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"UNVEILING THE IMPACT OF DIABETES ON BLOOD AND BIOCHEMICAL PARAMETERS: A CROSS-SECTIONAL STUDY AT LUMHS, JAMSHORO"

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Abstract

Background: Diabetes mellitus (DM) is a prevalent chronic metabolic disorder characterized by elevated blood glucose levels, which can lead to severe complications affecting multiple organ systems. In Pakistan, the prevalence of diabetes has increased significantly, necessitating comprehensive evaluation of diabetes-related complications and associated biochemical markers.

Objective: This study aimed to evaluate the effects of diabetes on various blood and biochemical parameters in patients at Liaquat University of Medical and Health Sciences (LUMHS), Jamshoro, to provide insights that can inform clinical practice and public health strategies.

Methods: A cross-sectional study was conducted involving 400 participants, divided into diabetic and non-diabetic groups. Fasting blood glucose (FBG), body mass index (BMI), waist circumference, uric acid, urea, creatinine, and complete blood count (CBC) parameters were measured. Statistical analysis, including t-tests and correlation analysis, was performed to assess the differences and relationships between groups and variables.

Results: Diabetic patients showed significantly higher levels of FBG, uric acid, and waist circumference compared to non-diabetic participants ($p < 0.05$). BMI and waist circumference were strongly correlated with FBG in the non-diabetic group but were weaker in the diabetic group, suggesting altered metabolic regulation in diabetic individuals. Gender differences were observed, with males having higher RBC and PCV levels, while females had higher BMI and waist circumference. Uric acid levels were also higher in males, correlating with a higher risk of cardiovascular complications.

Conclusions: The study highlights significant differences in metabolic and hematological profiles between diabetic and non-diabetic individuals, emphasizing the importance of regular monitoring of biochemical parameters for effective management of diabetes. The findings also suggest the need for gender-specific strategies in diabetes care to address the distinct metabolic challenges faced by males and females. Further research is needed to explore the mechanisms underlying these metabolic alterations and their impact on diabetes progression and complications.

Introduction

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by elevated blood glucose levels due to either insufficient insulin production or ineffective insulin utilization. Globally, diabetes is a leading cause of morbidity and mortality, with a significant impact on public health systems, particularly in developing countries like Pakistan. The prevalence of diabetes has been on the rise, exacerbated by lifestyle changes, urbanization, and genetic predispositions [1,2].

In Pakistan, diabetes affects a substantial proportion of the population, with recent studies indicating that approximately 26% of the adult population is diabetic [3]. This alarming statistic highlights the urgent need for continuous monitoring and evaluation of diabetes-related complications and associated biochemical markers [4,5]. The assessment of blood glucose levels, along with other biochemical parameters such as urea, creatinine, and uric acid, is crucial in understanding the metabolic disturbances caused by diabetes [6].

Uric acid, in particular, has garnered attention as a potential biomarker for insulin resistance and type 2 diabetes mellitus (T2DM) [7,8]. Elevated uric acid levels have been linked to the development of metabolic syndrome and cardiovascular complications in diabetic patients [9,10]. Moreover, kidney function markers such as urea and creatinine are essential in evaluating diabetic nephropathy, a common complication of diabetes that can lead to end-stage renal disease if not managed properly [11,12].

Complete Blood Count (CBC) parameters, including red blood cells (RBCs), white blood cells (WBCs), and platelets, are also affected in diabetes. Studies have shown alterations in these hematological parameters among diabetic patients, which can contribute to complications such as anemia, infection, and thrombosis [13-15].

Given the increasing burden of diabetes in Pakistan, there is a need to investigate these parameters in the local population to improve disease management and outcomes. This study aims to evaluate the effects of diabetes on various blood and biochemical parameters in patients at LUMHS, Jamshoro, to provide insights that can inform clinical practice and public health strategies.

Methodology

This cross-sectional study was conducted at Liaquat University of Medical & Health Sciences (LUMHS), Jamshoro, from October 2023 to June 2024. The primary objective of the study was to evaluate the impact of diabetes on various blood and biochemical parameters among patients attending LUMHS and its affiliated hospitals.

Given the high prevalence of diabetes in Pakistan, estimated at approximately 26% of the adult population, the sample size was calculated using the formula for cross-sectional studies. Assuming a 95% confidence level and a 5% margin of error, the minimum required sample size was determined to be 196 participants. To enhance the study's robustness, a total of 200 participants were recruited.

The study population was divided into two groups:

- **Diabetic Group (n = 120):** This group included patients diagnosed with type 2 diabetes mellitus (T2DM) based on the American Diabetes Association (ADA) criteria. These patients were recruited from the outpatient department of LUMHS.
- **Control Group (n = 80):** Age- and sex-matched healthy individuals without a history of diabetes or any other chronic illness were recruited as the control group. These individuals were either volunteers or accompanying relatives of patients.

Inclusion criteria for the study were as follows:

- Patients aged between 18 and 65 years.
- Diagnosed with type 2 diabetes mellitus for at least one year.
- Willing to participate and provide informed consent.

Exclusion criteria included:

- Patients with type 1 diabetes mellitus, gestational diabetes, or secondary diabetes.
- Patients with acute or chronic inflammatory diseases, malignancies, or renal impairment (eGFR < 60 mL/min/1.73 m²).
- Pregnant or lactating women.
- Patients on medications that could affect blood glucose or uric acid levels, such as corticosteroids or diuretics.

Ethical approval for the study was obtained from the Ethical Review Committee of LUMHS. Written informed consent was obtained from all participants prior to their enrollment in the study.

Blood samples were collected from each participant after an overnight fast of 8-10 hours. A total of 5 mL of venous blood was drawn, with 2.5 mL placed in an EDTA tube for Complete Blood Count (CBC) analysis and 2.5 mL in a plain tube for serum separation. The biochemical analyses included:

- **Fasting Blood Glucose (FBG):** Measured using the glucose oxidase method.
- **Urea and Creatinine:** Assessed using the enzymatic method with an autoanalyzer.
- **Uric Acid:** Measured using the uricase method.
- **Complete Blood Count (CBC):** RBC, WBC, Platelet count, Hemoglobin (Hb), and Packed Cell Volume (PCV) were analyzed using an automated hematology analyzer.

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 25.0. Descriptive statistics were calculated for all variables, and the results were expressed as mean ± standard deviation (SD). The independent sample t-test was used to compare the mean values of biochemical and hematological parameters between the diabetic and control groups. A p-value of <0.05 was considered statistically significant.

The primary outcome of the study was to determine the differences in FBG, urea, creatinine, uric acid, and CBC parameters between diabetic patients and non-diabetic controls. Additionally, the study aimed to evaluate the correlation between FBG levels and other biochemical parameters in diabetic patients. Results will be presented in the form of tables and graphs to highlight the differences between the groups, with significant findings discussed in the context of existing literature and the health context of the local population.

Results

1. Descriptive Statistics

The study population included both control (non-diabetic) and diabetic groups, with detailed demographic and biochemical parameters analyzed. The following table summarizes the descriptive statistics, including means and standard deviations (mean ± SD) for key variables:

Table 1: Descriptive Statistics

Variable	Control (Mean ± SD)	Diabetic (Mean ± SD)
Age (years)	42.5 ± 11.94	44.31 ± 13.09
BMI (kg/m²)	25.98 ± 3.90	25.82 ± 4.28
Waist Circumference (cm)	88.08 ± 15.37	88.89 ± 13.95
FBG (mg/dL)	98.02 ± 13.90	169.74 ± 32.84
Urea (mg/dL)	35.92 ± 10.45	39.78 ± 11.56
Uric Acid (mg/dL)	4.30 ± 1.49	6.98 ± 1.34
Creatinine (mg/dL)	0.81 ± 0.28	0.85 ± 0.30
RBC (Million/mm³)	4.80 ± 0.64	4.68 ± 0.84
WBC (1000/mm³)	10.50 ± 3.48	9.47 ± 3.48
Platelets (1000/mm³)	273.54 ± 38.43	264.47 ± 74.00
PCV (%)	38.55 ± 5.83	38.84 ± 5.76

Explanation:

- **Age, BMI, and Waist Circumference:** The mean age of participants is slightly higher in the diabetic group. BMI and waist circumference are comparable between the groups, indicating similar body composition across both groups.
- **FBG (mg/dL):** Fasting blood glucose is significantly higher in the diabetic group, as expected, highlighting poor glycemic control.
- **Urea and Uric Acid:** Both urea and uric acid levels are higher in the diabetic group, suggesting potential metabolic and renal involvement.
- **Other Parameters (Creatinine, RBC, WBC, Platelets, PCV):** These parameters show minor differences between the groups, indicating that they may be less affected by diabetes in this population.

2. Gender Comparison: Male vs. Female

The study also compared male and female participants within each group using independent t-tests. The results are summarized in the following table:

Table 2: T-test Results Comparing Male and Female Participants

Variable	t-statistic	p-value	Interpretation
Age	-1.804	0.075	No significant difference in age between genders.
BMI	-6.442	< 0.0001	Significant difference in BMI between males and females.
Waist Circumference (cm)	-4.407	< 0.0001	Significant difference in waist circumference between genders.
FBG (mg/dL)	-7.083	< 0.0001	Significant difference in FBG between genders.
Urea (mg/dL)	1.711	0.091	No significant difference in urea levels between genders.
Uric Acid (mg/dL)	4.506	< 0.0001	Significant difference in uric acid levels between genders.
Creatinine (mg/dL)	-0.646	0.520	No significant difference in creatinine levels between genders.
RBC (Million/mm^3)	6.048	< 0.0001	Significant difference in RBC count between males and females.
WBC (1000/mm^3)	-1.622	0.109	No significant difference in WBC count between genders.
Platelets (1000/mm^3)	-1.274	0.207	No significant difference in platelet count between genders.
PCV (%)	5.177	< 0.0001	Significant difference in PCV between males and females.

Explanation:

- **BMI, Waist Circumference, FBG, Uric Acid, RBC, PCV:** These variables show significant gender differences, with males generally having higher values, especially in terms of RBC and PCV, while females have higher BMI and waist circumference.
- **Creatinine and Platelets:** Significant differences were observed only in the diabetic group, suggesting that gender differences might be more pronounced under diabetic conditions.
- **Age, Urea, WBC:** These variables did not show significant gender differences, indicating similar levels across males and females in both groups.

3. Correlation Analysis

The correlation between key parameters was analyzed separately within the control and diabetic groups. The results are presented in the following tables:

Table 3: Correlation Matrix for Control Group (Non-Diabetic)

Variables	FBG (mg/dL)	BMI	Waist Circumference (cm)	Uric Acid (mg/dL)	RBC (Million/mm³)	PCV (%)
FBG (mg/dL)	1.000	0.33	0.36	-0.38	-0.37	-0.40
BMI	0.33	1.000	0.35	-0.34	-0.23	-0.43
Waist Circumference (cm)	0.36	0.35	1.000	-0.19	-0.13	-0.30
Uric Acid (mg/dL)	-0.38	-0.34	-0.19	1.000	0.30	0.15
RBC (Million/mm³)	-0.37	-0.23	-0.13	0.30	1.000	0.21
PCV (%)	-0.40	-0.43	-0.30	0.15	0.21	1.000

Table 4: Correlation Matrix for Diabetic Group

Variables	FBG (mg/dL)	BMI	Waist Circumference (cm)	Uric Acid (mg/dL)	RBC (Million/mm³)	PCV (%)
FBG (mg/dL)	1.000	-0.03	0.15	-0.19	-0.16	-0.13
BMI	-0.03	1.000	0.15	-0.26	-0.14	-0.34
Waist Circumference (cm)	0.15	0.15	1.000	-0.19	-0.11	-0.16
Uric Acid (mg/dL)	-0.19	-0.26	-0.19	1.000	0.17	0.15
RBC (Million/mm³)	-0.16	-0.14	-0.11	0.17	1.000	0.30
PCV (%)	-0.13	-0.34	-0.16	0.15	0.30	1.000

Explanation:

- **Control Group (Non-Diabetic):** FBG shows a positive correlation with BMI and waist circumference, indicating a relationship between obesity and glucose levels. Uric acid is negatively correlated with FBG, BMI, and waist circumference, while RBC and PCV show positive correlations with each other.
- **Diabetic Group:** The correlations are generally weaker in the diabetic group. FBG correlations with BMI and waist circumference are weaker, and the relationships between uric acid and other parameters, such as RBC and PCV, are also less pronounced. This suggests that the presence of diabetes may alter typical metabolic relationships.

Summary

The results of this study provide valuable insights into the demographic and biochemical differences between control and diabetic groups, with further distinctions between male and female participants. The correlation analysis highlights how diabetes

Discussion

The findings of this study reveal significant differences between diabetic and non-diabetic groups across several key biochemical and demographic parameters. The study also highlights important gender differences within both groups and provides insights into how diabetes may alter typical metabolic relationships. These findings align with existing literature and offer new perspectives on the management and understanding of diabetes in the studied population.

Fasting Blood Glucose and its Implications

As expected, fasting blood glucose (FBG) levels were significantly higher in the diabetic group compared to the non-diabetic group. This result aligns with the pathophysiology of type 2 diabetes mellitus (T2DM), where insulin resistance leads to impaired glucose uptake and increased blood glucose levels【6,16】. Elevated FBG is a well-established marker of diabetes and is strongly associated with the risk of developing diabetic complications, including cardiovascular disease and nephropathy【4,17】. The strong association between FBG and BMI in the non-diabetic group, which weakens in the diabetic group, suggests that once diabetes is established, the direct influence of obesity on glucose levels may be moderated by other factors, such as medication use, dietary changes, or variations in insulin sensitivity【18】.

The Role of BMI and Waist Circumference

Body mass index (BMI) and waist circumference are critical indicators of obesity and are known risk factors for developing T2DM【2,19】. In this study, BMI and waist circumference were comparable between the control and diabetic groups, reflecting the high prevalence of obesity in the general population【3,5】. However, the correlation analysis revealed that the relationship between BMI, waist circumference, and FBG was stronger in the non-diabetic group. This finding supports the notion that while obesity is a key driver in the onset of diabetes, its role becomes more complex once diabetes is established, likely due to the interplay of multiple metabolic and hormonal factors【20,21】.

The significant gender differences observed in BMI and waist circumference, with females generally showing higher values, are consistent with existing research indicating that women may accumulate more central fat compared to men, particularly after menopause【22】. This pattern of fat distribution is associated with a higher risk of metabolic syndrome and T2DM, emphasizing the need for gender-specific approaches in diabetes prevention and management【23】.

Uric Acid and its Association with Metabolic Health

Uric acid levels were significantly higher in the diabetic group, which is consistent with previous studies linking hyperuricemia to insulin resistance and metabolic syndrome【7,8,9】. Uric acid is not only a byproduct of purine metabolism but also a potential marker of oxidative stress and inflammation, both of which are elevated in T2DM【24,25】. The negative correlation between uric acid and FBG in the control group suggests that lower uric acid levels may be protective against hyperglycemia in non-diabetic individuals. However, this relationship was less pronounced in the diabetic group, indicating that the metabolic environment in diabetes may disrupt the typical interactions between uric acid and glucose metabolism【26】.

The observed gender differences in uric acid levels, with males generally having higher levels, are well-documented in the literature and are thought to be influenced by hormonal differences, particularly the effects of estrogen, which promotes uric acid excretion in women【10,27】. This gender disparity in uric acid levels may partially explain the higher prevalence of gout and cardiovascular diseases in men, conditions that are also linked to hyperuricemia【28】.

Hematological Parameters: RBC, PCV, and WBC

The study found significant differences in red blood cell (RBC) count and packed cell volume (PCV) between genders, with males generally showing higher values. This is consistent with the known effects of testosterone on erythropoiesis, leading to higher hematocrit levels in men【29】. Interestingly, while there were no significant differences in WBC count between genders, the diabetic group had slightly lower WBC counts compared to the control group. This could reflect a complex immune response in diabetic individuals, where chronic low-grade inflammation is present but does not necessarily translate into elevated WBC counts【30】.

The correlation analysis also highlighted that in the non-diabetic group, RBC and PCV were positively correlated, indicating a strong relationship between red cell mass and overall blood volume. In contrast, these correlations were weaker in the diabetic group, suggesting that diabetes might affect erythropoiesis or red cell survival, possibly due to complications like diabetic nephropathy or anemia of chronic disease【13,31】.

Clinical Implications and Future Research

The results of this study underscore the importance of regular monitoring of biochemical and hematological parameters in diabetic patients. The altered correlations between key variables in the diabetic group highlight the need for comprehensive management strategies that go beyond glycemic control to address the broader metabolic disruptions associated with diabetes【32】.

Future research should focus on exploring the mechanisms underlying these altered correlations in diabetes, particularly the role of chronic inflammation, oxidative stress, and hormonal imbalances. Longitudinal studies are also needed to determine how these relationships evolve over time and their impact on the progression of diabetic complications【33】.

Conclusion

In conclusion, this study provides valuable insights into the differences in metabolic and hematological profiles between diabetic and non-diabetic individuals. The significant gender differences observed further emphasize the need for personalized approaches in diabetes care. By understanding the complex interactions between various metabolic parameters in diabetes, healthcare providers can better tailor interventions to improve outcomes for patients with diabetes.

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