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# Comparative Analysis of Hematological Parameters and Body Mass Index among Diabetic , Hypertensive , and Healthy Individuals in Western Tripoli , Libya

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**Abstract**

**Hypertension and diabetes are among the most widespread chronic diseases in Libya, and both are associated with metabolic and hematological alterations measurable through Body Mass Index (BMI) and Complete Blood Count (CBC) parameters. This study aimed to compare BMI values and selected hematological indicators among diabetic patients, hypertensive patients, and healthy individuals in Western Tripoli, Libya, while also examining potential correlations between these variables. A case–control design was applied involving 120 participants, equally distributed by sex and health status. Demographic data were collected via questionnaires, CBC parameters were obtained using an automated hematology analyzer, and BMI was calculated using height and weight measurements. The results demonstrated a significant increase in BMI, platelet count, and white blood cell levels among females with diabetes or hypertension compared to healthy females ($p < 0.05$), indicating a possible inflammatory state. Conversely, no significant differences were observed among males across groups. These findings highlight gender–specific variations in metabolic and hematological responses to chronic conditions, emphasizing the need for interventions tailored particularly to women. Furthermore, the study provides valuable insights into the progression and burden of chronic diseases in Libya, contributing to future public health planning and preventive strategies.**

**Keywords:**

**Diabetes Mellitus ,Hypertension , Body Mass Index ( BMI ) , Complete Blood Count ( CBC ) , Hematological Parameters , Chronic Disease , Libya.**

**الملخص**

**تُعدّ ارتفاع ضغط الدم وداء السكري من أبرز الأمراض المزمنة المنتشرة في ليبيا، ويرتبطان بتغيرات أيضية ودموية يمكن قياسها من خلال مؤشر كتلة الجسم (BMI) ومعاملات تعداد الدم الكامل .(CBC) هدفت هذه الدراسة إلى مقارنة قيم مؤشر كتلة الجسم وبعض المؤشرات**

الدموية لدى مرضى السكري ومرضى ارتفاع ضغط الدم مقارنة بالأفراد الأصحاء في المنطقة الغربية من طرابلس – ليبيا، إضافة إلى تحليل الارتباط بين هذه المؤشرات. اعتمدت الدراسة على تصميم حالة–ضابطة وشملت 120 مشاركاً من الذكور والإناث، موزعين بالتساوي حسب الجنس والحالة الصحية. تم قياس المتغيرات الديموغرافية باستخدام الاستبيان، فيما أُجريت الفحوصات المخبرية لمعاملات CBC بواسطة محلل دموي آلي، وحُسب مؤشر كتلة الجسم اعتماداً على قياسات الطول والوزن. أظهرت النتائج ارتفاعاً ملحوظاً في مؤشر كتلة الجسم وعدد الصفائح الدموية وكريات الدم البيضاء لدى النساء المصابات بالسكري أو ارتفاع ضغط الدم مقارنة بالإناث الأصحاء عند مستوى دلالة($p<0.05$) ، ما يشير إلى وجود حالة التهابية مرافقة. بينما لم تُسجل فروق ذات دلالة بين المجموعات لدى الذكور. تستخلص الدراسة وجود فروق تعتمد على الجنس في الاستجابة الأيضية والدموية لهذه الأمراض، مما يؤكد أهمية وضع تدخلات علاجية ووقائية تراعي الخصائص الفسيولوجية للنساء في ليبيا. كما تسهم النتائج في دعم الجهود الصحية الوطنية للتعامل مع الأمراض المزمنة بفعالية أكبر.

**الكلمات المفتاحية:**

داء السكري، ارتفاع ضغط الدم، مؤشر كتلة الجسم(BMI) ، تعداد الدم الكامل(CBC) ، المؤشرات الدموية، الأمراض المزمنة، ليبيا.

## Introduction

Diabetes mellitus and hypertension are among the most prevalent chronic disorders globally and are major contributors to morbidity and mortality worldwide ( 1 ). In Libya , the burden of these conditions has increased notably over the past decade , posing a serious public health challenge due to rising incidence , lifestyle changes , and limited early–detection strategies.( 2 )

Hematological disturbances are frequently reported in patients with diabetes and hypertension as a result of chronic inflammation , endothelial dysfunction , and metabolic dysregulation , which influence red blood cell indices , white blood cell counts , and platelet activation ( 3 , 4 ). Furthermore , excess adiposity ( usually defined by BMI ) is a common risk factor that predominantly drives the development and progression of both diseases and increases the probability for complications , such as cardiovascular and microvascular events.( 5–7 )

While other studies from different countries of the world have addressed changes in CBC indices and BMI among those with metabolic disorders , local data is scarce in Libya in this field particularly as regards gender based combined differences since last 5 years in Libyan population. Hence , this study was conducted to compare the hematological parameters as well as BMI between hypertensive , diabetic and nondiabetic individuals in Western Tripoli , Libya and also to find the possible relationships among CBC indices with BMI

The results of this study can contribute to the understanding of metabolic and inflammatory disturbances in chronic illness patients and shape the creation of specific preventive and therapeutic interventions in the Libyan healthcare system.

## Objective:

This study aimed to compare hematological parameters and body mass index ( BMI ) between diabetic and hypertensive patients and healthy controls in West Tripoli , Libya , and to study the relationship between BMI and complete blood count ( CBC ) indices in diabetic and hypertensive patients.

## Specific Objectives:

1. To compare CBC parameters ( WBC , RBC , Hb , HCT , MCV , MCH , MCHC , and PLT ) among diabetic , hypertensive , and healthy individuals.
2. To compare BMI values among the three study groups.
3. To evaluate the correlations between CBC parameters and BMI in diabetic and hypertensive patients.
4. To investigate sex-based differences in hematological and BMI changes among the study groups.

## Methods

This analytical case–control study was conducted in Western Tripoli , Libya. A total of 120 participants were enrolled and categorized into three equal groups:

( 1 ) Diabetes Mellitus ( DM ) patients ( n = 40; 20 males and 20 females ) ,

( 2 ) Hypertension ( HTN ) patients ( n = 40; 20 males and 20 females ) , and

( 3 ) Healthy Controls ( HC ) ( n = 40; 20 males and 20 females ).

A convenience sampling technique was used to recruit eligible participants from outpatient clinics and community settings.

### Inclusion Criteria

- Adults aged 18–65 years.
- DM diagnosis based on ADA criteria ( FPG ≥ 126 mg/dL or history of antidiabetic therapy ).
- HTN diagnosis based on BP ≥ 140/90 mmHg or antihypertensive medication use.
- Controls: individuals free from diabetes and hypertension.

### Exclusion Criteria

- Presence of chronic illness ( e.g. , renal , hepatic , hematological disorders ).
- Acute infection within the last two weeks.
- Pregnant or lactating women.
- Current smokers or individuals on medications affecting hematologic parameters.

### Data Collection

Demographic data ( age , sex , medical history ) were collected using a structured questionnaire. CBC parameters ( WBC , RBC , Hb , HCT , MCV , MCH , MCHC , and PLT ) were measured using an automated hematology analyzer at a certified clinical laboratory.

BMI was calculated as:

BMI = weight ( kg ) / height ( $m^2$ )

All physiological measurements were performed by trained personnel following standardized procedures.

### Ethical Considerations

Ethical approval was obtained from the institutional review board in Western Tripoli. Written informed consent was collected from all participants prior to data collection.

### Data Collection

Demographic information including age , sex , and medical history was obtained through a structured questionnaire administered by trained personnel. Venous blood samples ( 2–3 mL ) were collected under aseptic conditions and analyzed on the same day. Complete Blood Count ( CBC ) parameters—including WBC , RBC , hemoglobin ( Hb ) , hematocrit ( HCT ) , MCV , MCH , MCHC , and platelet count ( PLT )—were measured using an automated hematology analyzer at a certified clinical laboratory in Western Tripoli.

Height and weight were measured with participants wearing light clothing and no shoes , using a calibrated digital scale and stadiometer. Body Mass Index ( BMI ) was then calculated as:

BMI ( $kg/m^2$ ) = weight ( kg ) / height ( m )²

**Statistical Analysis**

Data analysis was performed using IBM SPSS Statistics version 26. Descriptive statistics were presented as mean ± standard deviation ( SD ). Differences in CBC parameters and BMI among the three groups ( DM , HTN , HC ) were assessed using One-Way ANOVA , followed by Tukey's post-hoc test for pairwise comparisons. Sex-stratified analyses were also conducted. Pearson's correlation coefficient ( r ) was applied to examine the associations between CBC indices and BMI in DM and HTN groups. A significance level of $p < 0.05$ was considered statistically significant.

**Ethical Approval**

Ethical approval was obtained from the relevant institutional ethics committee in Western Tripoli , Libya. Written informed consent was obtained from all participants prior to data collection , and confidentiality of participant information was strictly maintained.

**Results**

A total of 120 participants were included in the study and equally distributed among the three groups: 40 patients with diabetes mellitus ( 20 males and 20 females ) , 40 patients with hypertension ( 20 males and 20 females ) , and 40 healthy controls ( 20 males and 20 females ).

Table ( 1 ). Sex-stratified comparison of hematological parameters among study groups ( mean ± SD ) using One-Way ANOVA ( DM vs HTN vs HC )

A. Males

| Parameter | HC ( n=20 ) | DM ( n=20 ) | HTN ( n=20 ) | p-value |
|---|---|---|---|---|
| WBC ( $\times 10^3/\mu L$ ) | 7.08 ± 1.74 | 7.66 ± 2.03 | 8.07 ± 1.74 | 0.241 |
| RBC ( $\times 10^6/\mu L$ ) | 4.76 ± 0.53 | 4.95 ± 0.53 | 5.03 ± 0.49 | 0.182 |
| Hb ( g/dL ) | 14.28 ± 1.44 | 14.61 ± 1.48 | 14.67 ± 1.58 | 0.540 |
| HCT ( % ) | 44.05 ± 5.67 | 42.94 ± 4.37 | 41.74 ± 5.56 | 0.211 |
| MCV ( fL ) | 82.98 ± 9.59 | 86.62 ± 4.48 | 84.02 ± 6.68 | 0.156 |
| MCH ( pg ) | 29.63 ± 2.11 | 29.28 ± 1.83 | 29.34 ± 1.86 | 0.733 |
| MCHC ( g/dL ) | 30.70 ± 4.83 | 33.54 ± 1.25 | 31.76 ± 4.21 | 0.098 |
| PLT ( $\times 10^3/\mu L$ ) | 242.85 ± 59.23 | 240.45 ± 75.67 | 262.95 ± 72.76 | 0.548 |

**B. Females**

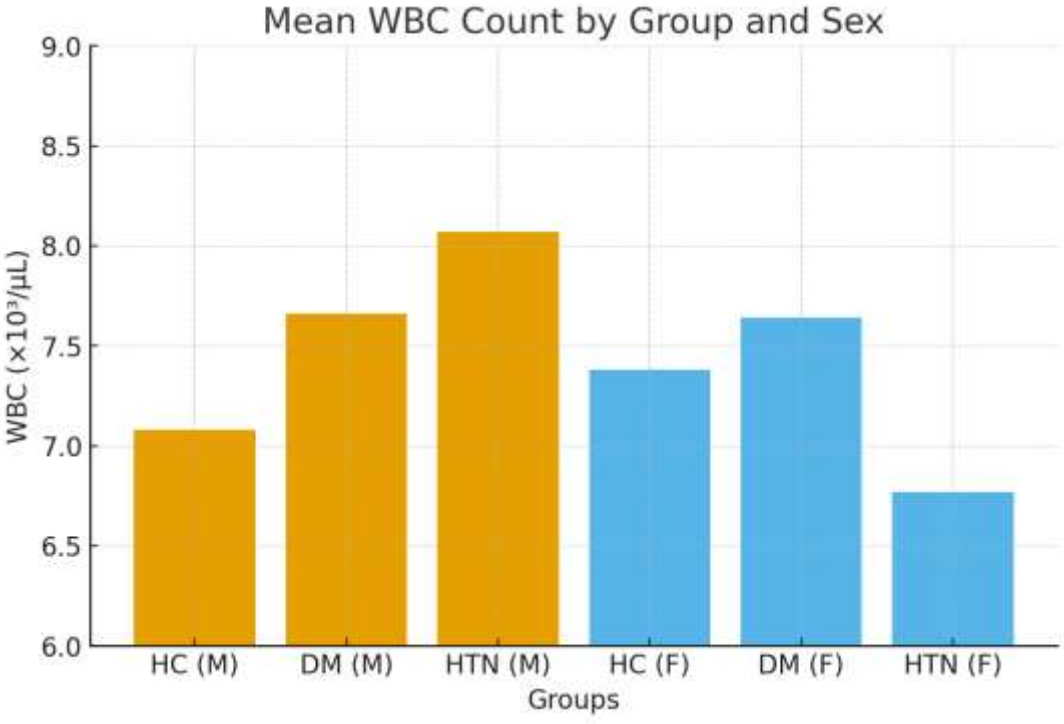
| Parameter | HC ( n=20 ) | DM ( n=20 ) | HTN ( n=20 ) | p-value |
|---|---|---|---|---|
| WBC ( $\times 10^3/\mu L$ ) | 7.38 ± 1.25 | 7.64 ± 1.36 | 6.77 ± 1.49 | 0.092 |
| RBC ( $\times 10^6/\mu L$ ) | 4.29 ± 0.64 | 4.25 ± 0.84 | 4.37 ± 0.34 | 0.611 |
| Hb ( g/dL ) | 11.89 ± 1.99 | 12.37 ± 1.94 | 12.30 ± 1.53 | 0.472 |
| HCT ( % ) | 35.49 ± 6.27 | 38.68 ± 5.36* | 36.49 ± 4.10 | 0.049* |
| MCV ( fL ) | 87.92 ± 12.89 | 85.77 ± 6.16 | 83.58 ± 6.40 | 0.310 |
| MCH ( pg ) | 27.26 ± 3.15 | 27.84 ± 2.56 | 27.88 ± 2.92 | 0.691 |
| MCHC ( g/dL ) | 33.01 ± 2.08 | 32.26 ± 2.26 | 33.50 ± 2.19 | 0.103 |
| PLT ( $\times 10^3/\mu L$ ) | 282.10 ± 66.54 | 234.95 ± 67.50* | 239.10 ± 65.74* | 0.021* |

*Significant difference vs. Healthy Controls ( HC ) at $p < 0.05$ using Tukey's post-hoc test.

**Interpretation of Group Comparisons**

Based on the male subgroup results , the HTN group showed slightly higher mean values of WBC and PLT compared to the DM group ( 8.07 vs. 7.66 $\times 10^3/\mu L$ and 262.95 vs. 240.45 $\times 10^3/\mu L$ , respectively ). Meanwhile , MCHC was lower in the HTN group ( 31.76 vs. 33.54 g/dL ).

However , these variations were not statistically significant ( $p > 0.05$ ) , indicating that the observed differences may reflect normal biological variability rather than clinically meaningful hematological alterations. Therefore , no conclusive differences can be inferred between DM and HTN males regarding these parameters.




"**Figure ( 1 ): Average WBC Count in the Different Study Groups**"

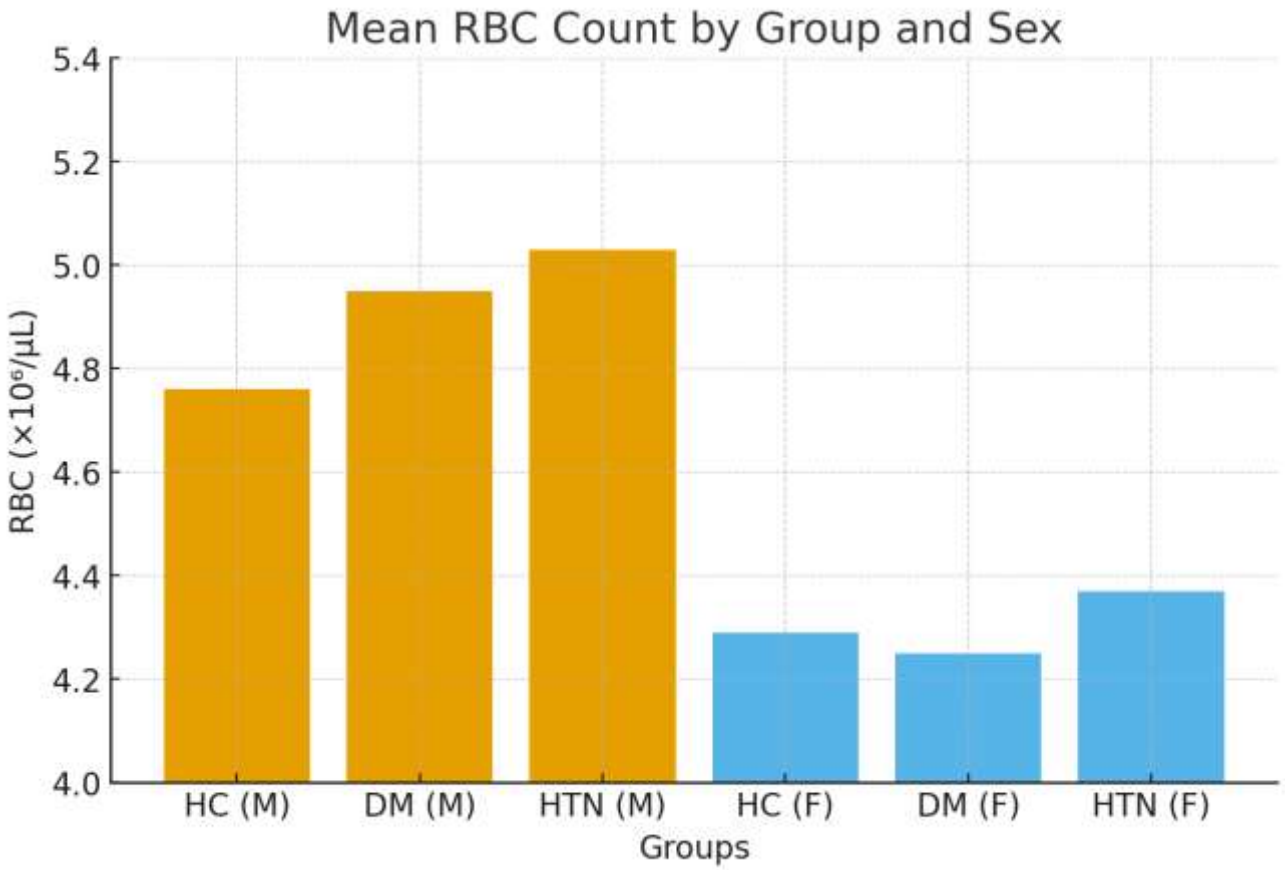



**Figure ( 2 ). Comparison of mean RBC counts among diabetic , hypertensive , and healthy individuals by sex**

**As illustrated in Figure ( 2 ) , hypertensive males recorded the highest mean RBC count ( 5.03 $\times 10^6$/µL ) , followed by diabetic males ( 4.95 $\times 10^6$/µL ) and healthy males ( 4.76 $\times 10^6$/µL ).**

**In contrast , the female groups demonstrated closer RBC values with minimal variation between HTN , HC , and DM participants.**

**Statistical analysis showed no significant differences among groups in either sex category ( $p > 0.05$ ) , indicating that both diabetes and hypertension did not appear to substantially alter erythrocyte concentration in the present sample.**

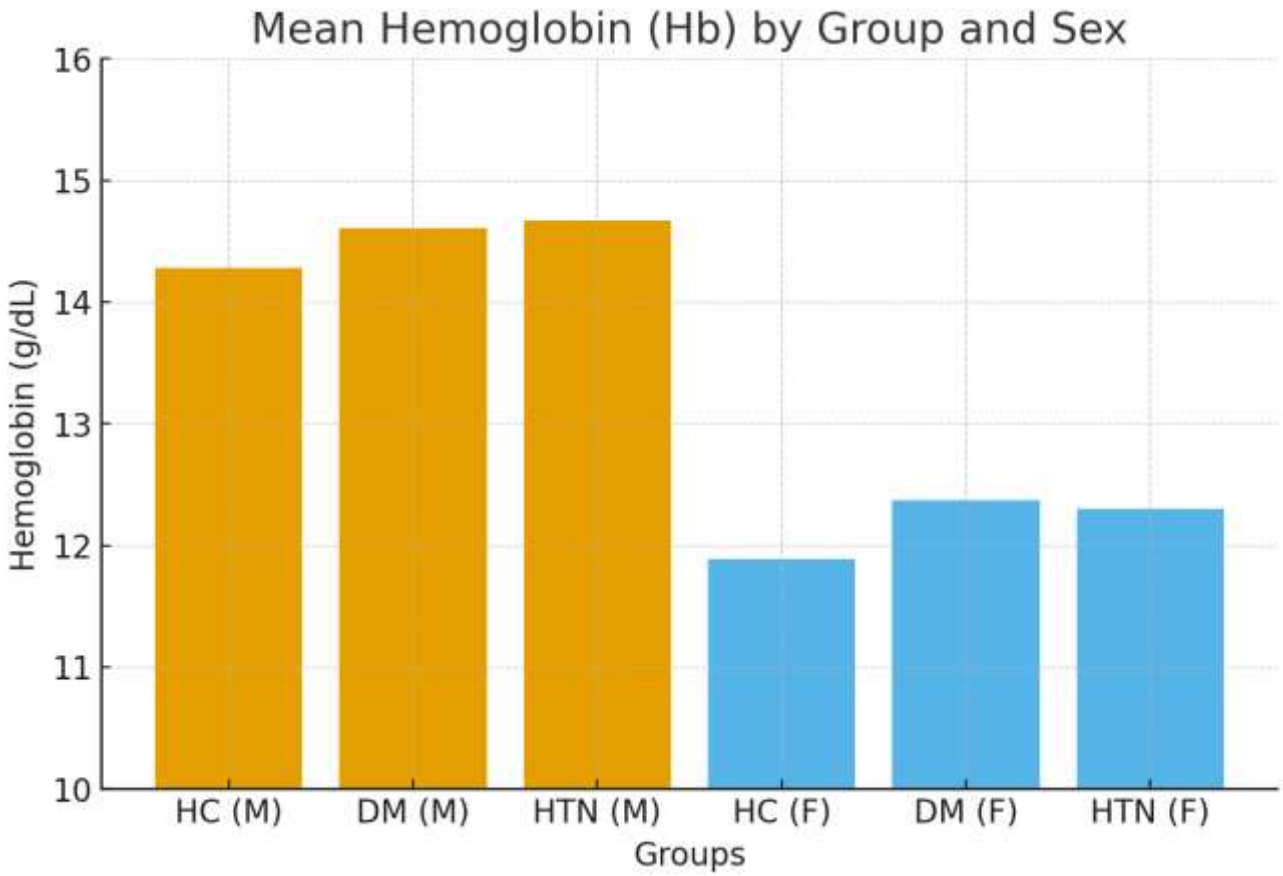



**Figure ( 3 ). Comparison of mean hemoglobin levels among diabetic , hypertensive , and healthy individuals by sex**

**As shown in Figure ( 3 ) , male participants presented higher hemoglobin levels compared to females across all study groups. Among males , the highest mean Hb was observed in the HTN group ( 14.67 g/dL ) , followed by the DM group ( 14.61 g/dL ) and healthy controls ( 14.28 g/dL ).**

**In females , Hb levels were slightly higher in the DM group ( 12.37 g/dL ) compared with the HTN ( 12.30 g/dL ) and healthy control groups ( 11.89 g/dL ).**

**Despite these minor variations , no statistically significant differences were found among the groups in either sex category ( $p > 0.05$ ) , indicating that diabetes and hypertension in this sample did not substantially influence hemoglobin concentrations.**

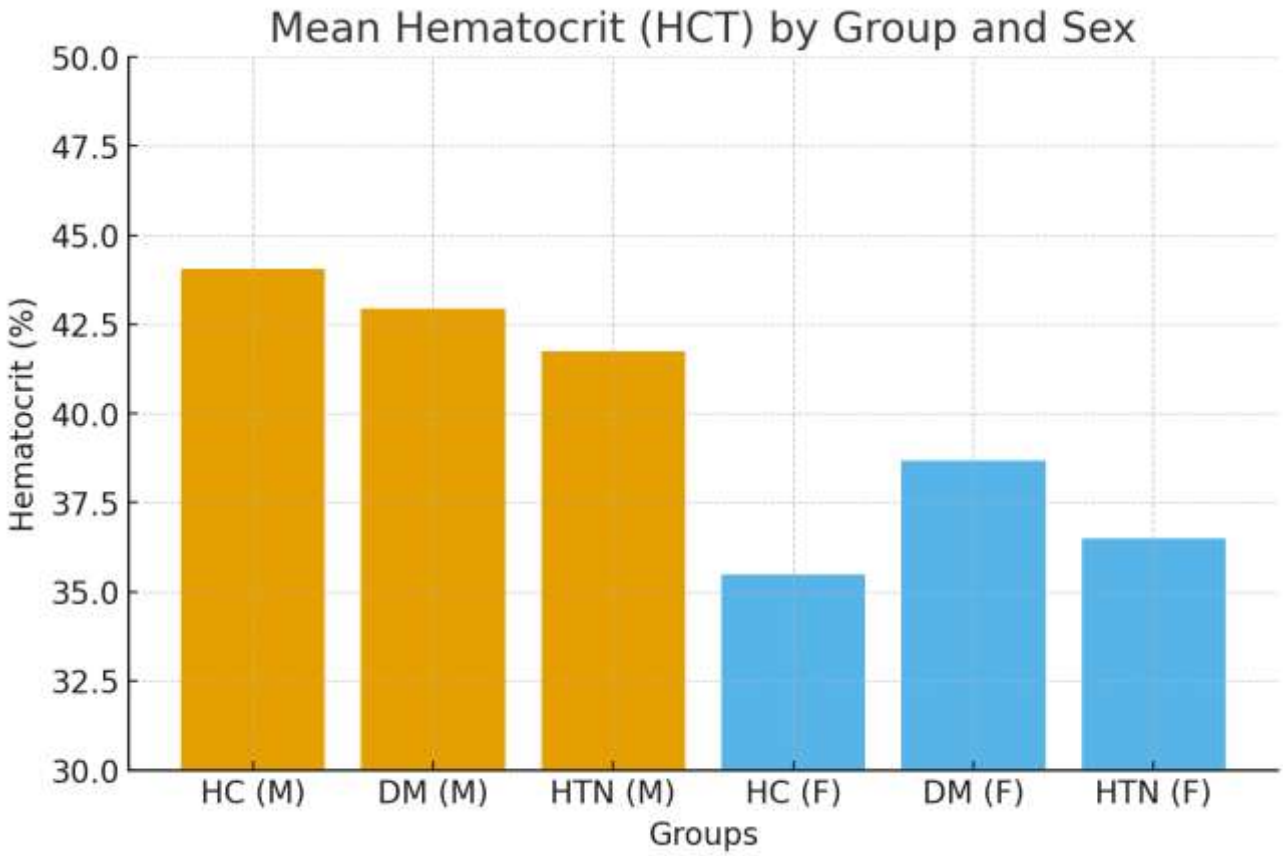



**Figure ( 4 ). Comparison of mean hematocrit ( HCT ) among diabetic , hypertensive , and healthy individuals by sex**

**As presented in Figure ( 4 ) , hematocrit levels were consistently higher in males than in females across all study groups.**

**Among males , the highest mean HCT was observed in the healthy control group ( 44.05% ) , followed by the DM group ( 42.94% ) and the HTN group ( 41.74% ).**

**In females , the DM group exhibited slightly higher HCT levels ( 38.68% ) compared with HTN ( 36.49% ) and healthy controls ( 35.49% ).**

**Statistical analysis indicated that the difference in HCT was significant only among females ( $p < 0.05$ ) , where diabetic participants showed notably elevated hematocrit compared to healthy controls.**

**This gender-dependent discrepancy may reflect disease-associated dehydration or erythrocytosis among diabetic women in the study sample.**

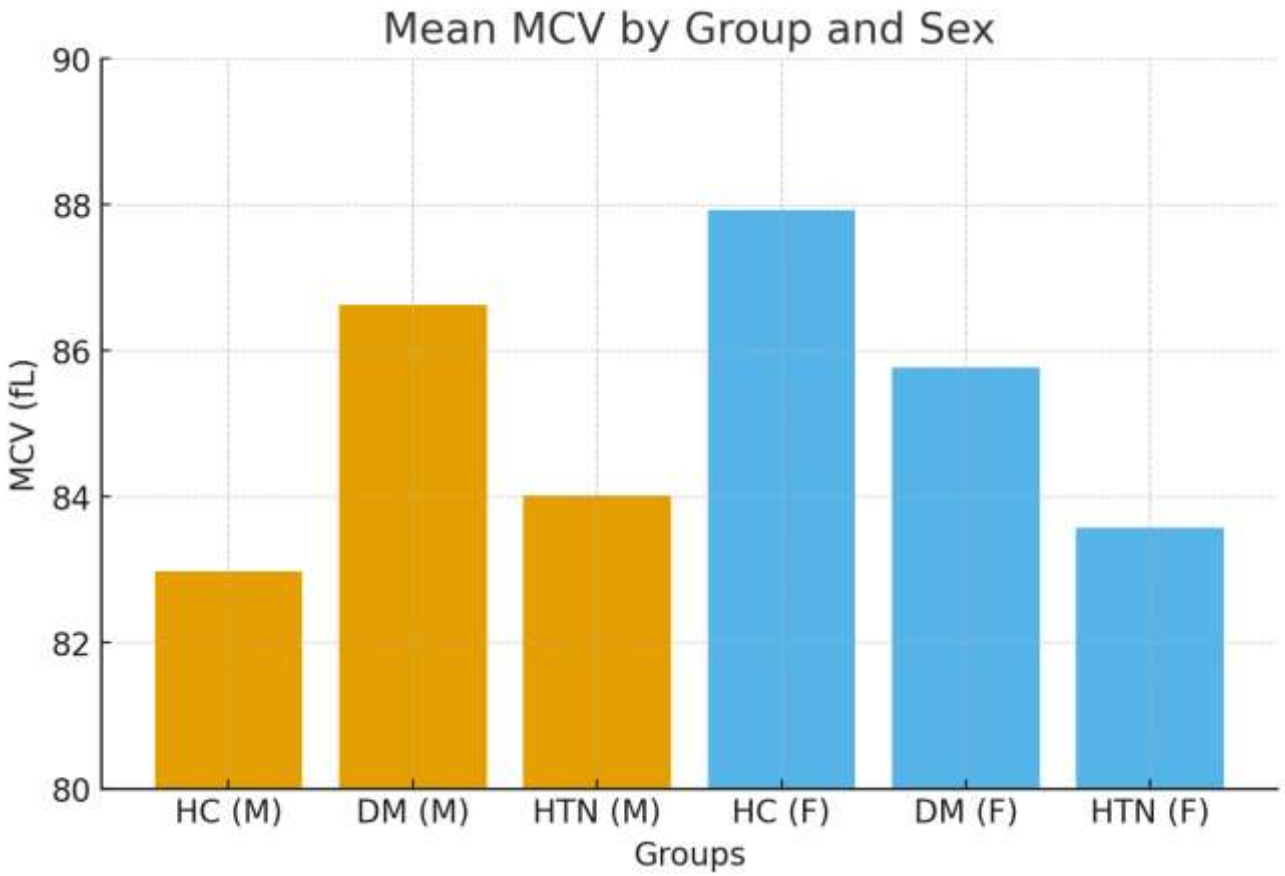



**Figure ( 5 ). Comparison of mean corpuscular volume ( MCV ) among diabetic , hypertensive , and healthy individuals by sex**

**As illustrated in Figure ( 5 ) , female participants showed higher MCV values than males in all groups. The highest MCV level among females was observed in healthy controls ( 87.92 fL ) , followed by diabetic females ( 85.77 fL ) and hypertensive females ( 83.58 fL ).**

**Among males , diabetic participants exhibited the highest MCV mean ( 86.62 fL ) , whereas healthy males recorded the lowest value ( 82.98 fL ).**

**Despite these observed differences , the variations in MCV were not statistically significant in either sex category ( p > 0.05 ) , indicating limited evidence that diabetes or hypertension influenced erythrocyte size in the present sample.**

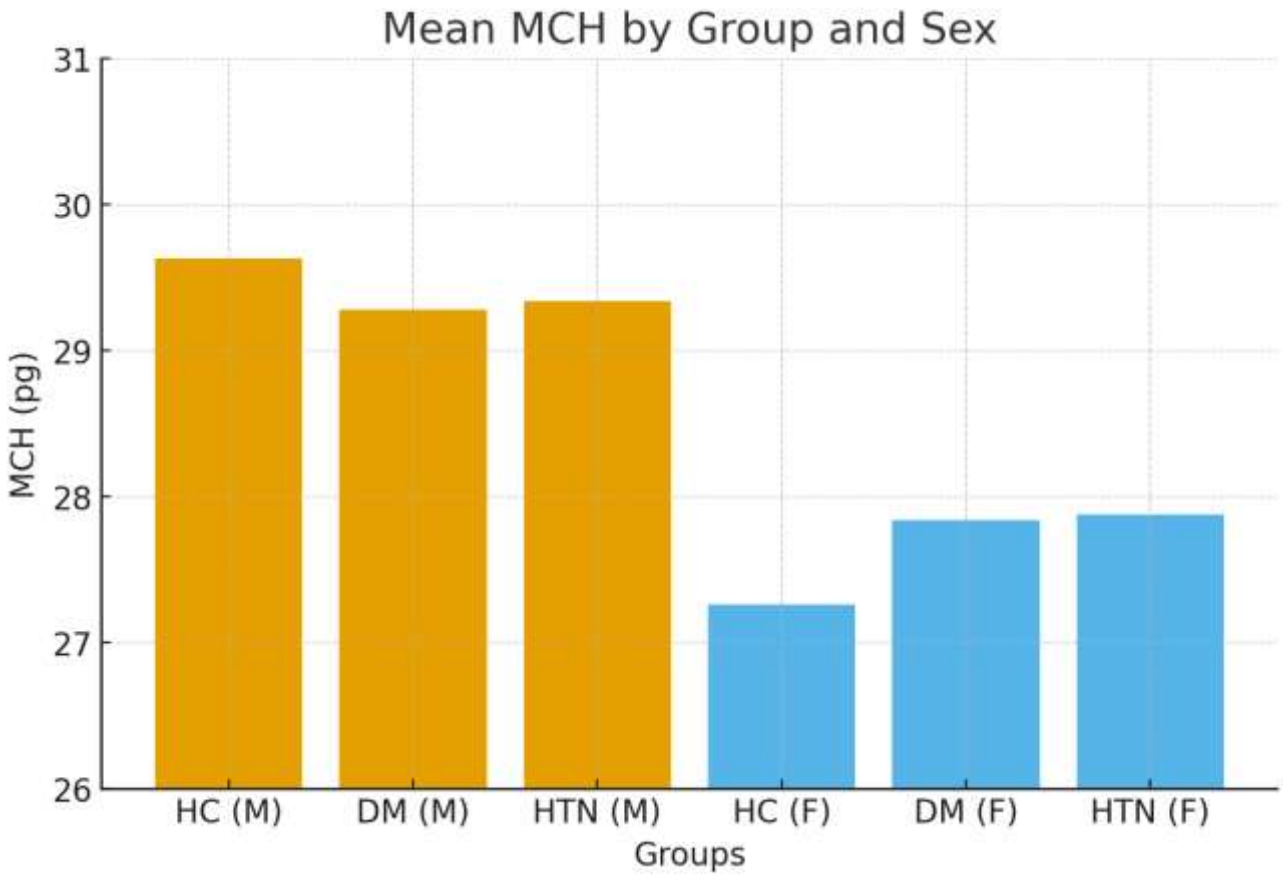



**Figure ( 6 ). Comparison of mean corpuscular hemoglobin ( MCH ) among diabetic , hypertensive , and healthy individuals by sex**

**As shown in Figure ( 6 ) , male participants exhibited higher MCH values than females in all study groups. Among males , healthy controls demonstrated the highest MCH ( 29.63 pg ) , while diabetic males showed slightly lower values ( 29.28 pg ).**

**In females , MCH values were relatively comparable across groups , ranging between 27.26 pg in healthy controls and 27.88 pg in the HTN group.**

**The observed differences in MCH across the study groups were not statistically significant for either sex category ( p > 0.05 ) , suggesting that diabetes and hypertension did not notably affect hemoglobin content per red cell in this population.**

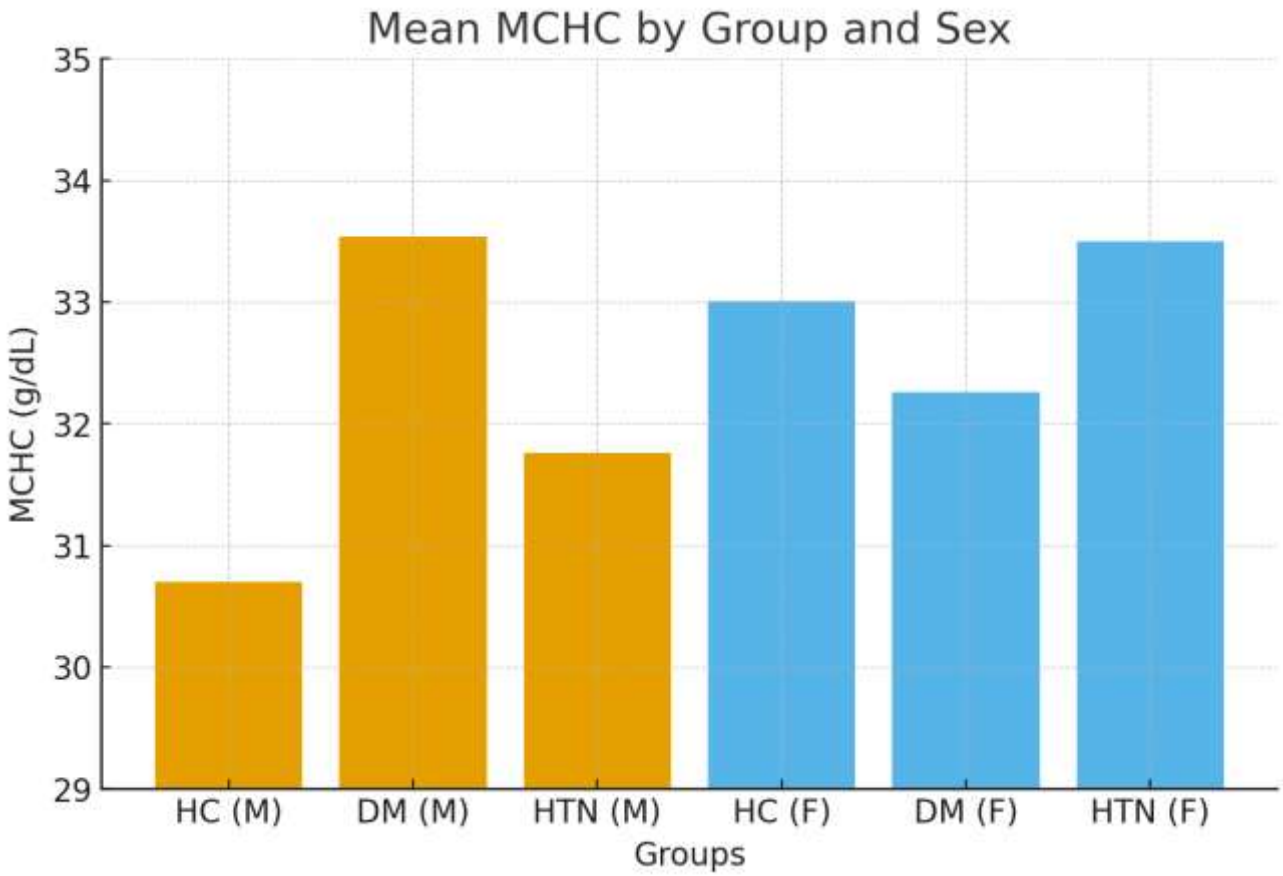



**Figure ( 7 ). Comparison of mean corpuscular hemoglobin concentration ( MCHC ) among diabetic , hypertensive , and healthy individuals by sex**

**As shown in Figure ( 7 ) , males in the DM group exhibited the highest MCHC value ( 33.54 g/dL ) , followed by hypertensive males ( 31.76 g/dL ) and healthy males ( 30.70 g/dL ).**

**In females , hypertensive participants presented the highest mean MCHC ( 33.50 g/dL ) , while diabetic females showed slightly lower MCHC ( 32.26 g/dL ) compared with healthy controls ( 33.01 g/dL ).**

**Despite these slight variations , the differences in MCHC were not statistically significant ( p > 0.05 ) for either sex category , indicating that hemoglobin concentration per red cell remained largely unaffected by diabetes or hypertension in this sample.**

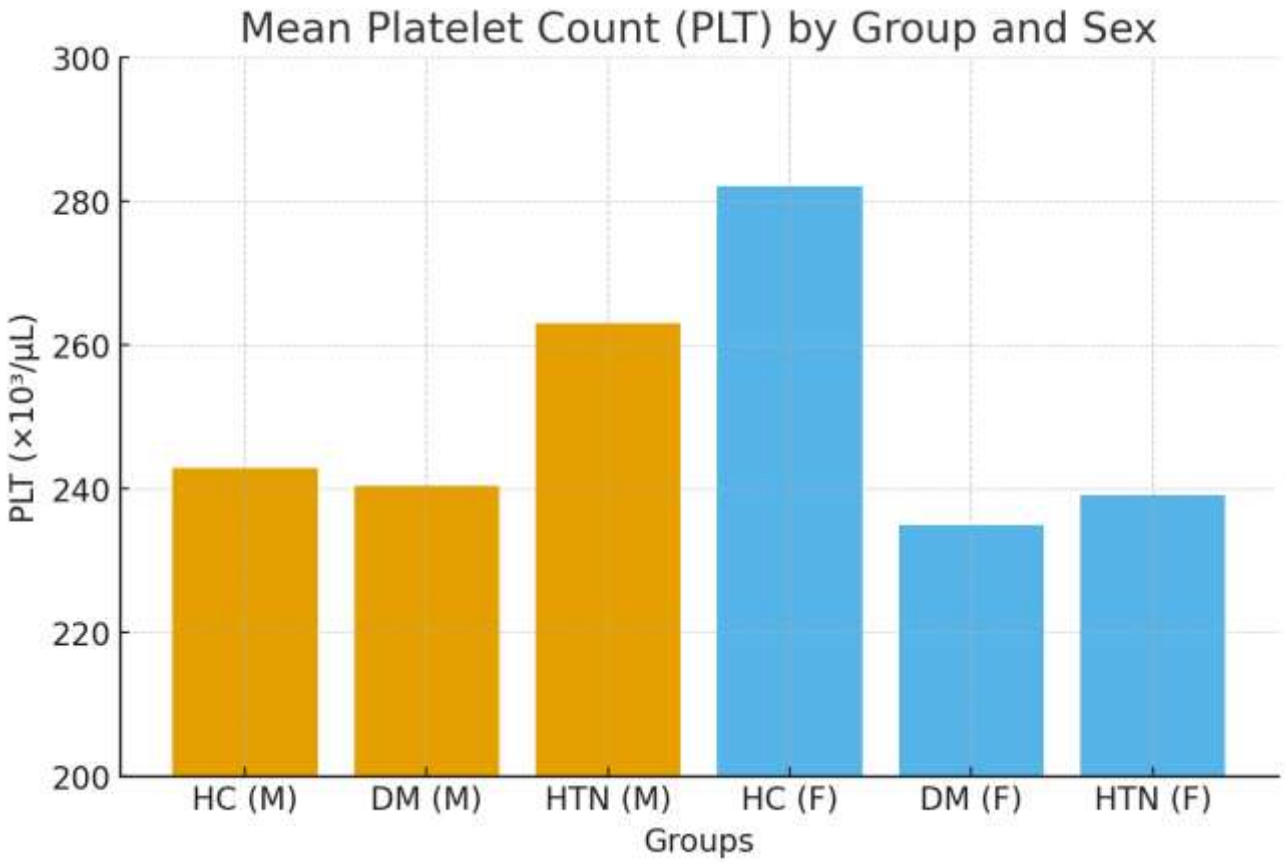



**Figure ( 8 ). Comparison of mean platelet count ( PLT ) among diabetic , hypertensive , and healthy individuals by sex**

**Female participants exhibited generally higher PLT levels compared to males in all groups. The highest platelet count was observed among healthy females ( 282.10 ×10³/µL ) , while diabetic females showed the lowest values ( 234.95 ×10³/µL ).**

**Among males , hypertensive participants demonstrated a comparatively higher PLT mean ( 262.95 ×10³/µL ) compared with diabetic and healthy males.**

**The differences in PLT across the study groups were statistically significant in females ( $p < 0.05$ ) , indicating possible platelet activation associated with diabetes in women , while no significant differences were found among males ( $p > 0.05$ ).**

**Table ( 2 ). Comparison of mean Body Mass Index ( BMI ) between study groups by sex**

| Sex | Group | BMI ( Mean ± SD ) | p-value |
|---|---|---|---|
| Male | HC | 26.83 ± 4.04 | — |
| | DM | 26.36 ± 4.01 | 0.714 |
| | HTN | 28.60 ± 4.24 | 0.186 |
| Female | HC | 26.95 ± 4.19 | — |
| | DM | 30.20 ± 4.07 | 0.017 ★ |
| | HTN | 34.07 ± 4.92 | 0.010 ★ |

As shown in Table ( 2 ) , BMI values were higher in hypertensive males compared with diabetic and healthy males , but the differences were not statistically significant ( $p > 0.05$ ).

In contrast , female participants with diabetes and hypertension exhibited significantly higher BMI compared with healthy females ( $p < 0.05$ ) , with the highest mean BMI observed in the HTN group ( 34.07 kg/m² ).

These findings suggest a stronger association between excess body weight and these chronic diseases among women in the current sample.

Table ( 3 ) :- Comparison of hematological parameters between the groups for both males and female ( mean ±STD ) .

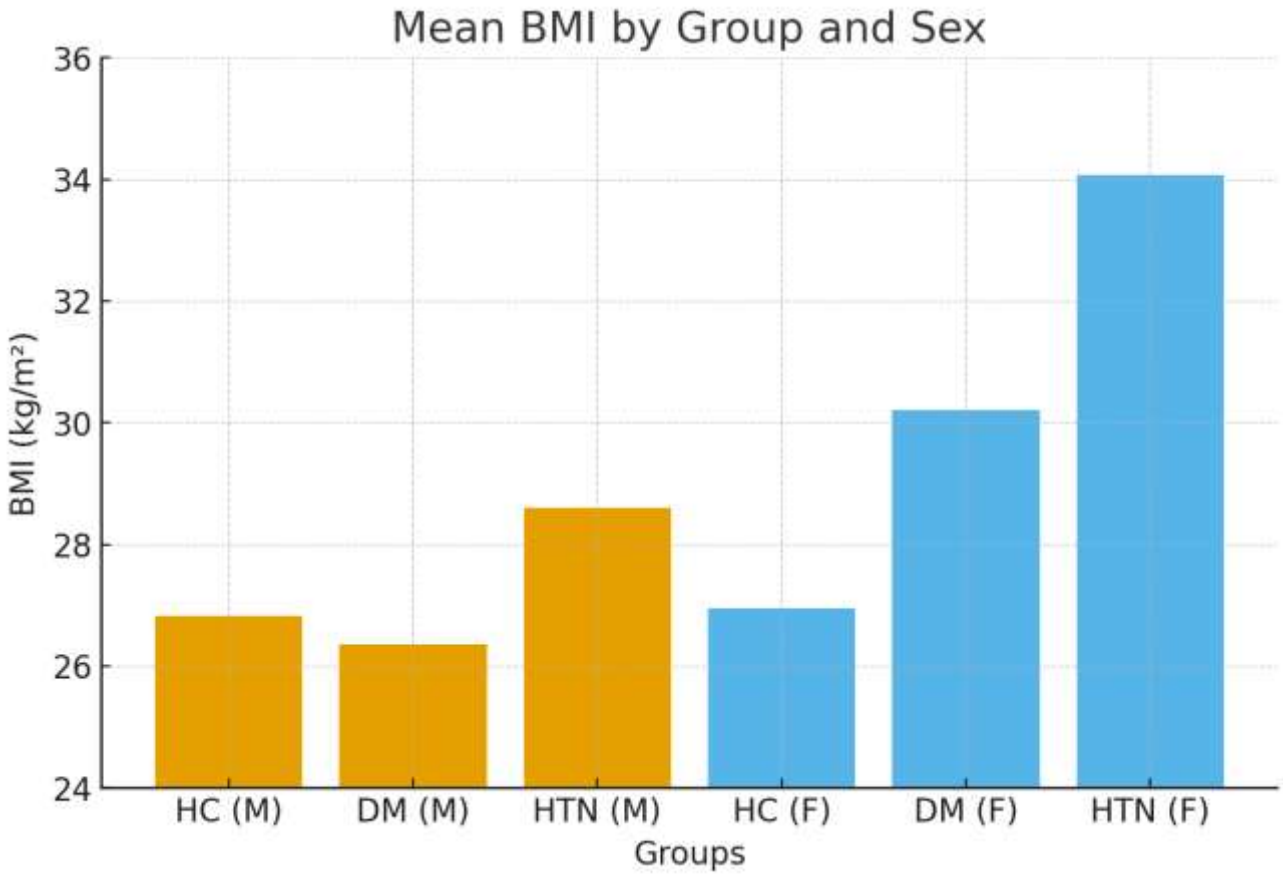



Figure ( 9 ). Comparison of mean BMI among diabetic , hypertensive , and healthy individuals by sex

As illustrated in Figure ( 9 ) , no statistically significant differences were found among males ( $p > 0.05$ ) , although hypertensive males showed a slightly elevated mean BMI ( 28.60 kg/m² ) compared with diabetic ( 26.36 kg/m² ) and healthy males ( 26.83 kg/m² ).

In contrast , female diabetic and hypertensive participants demonstrated significantly higher BMI compared with healthy females ( $p < 0.05$ ) , with the highest level observed in hypertensive females ( 34.07 kg/m² ).

These findings highlight a gender-related disparity in the association between chronic disease and obesity , suggesting that women with diabetes or hypertension may be at increased risk for obesity-related complications.

**Discussion**

**The primary aim of this study was to compare CBC parameters and BMI between diabetic , hypertensive , and healthy individuals in Western Tripoli , Libya , while also assessing sex-specific variations. The findings revealed clear differences , particularly among female participants.**

**A significant elevation in BMI was observed among both diabetic and hypertensive females when compared to female healthy controls ( $p < 0.05$ ). This supports previous evidence linking metabolic disorders—especially diabetes and hypertension—with increased adiposity and obesity-related metabolic risk ( 4 ,7 ). Conversely , BMI differences were not statistically significant among males , indicating that gender-related physiological , hormonal , or lifestyle factors may play a major role in disease-associated weight changes.**

**Regarding hematological parameters , females with diabetes and hypertension demonstrated higher WBC and PLT levels compared with female controls , with platelet count showing statistically significant elevation ( $p < 0.05$ ). Elevated PLT and WBC are commonly associated with a chronic low-grade inflammatory state and increased platelet activation , which are well-documented complications in metabolic and cardiovascular disorders ( 3 ,6 ). In contrast , male participants did not show significant hematological alterations across the groups , aligning with evidence suggesting sex-specific differences in hematologic response to metabolic disease.( 5 )**

**Altogether , these findings emphasize the importance of sex-based analysis in assessing metabolic and hematological changes linked to diabetes and hypertension. Females appear more vulnerable to obesity-related hematological disturbances , which may contribute to greater risk of cardiovascular events and disease progression. Therefore , integrating gender-focused preventive and therapeutic approaches may improve clinical outcomes and help reduce complications in the Libyan population.**

**Conclusion**

**This study demonstrated that diabetes and hypertension are associated with notable alterations in both metabolic and hematological profiles among adults in Western Tripoli , Libya. Out of a total of 120 participants ( 60 males & 60 females ) , female diabetic and hypertensive groups exhibited significantly higher BMI values ( $30.20 \pm 4.07$ and $34.07 \pm 4.92$ kg/m² , respectively ) compared with female controls ( $26.95 \pm 4.19$ kg/m² , $p < 0.05$ ). These findings indicate a greater burden of obesity-related risk in women living with chronic disease.**

**Hematologically , females with diabetes and hypertension also showed elevated platelet ( PLT ) and white blood cell ( WBC ) levels , with PLT differences reaching statistical significance ( $p < 0.05$ ) , reflecting a possible chronic inflammatory or pro-thrombotic state. In contrast , males did not demonstrate significant differences across BMI or CBC parameters , suggesting a sex-dependent physiological response to metabolic disorders.**

**Collectively , these findings highlight a gender-specific vulnerability , where females with chronic metabolic disease appear more prone to obesity and blood profile disturbances—factors known to worsen cardiovascular risk and disease progression. This study contributes important local data to the understanding of diabetes and hypertension in Libya and underscores the necessity of gender-tailored public health strategies , lifestyle-based preventive programs , and early hematological**

screening—particularly for women—to mitigate complications and improve long-term clinical outcomes.

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