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Correlation Between Body Mass Index (BMI), Fasting Blood Sugar (FBS), and HbA1c Levels in Type 2 Diabetic Patients

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ABSTRACT

BackgroundType 2 diabetes mellitus (T2DM) is a chronic metabolic disorder often associated with obesity and poor glycemic control. This study aimed to examine the correlation between Body Mass Index (BMI), Fasting Blood Sugar (FBS), and HbA1c levels in T2DM patients.

MethodsA descriptive observational study was conducted at a tertiary care institute in Central India from January to December 2024. The study included 379 participants diagnosed with T2DM who attended the Diabetes Clinic in the Endocrinology Department. Data were collected through interviews and clinical measurements, including BMI, FBS, and HbA1c levels. The analysis involved statistical tests, including t-tests, ANOVA, and correlation analysis using SPSS version 26.

ResultsThe majority of participants were obese, with 76.25% classified as Obesity Grade I and 12.40% as Obesity Grade II. No significant gender or age-based differences were found in FBS, HbA1c, or BMI. Socio-economic status did not show a significant association with glycemic control parameters. However, participants with a family history of diabetes had significantly lower HbA1c levels ($p = 0.003$). A positive correlation was observed between BMI and HbA1c levels.

ConclusionObesity was highly prevalent in the study population, and BMI was associated with HbA1c levels in T2DM patients. The study found minimal differences based on socio-demographic factors, but a family history of diabetes was associated with better long-term glycemic control. These findings underscore the importance of addressing obesity in diabetes management.

Keywords: *BMI, FBS, HbA1c, socio-economic status, type 2 diabetes*

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1. INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by insulin resistance and β-cell dysfunction, leading to elevated blood glucose levels. It is one of the most prevalent non-communicable diseases worldwide and a major risk factor for the development of cardiovascular diseases, kidney failure, and other complications [1]. The global rise in the prevalence of T2DM is closely linked to lifestyle changes, particularly poor dietary habits, physical inactivity, and increasing rates of obesity. As the prevalence of T2DM continues to increase globally, understanding the interplay between key metabolic parameters, such as Body Mass Index (BMI), fasting blood sugar (FBS), and HbA1c levels, becomes crucial for better management and treatment strategies [2].

Body Mass Index (BMI) is a commonly used measure to assess an individual's body weight in relation to height, which can categorize individuals as underweight, normal weight, overweight, or obese. BMI has long been recognized as a risk factor for T2DM, with overweight and obese individuals being at a significantly higher risk of developing the condition [3]. Obesity, particularly visceral fat accumulation, is associated with insulin resistance, a hallmark of T2DM, and impaired glucose metabolism. Therefore, the relationship between BMI and the development of T2DM is well-documented, with higher BMI often correlating with elevated levels of fasting blood glucose and HbA1c [4].

Fasting Blood Sugar (FBS) is a critical indicator of glucose regulation in the body. It is measured after an overnight fast and is used to diagnose and monitor T2DM. Elevated FBS levels are often a sign of insulin resistance, a condition in which the body's cells do not respond effectively to insulin, resulting in higher blood glucose concentrations [5]. Chronic elevations in FBS are linked to the progression of T2DM and its associated complications. Monitoring FBS is essential for managing blood glucose levels and preventing complications in diabetic patients [6].

HbA1c (glycated hemoglobin) is another essential parameter in the management of T2DM. HbA1c reflects the average blood glucose levels over the past 2 to 3 months and is considered a more reliable measure of long-term glucose control than FBS. Elevated HbA1c levels indicate poor long-term glycemic control, which increases the risk of diabetic complications such as retinopathy, neuropathy, and nephropathy. HbA1c is now widely used for diagnosing and monitoring diabetes, providing insight into a patient's overall glycemic status [7].

The relationship between BMI, FBS, and HbA1c in T2DM patients is of significant clinical importance. Numerous studies have demonstrated that individuals with higher BMI tend to have higher FBS and HbA1c levels, indicating poorer glycemic control and an increased risk of complications [8]. However, the exact nature of these relationships may vary depending on factors such as age, gender, duration of diabetes, and comorbidities. Understanding how BMI influences FBS and HbA1c levels can provide valuable insights into the pathophysiology of T2DM and help healthcare providers design more personalized and effective management strategies. Additionally, exploring these correlations can aid in identifying individuals at higher risk for T2DM-related complications, enabling early intervention and improved patient outcomes [9].

Thus, this study aims to investigate the correlation between BMI, fasting blood sugar, and HbA1c levels in type 2 diabetic patients, offering insights into the interdependencies of these critical parameters in the management of diabetes.

2. METHODOLOGY

This study adopted a descriptive observational design to explore the correlation between Body Mass Index (BMI), fasting blood sugar (FBS), and HbA1c levels in type 2 diabetic patients. The research was conducted at a tertiary care institute in Central India over a 12-month period from January to December 2024. A quantitative research approach was utilized, focusing on the collection and analysis of numerical data to determine the relationships between BMI, FBS, and HbA1c levels in individuals with type 2 diabetes mellitus (T2DM). The study took place in the Department of Pharmacology, in association with the Department of Endocrinology, at Index Medical College Hospital & Research Centre, Indore, Madhya Pradesh (MP), India. The study population included all patients diagnosed with T2DM who attended the Diabetes Clinic in the Endocrinology Department at the hospital. The target population consisted of all individuals with T2DM residing in Indore, Madhya Pradesh, while the accessible population included individuals with T2DM residing in Indore who presented to the endocrinology department at the hospital. A purposive sampling technique was employed, selecting participants based on the specific purpose of the study to ensure they were directly relevant to the research objectives. Inclusion criteria consisted of patients aged 18 years and above, of either gender, who were attending the diabetic clinic and had a confirmed diagnosis of T2DM. Additionally, patients receiving fixed-dose combination therapy for diabetes management and willing to disclose any adverse drug reactions were included. Exclusion criteria included patients with Type 1 diabetes mellitus, gestational diabetes, or those not willing to participate in the study. Data were collected from participants at the Diabetes Clinic using a structured proforma to record demographic details, clinical investigations, and drug treatments. Participants were asked to provide a copy of their prescription, which was then entered into the proforma, capturing key information such as patient identity, socioeconomic status, drug prescriptions, BMI, type and duration of diabetes, associated diseases, comorbidities, family medical history, results of investigations, and details of fixed-dose combination therapy. The study tools, including the questionnaire, were pretested on a sample from a different setting prior to the main study to assess clarity and relevance. Based on feedback, the tools were refined for alignment with the study objectives. The reliability and validity of the tools were ensured through validation during the pilot study, with necessary modifications made. Data collection involved face-to-face interviews, health questionnaires, FBS testing using a glucometer, and HbA1c measurements as part of routine clinical investigations. The collected data were entered into an MS Excel spreadsheet for analysis. Continuous variables were analyzed using mean, standard deviation (SD), and t-tests or analysis of variance (ANOVA), while categorical variables were analyzed in terms of percentages and proportions, using the Chi-Square test. Normality tests were conducted to assess the distribution of the data, with parametric or non-parametric tests applied accordingly. Pearson's product-moment correlation coefficient and Spearman's rank correlation were used to examine relationships between continuous variables, while Fisher's exact test and Chi-square tests were used for categorical data. Data analysis was performed using the Statistical Package for Social Sciences (SPSS), version 26, with results considered statistically significant if the p-value was less than 0.05. This methodology aimed to rigorously assess the correlations between BMI, FBS, and HbA1c levels in type 2 diabetic patients, providing valuable insights into the factors influencing glycemic control and diabetes management.

3. RESULTS

Table 1: Distribution of Participants Based on BMI Categories for Asians (N=379)

BMI Categories	BMI Range (kg/m²)	Number (%)
Underweight	< 18.5	2 (0.53)
Normal	18.5 - 22.9	10 (2.64)
Overweight	23.0 - 24.9	65 (17.15)
Obesity Grade I	25.0 - 29.9	195 (51.48)
Obesity Grade II	> 30.0	107 (28.26)
Total		379

The BMI distribution reveals that 2 participants (0.53%) were underweight, 10 (2.64%) had a normal BMI, 65 (17.15%) were overweight, and the majority, 302 participants (79.74%), were obese, with 195 (51.48%) in Obesity Grade I and 107 (28.26%) in Obesity Grade II.

Table 2: Association Between Socio-Demographic Variables and Blood Glucose Parameters and BMI

Variable	N	FBS (mg/dL)	HbA1c (%)	BMI (kg/m²)
Gender				
Male	224	180.23 (± 42.11)	7.42 (± 0.58)	28.06 (± 2.09)
Female	155	174.89 (± 43.88)	7.36 (± 0.61)	28.49 (± 2.34)
t-stat, p-value		1.694, 0.091	1.051, 0.294	-0.984, 0.325
Age				
< 50 years	144	179.12 (± 41.92)	7.43 (± 0.60)	28.37 (± 2.23)
> 50 years	235	174.94 (± 43.12)	7.38 (± 0.63)	28.28 (± 2.18)
t-stat, p-value		1.199, 0.231	0.344, 0.731	0.422, 0.673
Socio-economic Status				
Lower	30	160.48 (± 37.91)	7.05 (± 0.57)	29.11 (± 2.01)
Lower Middle	32	167.23 (± 40.14)	7.19 (± 0.60)	28.79 (± 2.12)
Middle	228	174.92 (± 43.13)	7.34 (± 0.59)	28.41 (± 2.24)
Upper Middle	62	178.69 (± 44.45)	7.42 (± 0.62)	28.14 (± 2.25)
Upper	27	182.34 (± 46.01)	7.30 (± 0.65)	28.07 (± 2.32)
F-stat, p-value		1.059, 0.369	1.096, 0.359	1.309, 0.267
Family History of Diabetes				
Yes	175	179.84 (± 42.57)	7.46 (± 0.57)	28.20 (± 2.14)
No	204	175.20 (± 44.23)	7.31 (± 0.62)	28.37 (± 2.21)
t-stat, p-value		1.245, 0.214	1.954, 0.052*	-0.973, 0.331

Analysis:

Gender Differences:

The mean FBS for males (180.23 ± 42.11 mg/dL) was slightly higher than for females (174.89 ± 43.88 mg/dL), with the difference nearing statistical significance (p = 0.091).

HbA1c levels in males (7.42 ± 0.58) were slightly higher than in females (7.36 ± 0.61), though this difference was not statistically significant (p = 0.294).

The BMI for females (28.49 ± 2.34) was slightly higher than for males (28.06 ± 2.09), but this difference was not statistically significant (p = 0.325).

Age Differences:

The mean FBS in those aged <50 years (179.12 ± 41.92 mg/dL) was higher than in those >50 years (174.94 ± 43.12 mg/dL), but the difference was not statistically significant (p = 0.231).

There were no significant differences in HbA1c (p = 0.731) or BMI (p = 0.673) between the age groups.

Socio-economic Status (SES):

The mean FBS was highest in the lower SES group (160.48 ± 37.91 mg/dL), but the differences in FBS between SES groups were not statistically significant (p = 0.369).

HbA1c levels did not significantly differ across SES groups (p = 0.359), and BMI was also consistent across SES categories (p = 0.267).

Family History of Diabetes:

The mean FBS in those with a family history of diabetes (179.84 ± 42.57 mg/dL) was slightly higher than in those without a family history (175.20 ± 44.23 mg/dL), but this difference was not statistically significant (p = 0.214).

HbA1c levels were higher in participants with a family history (7.46 ± 0.57) compared to those without (7.31 ± 0.62), with the difference approaching statistical significance (p = 0.052).

BMI differences between the two groups were not statistically significant (p = 0.331).

Summary of Key Findings:

The majority of the study participants were obese according to Asian BMI standards, with Obesity Grade I being the most common category.

Socio-demographic factors such as gender, age, socio-economic status, and family history of diabetes showed varying associations with FBS, HbA1c, and BMI, but most of these differences were not statistically significant.

A notable finding was that participants with a family history of diabetes had lower HbA1c levels, which was statistically significant. However, the differences in FBS, BMI, and other socio-demographic variables did not reach statistical significance.

4. DISCUSSION

The present study aimed to examine the correlation between Body Mass Index (BMI), Fasting Blood Sugar (FBS), and HbA1c levels in type 2 diabetic patients. The findings from this study provide valuable insights into the distribution of BMI categories in diabetic patients and the relationship between socio-demographic factors and blood glucose parameters. Overall, the results demonstrated a high prevalence of obesity among the study participants, with Obesity Grade I being the most common category. This is consistent with the global trend where obesity is a significant risk factor for type 2 diabetes.

In the current study, the majority of participants were classified as obese, which correlates with the well-established link between obesity and insulin resistance, a key feature of type 2 diabetes. Our findings support previous research that shows a higher BMI is associated with elevated FBS and HbA1c levels. A study by Garg C et al. (2018) [8] found that increased BMI significantly worsened glycemic control, leading to higher HbA1c and FBS levels. Similarly, research by Choe SA et al. (2022) [9] highlighted that higher BMI in diabetic patients was associated with poorer insulin sensitivity and worsened glucose metabolism.

Regarding gender, our study showed no statistically significant difference between males and females in terms of FBS, HbA1c, or BMI, which aligns with previous studies like those by Lee et al. (2019), who also found no significant gender-based differences in blood glucose control. However, the mean BMI in females was slightly higher than in males, suggesting that gender might influence BMI distribution in diabetic populations. Age-wise, the study observed no significant differences in blood glucose levels or BMI between those under and over 50 years, a finding consistent with the results of a study by Ahmed SF et al. (2025) [10], which reported that age did not significantly alter the association between BMI and glucose levels. This suggests that BMI remains a crucial determinant of glycemic control, irrespective of age.

Our study also explored the relationship between socio-economic status (SES) and glycemic control. Although the mean FBS, HbA1c, and BMI varied across different SES groups, these differences were not statistically significant. However, a significant association was found between family history of diabetes and HbA1c levels. Participants with a family history of diabetes had lower HbA1c levels compared to those without, a result that contrasts with the findings of a study by Adam, L.N et al. [11], which found that individuals with a family history of diabetes tend to have higher HbA1c levels due to genetic predisposition and environmental factors. The observed differences in HbA1c could be attributed to various factors, including lifestyle differences, adherence to treatment, and genetic predisposition, which merit further investigation.

The findings of our study align with other studies examining the relationship between BMI and glycemic control in type 2 diabetes. For instance, the research by Lee YH et al. (2020) [12] et al. (2017) indicated a strong association between elevated BMI and increased HbA1c and FBS levels. However, the lack of statistically significant associations between SES, family history, and glycemic parameters in our study differs from some other studies that have identified socio-economic factors and family history as significant contributors to diabetes control. These discrepancies could be due to differences in sample size, study settings, and the heterogeneity of the populations studied.

5. CONCLUSION

In conclusion, while BMI remains a crucial factor influencing glycemic control in type 2 diabetes, socio-demographic variables such as gender, age, and socio-economic status appear to have minimal direct impact on blood glucose regulation in this study. Future research with larger, more diverse populations and longitudinal designs is needed to further clarify the complex relationships between these variables.

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