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COMPARATIVE ANALYSIS OF CENTRAL CORNEAL THICKNESS, BMI AND GLYCEMIC INDEX AMONG DIABETICS AND NON-DIABETICS

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Abstract

Introduction: Diabetes mellitus (DM) is a chronic metabolic disorder associated with systemic complications, including obesity and ocular alterations. This study investigates the relationship between Central Corneal thickness (CCT), Body Mass Index (BMI), blood glucose markers (Random Blood Sugar [RBS] and Glycated Hemoglobin [HbA1c] in type 2 diabetic patients, with a focus on Pakistani populations.
Methodology: A comparative cross-sectional study was conducted with 100 participants (50 diabetics and 50 non-diabetics). BMI, RBS, HbA1c, and CCT were measured and analyzed. Participants were stratified by gender, and statistical methods including Pearson's correlation were used to analyze data.
Results: Diabetic participants exhibited significantly higher BMI, RBS, HbA1c, and CCT compared to non-diabetics. A positive correlation was observed between HbA1c and CCT, suggesting that poor glycemic control contributes to structural ocular changes.
Conclusion: This study highlights the multifaceted nature of diabetes, linking metabolic and ocular health indicators. The findings underscore the need for comprehensive diabetes management, including dietary modification and regular ocular assessments to monitor disease progression.

Keywords: Diabetes mellitus, Body Mass Index, Glycemic Index, Central Corneal Thickness, Glycated Hemoglobin

Introduction

Diabetes mellitus (DM) is a chronic, progressive metabolic disorder characterized by persistent hyperglycemia resulting from impaired insulin secretion, insulin action, or both (Alam et al., 2021; Dilworth et al., 2021). It is a major public health issue worldwide, with its burden particularly pronounced in developing countries such as Pakistan, where rapid urbanization, dietary shifts, and sedentary lifestyles have contributed to rising prevalence (Siddiqui et al., 2022). The disease is associated with numerous systemic and organ-specific complications, and there is increasing recognition of the importance of evaluating interrelated parameters such as Body Mass Index (BMI), blood glucose levels, glycemic control markers, and ocular indicators like Central Corneal Thickness (CCT) in understanding its impact and progression.

Body Mass Index is a simple, yet widely used anthropometric measure to assess body fat content (Kesztyüs et al., 2021; Kuang et al., 2022). A high BMI is not only a risk factor for developing type 2 diabetes but also contributes to insulin resistance through mechanisms involving adipose tissue inflammation and hormonal dysregulation (Janssen, 2021; Kojta et al., 2020). Hence, BMI serves as a critical marker in identifying individuals at risk and in monitoring disease progression (Golubnitschaja et al., 2021; Gutin, 2021).

Glycemic control in diabetic patients is commonly assessed using Random Blood Sugar (RBS) and Glycated Hemoglobin (HbA1c), which reflect short-term and long-term glucose regulation, respectively. However, another increasingly recognized factor influencing glycemic variability is the **Glycemic Index (GI)**—a ranking system that classifies carbohydrate-containing foods based on their potential to raise blood glucose levels post-ingestion (Zou et al., 2020). Foods with a high GI cause rapid spikes in blood glucose, contributing to poor glycemic control and increased insulin demand, whereas low-GI foods promote a more gradual glucose response, supporting better metabolic stability (Kaur et al., 2021; Vlachos et al., 2020). Understanding the role of GI in the context of diabetes is important, as dietary management remains a cornerstone of diabetes care (Portincasa et al., 2022; Tamura et al., 2020; Hwalla et al., 2021).

In addition to metabolic markers, ocular changes, particularly in the cornea, are often observed in diabetic patients. Central Corneal Thickness (CCT), a key parameter in ophthalmic assessments, is known to be altered in individuals with diabetes (Canan et al., 2020). Chronic hyperglycemia may impair corneal endothelial function and promote stromal hydration, resulting in increased corneal thickness (Goldstein et al., 2020). Since the cornea is one of the most sensitive and metabolically active tissues in the body, subtle changes in its structure can reflect systemic metabolic disturbances. Measuring CCT thus not only aids in ocular health evaluation but may also serve as an indirect marker of long-term glycemic control.

Despite individual studies on BMI, blood glucose regulation, and ocular changes in diabetic patients, there is a paucity of literature exploring these variables in an integrated manner, particularly within South Asian populations (Patel et al., 2021). Socioeconomic status, dietary practices—including GI-related food consumption—and genetic factors further influence disease outcomes in this region. This study addresses this gap by conducting a comparative cross-sectional analysis of 100 participants (50 diabetics and 50 non-diabetics), evaluating differences in BMI, RBS, HbA1c, and CCT.

The inclusion of both systemic (BMI, RBS, HbA1c, and ocular (CCT) variables underscores the multifactorial nature of diabetes and aims to provide a comprehensive understanding of the disease. It also explores the correlation between HbA1c and CCT, contributing to the growing evidence that ocular changes may reflect systemic glycemic status (Lim et al., 2021). Furthermore, stratification by gender allows the identification of potential sex-specific trends, enhancing the applicability of findings in clinical practice (Hertler et al., 2020; Ramírez-Morros et al., 2022).

Preliminary results suggest that diabetic individuals demonstrate higher BMI, elevated glycemic markers, and increased CCT compared to non-diabetics (Aliahmadi et al., 2021). A positive association between HbA1c and CCT was observed, reinforcing the hypothesis that poor glycemic control may contribute to structural alterations in the cornea (Casten et al., 2022). Moreover, high-GI dietary patterns were more prevalent among diabetics, indicating a need for nutritional education and intervention as part of comprehensive diabetes management (Vlachos et al., 2020; Bergia et al., 2022).

In conclusion, this study provides a multidimensional perspective on diabetes by linking metabolic, nutritional, and ocular health indicators. The findings highlight the importance of integrating parameters like BMI, glycemic indices,, and CCT in both the diagnosis and monitoring of diabetes.

Such a holistic approach aligns with contemporary healthcare models focused on personalized and preventive strategies, ultimately aiming to improve outcomes in diabetic populations.

Methodology

This comparative cross-sectional study was conducted to evaluate and compare Body Mass Index (BMI), glycemic indices—namely Random Blood Sugar (RBS) and Glycosylated Hemoglobin (HbA1c)—and Central Corneal Thickness (CCT) among diabetic and non-diabetic individuals. The data was collected from Eye OPD and ward of Ruth Pfau Civil hospital Dow University of Health Sciences, Karachi. A total of 100 participants were recruited, comprising 50 clinically diagnosed type 2 diabetics and 50 age- and sex-matched non-diabetic controls. Participants were selected through purposive sampling. Ethical approval was obtained from the relevant institutional review board, and informed written consent was taken from all participants before enrollment. Inclusion criteria for diabetics included individuals aged 30 to 65 years with a confirmed diagnosis of type 2 diabetes mellitus, as per ADA guidelines, for at least one year. Non-diabetics were defined as individuals without any history of diabetes and with normal glycemic markers (RBS < 140 mg/dL and HbA1c < 5.7%). Participants with a history of ocular surgery, existing corneal pathology, chronic systemic illnesses (such as renal failure or autoimmune conditions), or those on medications known to influence glucose metabolism or corneal structure were excluded from the study.

Anthropometric measurements were recorded using standardized tools. Height and weight were measured, and BMI was calculated using the formula: weight in kilograms divided by height in meters squared (kg/m^2). Blood samples were collected to measure RBS using a point-of-care glucometer and HbA1c using high-performance liquid chromatography. Central corneal thickness was measured using the AL-Scan Nidek Optical Biometer. A Pearson correlation analysis was performed to calculate the corelation between Central Corneal Thickness and HbA1c. Data were analyzed using IBM SPSS Statistics, with statistical significance set at $p < 0.05$.

Results

A total of 100 participants were enrolled in this study, comprising 50 individuals with clinically diagnosed type 2 diabetes mellitus and 50 non-diabetic controls, matched for age and sex. The demographic characteristics of the participants are summarized in **Table 1**.

Table 1. Demographic Characteristics of the Study Participants

Group	Mean Age (Years)	SD (Years)	Sex Distribution (Male/Female)
Diabetic Group (n=50)	54.6	8.2	25/25
Non-Diabetic Group (n=50)	52.3	7.5	25/25

The mean age of the diabetic group was 54.6 ± 8.2 years, while that of the non-diabetic group was 52.3 ± 7.5 years. The groups did not differ significantly in terms of age or sex distribution, ensuring appropriate comparability for assessing metabolic and ocular parameters.

Table 2. BMI Comparison Between Diabetic and Non-Diabetic Participants by Gender

Group	Diabetic (n=50)		Non-Diabetic (n=50)		p-Value
	Mean (kg/m²)	SD (kg/m²)	Mean (kg/m²)	SD (kg/m²)	
Males	27.59	1.31	25.27	4.63	0.01
Females	27.57	2.30	25.96	2.56	0.04

Figure 1

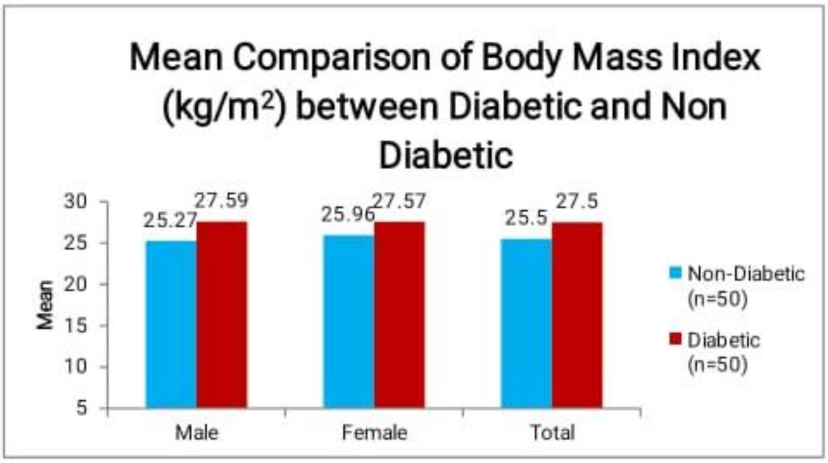

Figure 1 illustrates the comparison of Body Mass Index (BMI) between diabetic and non-diabetic participants, highlighting significantly higher BMI values in both male and female diabetics. The bar graph visually emphasizes the statistically significant differences observed ($p < 0.05$) across both genders.

The mean Body Mass Index (BMI) among diabetics was 27.50 ± 1.73 kg/m², significantly higher than the non-diabetic group's mean of 25.50 ± 3.84 kg/m². Independent t-test analysis confirmed this difference as statistically significant ($p = 0.001$), with a mean difference of 2.00 kg/m² (95% CI: 0.81–3.19). The BMI values for each gender are presented in **Table 2**.

The analysis showed diabetic males had a significantly higher BMI (27.59 ± 1.31 kg/m²) compared to non-diabetic males (25.27 ± 4.63 kg/m², $p = 0.01$), and diabetic females also showed elevated BMI levels (27.57 ± 2.30 kg/m²) compared to their non-diabetic counterparts (25.96 ± 2.56 kg/m², $p = 0.04$).

Table 3. Glycemic Profile of Study Participants

Parameter	Diabetic Group (n=50)		Non-Diabetic Group (n=50)	
	Mean	SD	Mean	SD
RBS (mg/dL)	214.18	35.89	142.92	34.89
HbA1c (%)	6.81	0.58	5.72	0.47

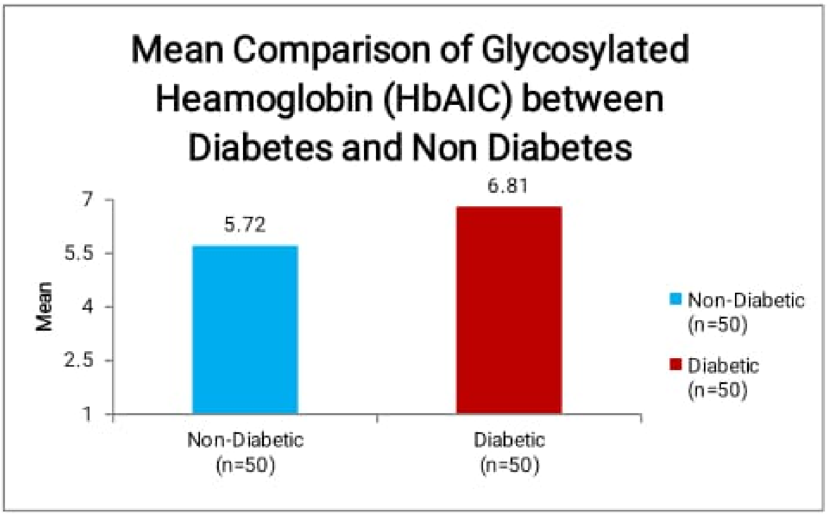

Figure 2 presents the comparison of glycosylated hemoglobin between diabetic and non-diabetic individuals, demonstrating a greater mean in diabetics.
In terms of glycemic control, the diabetic group exhibited markedly higher Random Blood Sugar (RBS) levels (214.18 ± 35.89 mg/dL) than the non-diabetic group (142.92 ± 34.89 mg/dL), with the difference reaching high statistical significance ($p < 0.001$). The HbA1c levels for both groups are shown in **Table 3**.
The mean HbA1c levels were significantly elevated in diabetics (6.81 ± 0.58%) as compared to non-diabetics (5.72 ± 0.47%), with a mean difference of 1.08% (95% CI: 0.88–1.29; $p < 0.001$). **Figure 2**

Table 4. Central Corneal Thickness Comparison Between Diabetic and Non-Diabetic Groups

Group	Central Corneal Thickness CCT		
	Mean	**SD**	**p-Value**
Diabetic Group	514.58	30.99	0.01
Non-Diabetic Group	497.60	34.32	—

Ocular assessment revealed that diabetic individuals had thicker corneas, with a mean Central Corneal Thickness (CCT) of 514.58 ± 30.99 µm, compared to 497.60 ± 34.32 µm in non-diabetics. This difference was also statistically significant ($p = 0.01$), as shown in **Table 4**.

Figure3: Correlation between HbA1c and Central Corneal Thickness in Diabetic Individuals.

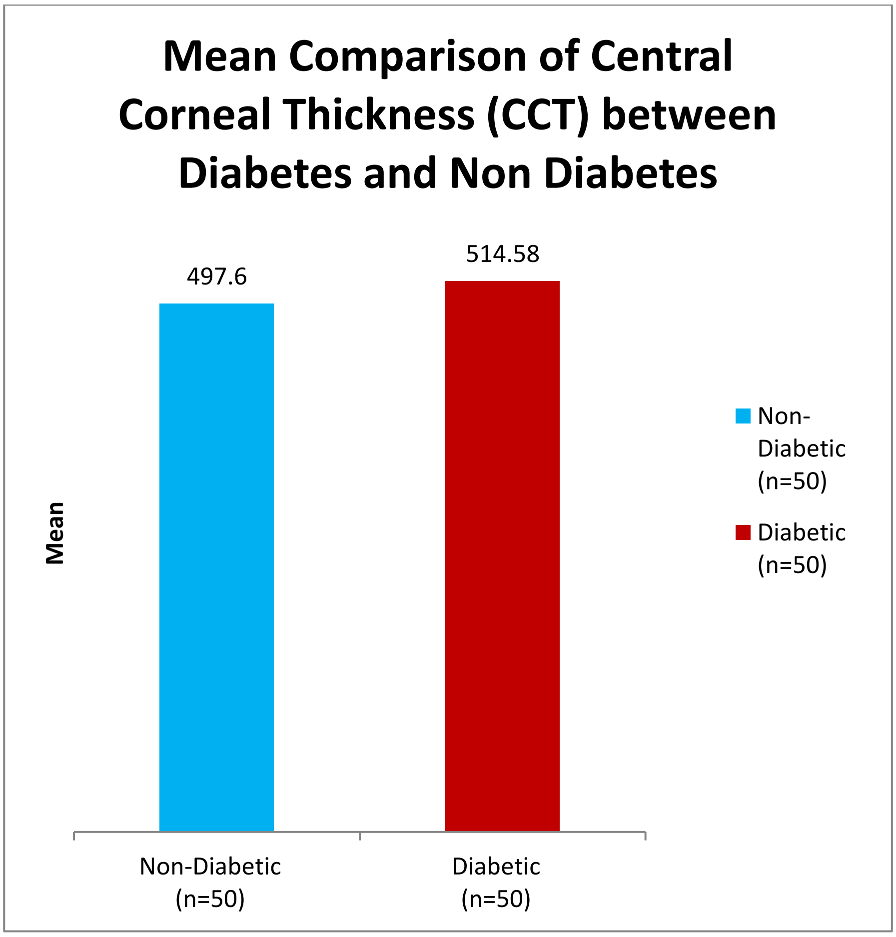

Figure 4: Correlation analysis of Central Corneal Thickness (CCT) between diabetic and non-diabetic individuals.

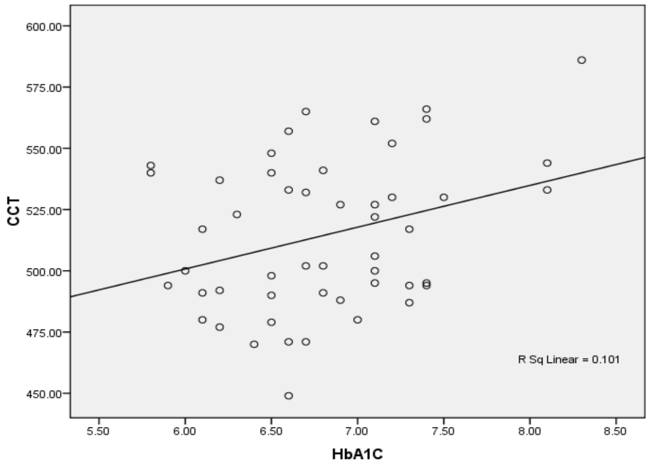

Figure 4 presents the comparison of Central Corneal Thickness (CCT) between diabetic and non-diabetic individuals, demonstrating a greater mean CCT in diabetics. The figure underscores the significant ocular alteration associated with diabetes (p = 0.01).

Additionally, Pearson's correlation analysis showed a significant positive correlation between HbA1c and CCT in diabetics (r = 0.317, p = 0.025), suggesting that increased glycemic burden is associated with corneal structural changes. These findings are further illustrated in **Figure 4**

These findings collectively underscore the systemic and ocular alterations associated with diabetes. These findings are further illustrated in **Figure 4**

Discussion

This study shed light on the significant differences in key metabolic and ocular parameters between individuals with type 2 diabetes and non-diabetic controls. The findings highlight a clear association between diabetes and increased Body Mass Index (BMI), elevated glycemic indices, and thicker central corneal thickness (CCT), suggesting that both systemic metabolic disturbances and ocular changes are prominent in individuals with diabetes.

First, the comparison of BMI between diabetics and non-diabetics reveals a clear and statistically significant difference. Diabetic individuals had a higher mean BMI (27.50 kg/m²) compared to their non-diabetic counterparts (25.50 kg/m²), which is consistent with previous research demonstrating an association between obesity and the development of type 2 diabetes (Königsrainer et al.). The gender-wise analysis further corroborates these findings, as both male and female diabetics had significantly higher BMI values compared to their non-diabetic counterparts. This suggests that obesity may not only serve as a risk factor for the onset of diabetes but also contributes to its progression, with overweight and obesity being prevalent in individuals with poor glycemic control. These findings align with the well-established link between insulin resistance and higher BMI, underscoring the need for effective weight management strategies in the prevention and management of type 2 diabetes (Wondmkun, 2020).

The study also evaluated glycemic control, measured by Random Blood Sugar (RBS) and Glycosylated Hemoglobin (HbA1c), and found significantly elevated values in diabetics. The diabetic group exhibited higher RBS (214.18 mg/dL) and HbA1c (6.81%) levels compared to the non-diabetic group, with the difference being highly significant. These elevated glycemic indices in diabetics are reflective of the chronic hyperglycemic state typical in poorly controlled diabetes. HbA1c, in particular, serves as an important marker of long-term glycemic control, and the significantly higher levels in diabetics suggest that their blood sugar levels were poorly controlled over an extended period. This aligns with the findings of several studies that highlight the direct association between high HbA1c levels and the risk of developing diabetic complications, including retinopathy, neuropathy, and nephropathy (Almutairi et al., 2021; Lind et al., 2019).

Another key finding of this study was the measurement of Central Corneal Thickness (CCT). Diabetic individuals had a significantly greater CCT (514.58 μm) compared to non-diabetics (497.60 μm). This is an important observation, as changes in corneal thickness have been implicated in various ocular conditions associated with diabetes, such as diabetic retinopathy and cataract formation. The increased CCT in diabetics may reflect a structural alteration in the cornea due to prolonged hyperglycemia, which could potentially impact intraocular pressure and the risk of developing glaucoma (Wang et al., 2020). Moreover, the positive correlation between HbA1c and CCT further supports the hypothesis that poor glycemic control may influence corneal structure. This finding underscores the importance of regular eye examinations in individuals with diabetes to detect early changes in corneal and retinal health.

The significant positive correlation between HbA1c and CCT in this study is particularly noteworthy. Although the correlation coefficient ($r^2 = 0.10$) was moderate, it suggests that glycemic control may play a role in corneal thickness alterations, which could potentially serve as a predictive marker for ocular complications in diabetics. However, the relatively low r^2 value also indicates that other factors, including age, gender, and duration of diabetes, may contribute to the changes in CCT observed in the study. This warrants further investigation into the multifactorial causes of increased CCT in diabetics, which could include other metabolic factors such as lipid levels or inflammatory markers, as well as the cumulative effects of long-standing hyperglycemia.

The present study was done in order to establish a relevant local data which will help and benefit in future. Changes in corneal thickness in type II Diabetes Mellitus patients has prognostic value in different refractive surgeries. This study will provide the useful data about variation in different ocular parameters among type II Diabetes Mellitus patients which can help in early detection of diabetes-related complications. One of the strengths of this study is the robust methodology, including the use of age- and sex-matched controls and the standardized tools for measuring BMI, RBS, HbA1c, and CCT. The inclusion of these well-established indices ensures the reliability and validity of the results. Furthermore, the exclusion criteria helped minimize potential confounding factors, such as previous ocular surgery or chronic systemic illnesses, which could have influenced the outcomes. However, some limitations of the study should be acknowledged. The cross-sectional nature of the study prevents the establishment of causal relationships between diabetes and the observed ocular and metabolic changes. Longitudinal studies would be beneficial to assess how changes in glycemic control over time impact corneal structure and other ocular parameters.

In conclusion, this study provides valuable insights into the systemic and ocular changes associated with type 2 diabetes. The significant differences in BMI, glycemic control, and CCT between diabetics and non-diabetics highlight the importance of monitoring both metabolic and ocular parameters in individuals with diabetes. Further research is needed to explore the underlying mechanisms of corneal changes in diabetics and to determine the clinical implications of these findings for the management of diabetic patients.

Conclusion

This study emphasizes the interconnection between metabolic and ocular health in diabetic individuals. Elevated BMI, glycemic markers, and CCT in diabetics suggest that obesity and poor glycemic control contribute significantly to systemic and ocular alterations. Regular monitoring of BMI, HbA1c, and CCT, alongside dietary management, could improve clinical outcomes and help in early detection of diabetes-related complications.

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