (Second Advance Medical Company, Riyadh, Saudi Arabia). For the lipid profile assessment, blood samples were collected into clot activator vacutainer tubes (Second Advance Medical Company, Riyadh, Saudi Arabia). Subsequently, serum samples were obtained by centrifugation at 5,000 revolutions per minute for 5 minutes. The serum samples were stored at a temperature of 2–8 °C for a maximum of 7 days before analysis.

### *Determination of the differential complete blood counts*

The CBC analysis was conducted using the Alinity hq system instrument (Abbott Laboratories, Abbott Park, Illinois,

USA) using the reagents recommended by the manufacturer (Abbott Laboratories, Abbott Park, Illinois, USA).

### *Statistical analysis*

Statistical analysis for all results was performed using the IBM SPSS statistics program, version 25.0 (IBM Corp., Armonk, NY, USA). The Independent samples t-test was used to assess the significance of the differences between the groups for all the parameters. The mean, standard deviation (SD), and P-values were calculated for all blood parameters and a P-value < 0.05 was considered a statistically significant difference while a  $P \geq 0.05$  was considered a statistically non-significant difference.

## III. RESULTS

### *Subjects and lifestyle questionnaire*

The age range for the participants was from 39–83 years with female age mean  $\pm$  SD was  $58.56 \pm 9.95$  years and for males it was  $59.54 \pm 7.08$  years. As shown in Table 1, the number of female subjects was smaller than the male subjects (30 females and 33 males) and most of the female (76.7%) and male (75.8%) subjects were Saudi versus non-Saudi (23.3% and 24.2%, respectively). A total of 81.4% of participants were classified as either overweight or obese, whereas only 18.6% had a normal BMI with most of them (75%) being males. Moreover, the results indicated that most (60.3%) of the participants had stable blood glucose levels throughout the day. Although, an equal number of females had stable or unstable blood sugar levels, while most males (70%) had stable blood sugar levels. Additionally, most participants were non-smokers (79.4%), with more women than men being non-smokers, and had a family history of diabetes (87.3%). Exactly 61.4% of the participants were affected by additional chronic conditions, including hypertension, thyroid disorders, and rheumatic diseases. Hypertension was more prevalent among male participants (69%) compared to females (31.0%) and it was the most common co-morbidity for both female (64.3% of females with co-morbidity) and male (95.2% of males with co-morbidity) subjects. In contrast, thyroid disorders (4 cases) were predominantly observed among female participants with only one case reported among males, while only females reported being afflicted with hypertension/thyroid disorders and/or rheumatism.

Most participants (61.9%) were physically inactive and an equal number of participants ( $n = 20$ , 31.7%) reported sleeping either 6 hours or less than 4 hours per day. Among females, most of them (43.3%) reported less than 4 hours of sleep, followed closely by 33.3% sleeping 6 hours per day. Among males, most of them (both 30.3%) slept 6 hours or 8 hours per day. Regarding the number of meals consumed per day, most females (46.7%) ate two meals per day while most males (57.6%) reported eating three meals daily. Finally, most females (57.7%) and males (41.7%) visited the hospital or a healthcare center three times per month.

TABLE 1: Lifestyle questionnaire answers for the subjects.

Factor	n	Female Count (%)	Male Count (%)
Saudi	48	23 (76.7%)	25 (75.8%)
Non-Saudi	15	7 (23.3%)	8 (24.2%)
BMI			
Normal	8	2 (7.7%)	6 (20.0%)
Overweight	19	8 (30.8%)	11 (36.7%)
Obese	16	16 (61.5%)	13 (43.3%)
Blood sugar level is stable	38	15 (50.0%)	23 (69.7%)
Blood sugar level is unstable	25	15 (50.0%)	10 (30.3%)
Smoker	13	1 (3.3%)	12 (36.4%)
Non-smoker	50	29 (96.7%)	21 (63.6%)
Diabetes in other family members	55	27 (90.0%)	28 (84.8%)
No diabetes in other family members	8	3 (10.3%)	5 (15.2%)
Other disease			
Yes	35	14 (56.0%)	21 (65.6%)
No	22	11 (37.9%)	11 (34.4%)
Hypertension	29	9 (31.0%)	20 (62.5%)
Thyroid disease	4	3 (10.3%)	1 (3.1%)
Hypertension/Thyroid disorders	4	4 (13.8%)	0 (0%)
Rheumatism	2	2 (6.9%)	0 (0%)
Exercise			
More than once/week	16	6 (20.0%)	10 (30.3%)
Once/week	8	5 (16.7%)	3 (9.1%)
Never	39	19 (63.3%)	20 (60.6%)
Sleeping hours/day			
Less than 4	20	13 (43.3%)	7 (21.2%)
4 hours	4	1 (3.3%)	3 (9.1%)
6 hours	20	10 (33.3%)	10 (30.3%)
8 hours	14	4 (13.3%)	10 (30.3%)
10 hours	5	2 (6.7%)	3 (9.1%)
Number of meals/day			
One	4	1 (3.3%)	3 (9.1%)
Two	24	14 (46.7%)	10 (30.3%)
Three	29	10 (33.3%)	19 (57.6%)
Four	5	5 (16.7%)	0 (0%)
More than four	1	0 (0%)	1 (3.0%)
Frequency of hospital visits/month			
One	1	0 (0%)	1 (4.2%)
Three	25	15 (57.7%)	10 (41.7%)
Six	13	6 (23.1%)	7 (29.2%)
Irregular	10	5 (19.2%)	6 (25%)

n: number of subjects

TABLE 2: Statistical analysis for the differential CBC for the subjects.

Parameter	Sex	n	Min	Max	Mean ± SD	P-value
RBC	Female	26	4.07	5.63	4.79 ± 0.45	0.001*
10 <sup>6</sup> /mL	Male	32	3.80	6.23	5.28 ± 0.61	
WBC	Female	26	3.44	11.90	7.25 ± 1.91	0.913
10 <sup>3</sup> /mL	Male	32	3.70	12.00	7.31 ± 2.00	
Hemoglobin	Female	26	9.02	16.80	12.80 ± 1.40	0.000*
g/dL	Male	32	10.90	18.40	14.97 ± 1.81	
Platelets	Female	26	155	460	310 ± 81	0.021*
10 <sup>3</sup> /mL	Male	32	112	438	261 ± 74	
Lymphocyte	Female	24	1.54	4.15	2.95 ± 0.73	0.041*
10 <sup>3</sup> /mL	Male	31	1.47	4.32	2.50 ± 0.81	
Monocyte	Female	24	0.28	0.78	0.52 ± 0.12	0.016*
10 <sup>3</sup> /mL	Male	31	0.25	1.14	0.65 ± 0.21	
Neutrophil	Female	24	1.27	6.39	3.40 ± 1.09	0.328
10 <sup>3</sup> /mL	Male	31	1.33	7.19	3.73 ± 1.35	
Eosinophil	Female	24	00	0.49	0.02 ± 0.10	0.975
10 <sup>3</sup> /mL	Male	31	00	0.34	0.02 ± 0.09	
Basophil	Female	24	0.01	0.30	0.09 ± 0.07	0.721
10 <sup>3</sup> /mL	Male	31	00	0.74	0.10 ± 0.13	

Independent t-test was used for the test of significance

n: number of subjects, Min: minimum, Max: maximum, SD: standard deviation

\*Statistically significant P-value (P < 0.05)

P ≥ 0.05 is non-significantly different

TABLE 3: Statistical analysis of the hematological markers for the subjects.

Parameter	Sex	n	Min	Max	Mean ± SD	P-value
HCT	Female	26	29.30	50.80	40.37 ± 4.26	0.000*
%	Male	32	35.10	56.10	46.84 ± 5.42	
MCV	Female	26	53.50	98.60	84.68 ± 9.34	0.064
fL	Male	32	74.10	99.70	88.86 ± 5.83	
MCH	Female	26	16.50	33.20	26.93 ± 4.37	0.064
pg	Male	32	23.30	31.60	28.35 ± 2.21	
MPV	Female	26	9.12	12.50	10.38 ± 0.97	0.818
fL	Male	32	8.39	13.70	10.32 ± 1.04	
MCHC	Female	26	29.00	34.00	31.69 ± 1.56	0.488
g/dL	Male	32	29.30	34.90	31.95 ± 1.27	
RDW-CV	Female	26	13.20	19.70	14.83 ± 1.48	0.005*
%	Male	32	12.40	17.80	13.80 ± 1.15	
Reticulocyte	Female	14	62.50	121.00	85.12 ± 18.01	0.360
10 <sup>3</sup> /mL	Male	12	58.30	121.00	91.50 ± 16.56	
NLR	Female	23	0.37	2.16	1.19 ± 0.37	0.008*
	Male	31	0.71	3.25	1.60 ± 0.70	
LMR	Female	24	3.82	8.44	5.72 ± 1.26	0.000*
	Male	31	1.46	9.68	4.10 ± 1.46	
PLR	Female	24	47.71	201.19	109.88 ± 39.24	0.868
	Male	31	52.48	180.95	111.64 ± 38.64	

Independent t-test was used for the test of significance

n: number of subjects, Min: minimum, Max: maximum, SD: standard deviation

\*Statistically significant P-value (P < 0.05)

P ≥ 0.05 is non-significantly different

Hematocrit (HCT), Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), Mean Corpuscular Hemoglobin Concentration (MCHC), Mean Platelets Volume (MPV), Red Cell Distribution Width-Coefficient of Variation (RDW-CV), Neutrophil-to-Lymphocyte Ratio (NLR), Lymphocyte-to-Monocyte Ratio (LMR), Platelets-to-Lymphocyte Ratio (PLR).

#### Determination of the differential complete blood counts

Table 2 shows the mean concentration of hemoglobin and the mean counts of RBCs, WBC and their types, and platelets for both female and male subjects. The mean RBC and monocyte counts and hemoglobin levels were significantly lower for females compared to males. In contrast, mean platelets and lymphocyte counts were significantly higher for the female subjects compared to males. All other cell counts showed no significant differences between male and female subjects.

Table 3 shows the mean levels/percents for the remaining hematological parameters. Female subjects had significantly lower hematocrit percent (HCT%) and neutrophil-to-lymphocyte ratio (NLR), while they had higher red cell distribution width-coefficient of variation percent (RDW-CV%) and lymphocyte-to-monocyte ratio (LMR) compared to male subjects. All remaining parameters did not show significant differences between male and female subjects.

#### IV. DISCUSSION

The present study revealed statistically significant differences in the mean values of several hematological parameters between female and male subjects with T2DM living in Jeddah, Saudi Arabia. In addition, important differences in lifestyle choices were observed. These findings are especially meaningful given the relative scarcity of research studies addressing these sex-based hematological variations in Saudi Arabia. A limitation of this study is the small sample size that was mainly due to time constraints. Nevertheless, the results give a good picture or overview of the diabetic patients in the cohort that was studied. Thus, this study serves as a good starting point for further research on T2DM patients living in Jeddah, Saudi Arabia.

The analysis of the lifestyle questionnaire shows important differences among the study participants. Most of both sexes were Saudi nationals, and females were fewer in number compared to males. Most of the participants were overweight or obese, which is likely related to the low levels of physical activity reported by most of the subjects. In addition, many participants reported having one or more additional chronic conditions, mostly hypertension, which is expected since both diabetes and hypertension are linked and they are both linked to overweight and obesity (Mahassni and Bashanfar 2016). Furthermore, most participants indicated that one or more of their family members had T2DM, which is not surprising since diabetes has a strong hereditary link. In addition, the higher prevalence of smoking among male participants may be relevant to the increased rates of hypertension observed (Mahassni, Bukhari, Bukhari, and Al Khathami 2016), highlighting tobacco use as a modifiable cardiovascular risk factor, as previously reported (Fagard 2009; Jareebi 2025). These findings are consistent with previous research conducted in Saudi Arabia that identified elevated BMI as a significant predictor of hypertension among diabetic patients (Alharbi et al. 2024) and is strongly associated with chronic conditions such as diabetes and hypertension, particularly among women (Alghnam et al. 2021). Moreover, most participants reported stable blood glucose levels throughout the day, with regular follow-up visits every three months, thus this self-reported routine care could be a contributing factor to their perceived glycemic stability. This is consistent with findings from previous research studies that showed that regular follow-up care frequency was significantly associated with better HbA1c control (Aldhabbah and Jahan 2025), lower glycemic burden, and better long-term control (Anjana et al. 2015; Elfakki et al. 2022). These findings emphasize the

importance of addressing lifestyle-related risk factors in the management of T2DM.

Female subjects had significantly lower mean RBC and monocyte cell counts, NLR, hemoglobin concentration, and HCT%, while, on the other hand, they had significantly higher mean platelet and lymphocyte cell counts, LMR, and RDW-CV compared to the respective means in male subjects. All other hematological parameters showed no statistically significant sex-related differences, suggesting that gender may not substantially influence these markers in healthy individuals.

Lower androgen levels and regular menstrual blood loss in females may lead to reduced erythropoiesis and lower red blood cell mass (Shahani et al. 2009; Shaheen et al. 2025). One proposed mechanism is hyperinsulinemia, which can stimulate erythropoiesis, leading to increased production of erythropoietin, which promotes red blood cell formation and may explain the elevated RBC and HCT levels observed in diabetic individuals (Treins et al. 2002; Nah et al. 2022). The present findings agree with the results reported in a study of patients with T2DM in Ghana (Antwi-Baffour et al. 2018), which found that RBC counts, hemoglobin concentration, and HCT were higher in males than females. Additionally, a study among healthy Saudi adults (Shaheen et al. 2022) reported that RBC counts, hemoglobin concentrations, and HCT were significantly higher in males than in females, in agreement with the current findings. Consistent findings were also reported in an Omani population-based study (Al-Mawali et al. 2018) conducted on non-diabetic individuals, which showed significantly lower RBC and HCT levels in females compared to males. While prior studies have variably reported sex-based differences in red blood cell indices, many were either conducted in non-diabetic populations or did not focus specifically on sex stratification in T2DM. Our findings contribute more directly to this gap. These results suggest that female patients may exhibit distinct hematological patterns, potentially influenced by hormonal status, iron balance, and the interplay between hyperglycemia and erythropoiesis.

Estrogen has been shown to modulate immune responses and may suppress monocyte production or activity, which could explain the lower monocyte counts found here and commonly observed in females (Sciarra et al. 2023). The higher monocyte counts in males may reflect a state of chronic low-grade inflammation that is a hallmark of T2DM (Mokgalaboni et al. 2020). Monocytes in individuals with T2DM have been shown to lead to elevated inflammation by higher secretion of cytokines, leading to delayed wound healing and increased insulin resistance (Hatanaka et al. 2006; Donath and Shoelson 2011; Barman and Koh 2020). Additionally, it was reported (Allahyani et al. 2023) that diabetic patients exhibit significant alterations in the monocyte cell counts, leading to a shift toward a more pro-inflammatory monocyte phenotype in T2DM. Elevated monocyte counts may also result from disease-related inflammation (Shi and Pamer 2011; Ziegler-Heitbrock 2014). Sex-based differences in monocyte levels have also been observed in healthy individuals, where a study (van Zeverter et al. 2022) demonstrated that males consistently exhibited higher

monocyte counts than females, even in the absence of chronic disease. This suggests that such differences may be driven by differences between females and males rather than being solely attributed to diabetes.

Additionally, the lower NLR observed in females may reflect a less pronounced systemic inflammatory response (Lee et al. 2018; Pellegrino et al. 2023). Within the hyperglycemic Saudi population, older females had higher NLR levels compared to males of the same age group (Alfhili et al. 2022). Moreover, it was demonstrated (Mohammed et al. 2024) that NLR showed equivalent efficacy to HbA1c in predicting glycemic control, with a positive correlation observed between the two markers. Similarly, another study (Rafat et al. 2019) evaluating newly diagnosed T2DM patients found that elevated NLR was significantly associated with increased insulin resistance. In a previous study (Kweon et al. 2016), it was found that NLR was significantly associated with fasting glucose levels among healthy Korean individuals. This positive correlation indicates that higher fasting glucose, even within a non-diabetic range, corresponds to an elevated NLR, reflecting a state of low-grade systemic inflammation. Elevated NLR has been linked to higher all-cause and cardiovascular mortality in individuals with diabetes and prediabetes, highlighting its potential as a simple marker of inflammation and risk (Chen et al. 2018). Thus, the increase in NLR may serve as an early indicator of metabolic dysregulation related to glucose metabolism and systemic inflammation. It is important to note that elevated NLR values are not exclusively indicative of pathological states. A recent study (Wang et al. 2025) demonstrated that female athletes had higher NLR values compared to males, despite the absence of clinical disease or inflammation. Therefore, physiological differences, such as sex-related immune responses, may contribute to variations in NLR and should be considered when interpreting this parameter in clinical and research settings.

The significantly higher values of platelets count and RDW-CV in female subjects may be linked to estrogenic effects on megakaryocyte maturation, contributing to increased platelets production (Biino et al. 2013; Shaheen et al. 2025). Higher RDW-CV in females may be due to greater variability in iron status and red blood cell morphology influenced by hormonal fluctuations (Shaheen et al. 2022). One other possible explanation for the alterations in platelet and erythrocyte parameters observed in diabetic patients is the presence of multiple metabolic disturbances. Hyperglycemia, insulin resistance, and insulin deficiency may increase platelet reactivity through glycation of platelet proteins, leading to structural and functional changes (Schneider 2009; Ebrahim et al. 2022). Meanwhile, hyperosmolarity, oxidative stress, inflammation, and lipid metabolism disorders can impair red blood cell metabolism by promoting aggregation, reducing deformability, and compromising membrane fluidity. These effects collectively shorten erythrocyte lifespan and impair their function, potentially contributing to the progression of diabetic complications (Wang et al. 2021; Obeagu 2024). A previous study (Zhang et al. 2021) reported that women had higher RDW values than men, although the difference was not

statistically significant. Additionally, a previous study (Ebrahim et al. 2022) reported a positive correlation between RDW-CV and fasting blood glucose levels, suggesting that higher RDW-CV may be linked to poor glycaemic control. There is a lack of published evidence indicating that diabetic patients typically present with low RDW-CV values, while, on the other hand, the majority of studies (Patel et al. 2009; Malandrino et al. 2012; Magri and Fava 2014; Ma et al. 2021; Ebrahim et al. 2022) report that RDW-CV tends to be elevated in individuals with diabetes and is often associated with inflammatory processes, oxidative stress, or the presence of chronic complications such as nephropathy and cardiovascular disease (Ebrahim et al. 2022). On the other hand, several studies have reported elevated platelet counts in patients with diabetes (Adane et al. 2021; Jena et al. 2025). The potential role of RDW-CV and platelets is as an early indicator of glycaemic dysregulation prior to the onset of overt diabetes. It is worth noting that there are no studies examining the effects of RDW-CV and platelet indices, compared between males and females, in diabetic patients.

In the present study, as mentioned above, lymphocyte count and LMR were significantly higher in females. Higher lymphocyte counts and LMR were associated with a reduced risk of all-cause and cardiovascular mortality and renal function decline in patients with T2DM (Cardoso et al. 2021). Thus, LMR may serve as a useful prognostic marker in diabetic populations (Cardoso et al. 2021). In contrast to the present findings, a previous study (Antwi-Baffour et al. 2018) reported lower lymphocyte counts in female patients with T2DM compared to males, which may contribute to increased susceptibility to infections in female diabetics (Allahyani et al. 2023). These findings underscore the heterogeneity in lymphocyte dynamics among individuals with T2DM, potentially influenced by sex, glycaemic status, and immune function. The observed higher lymphocyte counts and LMR in females may reflect sex-specific immunological responses, possibly modulated by hormonal and metabolic differences.

Although direct comparative studies between males and females with T2DM remain limited, the emerging evidence supports the need for sex-based analyses to better understand immune alterations in diabetics. Such differences may have important prognostic implications and should be considered in both clinical evaluation and future research design.

In conclusion, the present findings emphasize the importance of using sex-specific reference intervals when interpreting hematological values in both clinical and research setting in T2DM patients. These sex-dependent differences were found in the counts of some types of white blood cells, red blood cell, and platelets; hemoglobin concentrations; and related indices to these hematological parameters. Thus, differences between females and males occur in immunological and non-immunological parameters suggesting variations in inflammatory and immune responses.

It is recommended that large-scale studies be carried out to confirm these findings, clarify the mechanisms underlying these differences, and to explore their clinical implications in diabetes management.

#### Competing interests

The authors have no competing interests.

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