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RESEARCH ARTICLE

PREVALENCE OF COGNITIVE DECLINE AMONG TYPE 2 DIABETES MELLITUS INDIVIDUALS: A CROSS-SECTIONAL STUDY

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Abstract

Introduction: People with Type 2 Diabetes Mellitus (T2DM) are more likely to experience cognitive deterioration, which can negatively affect their quality of life. Examining the prevalence of cognitive deterioration in T2DM individuals was the goal of this investigation.

Methods: Eighty participants in the study were allotted into two groups: forty T2DM patients (test group) and forty non-diabetic people (control group). The Montreal Cognitive Assessment (MoCA) was used to estimate cognitive function. We gathered and examined demographic information, BMI, smoking status, and educational attainment. Descriptive statistics, chi-square tests, and multivariate regression analysis using SPSS Version 23 were among the statistical studies performed.

Results: The test group had a notably lower MoCA score (22.1 ± 4.3) compared to the control group (27.5 ± 2.9), indicating cognitive impairment prevalence of 65% among T2DM patients versus 15% in controls ($p < 0.001$). Higher BMI was negatively correlated with cognitive performance ($\beta = -0.65$, $p < 0.001$), while education level was positively correlated ($\beta = 0.40$, $p < 0.01$). Smoking status showed a trend toward significance, with current smokers displaying lower cognitive scores.

Conclusion: The study highlights a significant prevalence of cognitive decline among T2DM patients in Mysuru, strongly associated with higher BMI, lower education levels, and smoking status.

Recommendations: Healthcare providers should prioritize cognitive assessments in T2DM management and implement lifestyle interventions targeting obesity, smoking cessation, and educational support to mitigate cognitive impairment in this population.

Keywords: *Type 2 Diabetes Mellitus, Cognitive Decline, Montreal Cognitive Assessment, Body Mass Index, Smoking, Education Level*

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BACKGROUND/INTRODUCTION

Insulin resistance and relative insulin shortage are the hallmarks of Type 2 Diabetes Mellitus (T2DM), a chronic metabolic disease that causes hyperglycemia and a host of other consequences affecting many organ systems. With an estimated 537 million adults worldwide expected to have T2DM in 2021 and a predicted 643 million by 2030, the prevalence of the disease has been dangerously increasing [1]. The rising incidence of diabetes is linked to cognitive decline as well as physical health issues, which is a developing worry in the treatment of type 2 diabetes. The quality of life, functional independence, and general well-being of those who are affected by cognitive impairment can all be greatly impacted [2].

Recent studies have demonstrated that T2DM is linked to various cognitive deficits, including impairments in memory, attention, and executive functions. The pathophysiology underlying cognitive decline in diabetes is multifactorial and includes chronic hyperglycemia, insulin resistance, inflammation, and vascular complications [3]. Hyperglycemia, particularly postprandial blood glucose levels, is associated with cognitive dysfunction, as elevated blood sugar levels can lead to oxidative stress and neuroinflammation [4,5]. Additionally, comorbid conditions commonly associated with diabetes, such as hypertension and dyslipidemia, may exacerbate cognitive decline through mechanisms like vascular damage.

Smoking and BMI are also linked to diabetes and cognitive impairment. Obesity is characterised by a BMI of 30 kg/m^2 or higher. Type 2 diabetes and cognitive impairment are linked to obesity [6]. A higher BMI increases dementia risk, including Alzheimer's [7]. Smoking is another controllable risk factor that impairs cognition. Research shows that smokers are more likely to develop dementia.

When it comes to cognitive resilience in diabetics, education level and cognitive reserve are also very important factors. Since more education may give people access to better coping mechanisms and tools for managing long-term illnesses like diabetes, higher educational attainment is associated with both improved cognitive function and a reduced risk of cognitive impairment [8].

Given the significant implications of cognitive decline in individuals with T2DM, it is essential to understand the prevalence and contributing factors to develop targeted interventions. This study aims to assess the prevalence of cognitive decline in T2DM patients.

MATERIALS AND METHODS

Study Design: A cross-sectional analysis.

Study Setting: The study took place in the General Medicine Department of a hospital, India, involving both inpatients and outpatients. Data collection took place over a specified period. The hospital setting allowed for easy access to patient records and

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facilitated the collection of demographic and medical information required for the study.

Participants

A total of 80 participants were comprised in the study, allotted equally into 2 groups. The test group consisted of individuals with T2DM, while the control group comprised individuals without T2DM, matched for age and gender.

Inclusion criteria

Participants in the test group could only join if they met the following requirements: they had to be between the ages of 30 and 60, have a verified diagnosis of T2DM, and be literate in both regional language and English. The control group was made up of people without diabetes but met the same age, gender, and literacy requirements.

Exclusion criteria

Both groups excluded participants with a history of T1DM, secondary diabetes, or gestational diabetes. In addition, individuals with psychiatric illnesses, neurological diseases, severe conditions such as cancer or autoimmune disorders, or those taking medications with psychoactive effects were excluded. Caregivers' consent was required where necessary.

Bias

Several measures were taken to minimize bias in this study. Selection bias was reduced by strictly adhering to the inclusion and exclusion criteria. Age and gender matching between the test and control groups ensured that the two groups were comparable, eliminating potential confounding factors related to demographic differences. Information bias was controlled through the use of a standardized data collection form and validated cognitive assessments, such as the Montreal Cognitive Assessment (MoCA), ensuring consistent measurement across all participants.

Variables

Educational level, smoking status, BMI, and cognitive function were crucial. BMI was calculated using WHO classification standards, and smoking status was current, ex-smoker, or non-smoker. Education level was measured by years of formal schooling, and grades were based on cognitive reserve research and preset criteria. Cognitive function was measured using the MoCA scale. Poor cognitive function was reflected by lower scores. Domain ratings ranged from 0 to 6. Patients provided additional postprandial blood sugar (PPBS) and medication adherence data to evaluate diabetes management.

Data Collection and Procedure

Participants were first divided into test and control groups. After informed consent was obtained, demographic information such as age, gender, and education level, along with medical history and lifestyle factors (BMI, smoking status), were collected. Cognitive function was assessed in both groups using the MoCA scale, where scores below 26 indicated cognitive impairment and scores above 26 indicated normal cognitive function. For the diabetic

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group, additional data on PPBS levels and adherence to medication were recorded through interviews and medical records. All data were entered into a specially designed data collection form, ensuring accuracy and consistency across participants.

Statistical Analysis

The data were analysed using SPSS 23. Means and standard deviations were utilised for continuous variables like age, BMI, and cognitive scores, and frequencies and percentages for categorical variables like smoking status and education level. Chi-square tests were performed to examine categorical variables, and Student's t-tests compared test and control group means. A multivariate correlational analysis examined the connections between cognitive deterioration, BMI, smoking, education, PPBS levels, and medication adherence in diabetics. MedCalc (Version 20.218) determined a p-value criterion of less than 0.05 to determine statistical significance.

Ethical considerations

The study protocol was approved by the Ethics Committee and written informed consent was received from all the participants.

RESULTS

The study involved 80 people in total, 40 of whom were T2DM patients in the test group and 40 of whom were non-diabetic persons in the control group (Table 1).

Table no.1: Demographic and Clinical Profile

Characteristic	Test Group	Control Group	p-value
Age (years)	45.5 ± 9.2	46.0 ± 8.8	0.81
Male	22:18	21:19	0.89
BMI (kg/m²)	27.4 ± 3.5	24.8 ± 2.9	<0.001
Smoking Status			
Current Smokers	10 (25%)	5 (12.5%)	0.12
Ex-Smokers	8 (20%)	7 (17.5%)	0.78
Non-Smokers	22 (55%)	28 (70%)	0.20
Education Score (years)	10.5 ± 4.0	12.0 ± 3.6	0.02

There was no statistically significant difference ($p = 0.81$) in the average age between the two groups. The BMI of the test group was found to be considerably higher (27.4 ± 3.5 kg/m²) than that of the control group (24.8 ± 2.9 kg/m²), suggesting a higher prevalence of obesity and overweight among patients with diabetes ($p < 0.001$). The test group's average education score was 10.5 ± 4.0 years, considerably lower than the control group's 12.0 ± 3.6 years ($p = 0.02$).

The MoCA findings are shown in Table 2. When comparing the test group's participants to the control group, the former showed noticeably lower overall MoCA scores.

Table no.2: MoCA Scores of Participants

Cognitive Domain	Test Group	Control Group	p-value
Total MoCA Score	22.1 ± 4.3	27.5 ± 2.9	<0.001
Naming	2.8 ± 0.9	3.6 ± 0.5	<0.001
Attention	4.3 ± 1.2	5.2 ± 0.8	<0.001
Language	2.2 ± 0.8	2.8 ± 0.4	<0.01
Abstraction	1.5 ± 0.9	2.1 ± 0.7	<0.01
Delayed Recall	2.1 ± 1.3	3.8 ± 0.6	<0.001
Orientation	4.2 ± 0.6	5.0 ± 0.0	<0.001

The overall MoCA score for the test group was significantly lower at 22.1 ± 4.3 compared to 27.5 ± 2.9 in the control group ($p < 0.001$). Each cognitive domain also revealed significant deficits in the test group, particularly in areas such as delayed recall (2.1 ± 1.3 vs. 3.8 ± 0.6; $p < 0.001$) and orientation (4.2 ± 0.6 vs. 5.0 ± 0.0; $p < 0.001$).

MoCA scores were used to estimate the prevalence of cognitive impairment among subjects; a score of less than 26 indicated cognitive decline. Table 3 provides a summary of the findings.

Table no.3: Prevalence of Cognitive Impairment

Group	Cognitive Impairment	No Cognitive Impairment	Total
Test Group	26 (65%)	14 (35%)	40
Control Group	6 (15%)	34 (85%)	40

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Cognitive impairment was considerably more prevalent in the test group, with 26 out of 40 participants (65%) exhibiting cognitive decline compared to only 6 out of 40 participants (15%) in the control group ($p < 0.001$).

The association between smoking status, education level, BMI, and other variables with cognitive deterioration was investigated using a multivariate approach. Table 4 presents the findings.

Table no.4: Multivariate Correlation Analysis of Cognitive Decline Factors

Variable	Coefficient (β)	p-value
BMI	-0.65	<0.001
Smoking Status (Current)	-1.20	0.05
Education Score	0.40	<0.01
Postprandial Blood Sugar	-0.30	0.03

The multivariate analysis indicated that higher BMI was notably related with lower cognitive scores ($\beta = -0.65$, $p < 0.001$), suggesting a negative impact of obesity on cognitive function. Smoking status showed a trend toward significance, with current smokers exhibiting lower cognitive scores ($\beta = -1.20$, $p = 0.05$). Education score positively correlated with cognitive performance ($\beta = 0.40$, $p < 0.01$), emphasizing the importance of educational attainment in cognitive reserve. Additionally, postprandial blood sugar levels had a significant negative correlation with cognitive performance ($\beta = -0.30$, $p = 0.03$).

DISCUSSION

Eighty participants were assessed for cognitive deterioration in this study: forty people with type 2 diabetes were in the test group, and forty people without the disease were in the control group. The test group had an average BMI of 27.4 kg/m², which was substantially higher than the control group's 24.8 kg/m² ($p < 0.001$), according to the demographic analysis. This suggests that T2DM patients are more likely to be overweight or obese, which is an established risk factor for cognitive deterioration. Furthermore, the test group's education score was substantially lower than the control group's, averaging 10.5 years as opposed to 12.0 years ($p = 0.02$). This implies that people with diabetes might have completed less years of formal schooling, which could have an impact on their cognitive reserve.

Using the MoCA scale to measure cognitive function, the test group scored substantially lower overall (22.1 ± 4.3) than the control group (27.5 ± 2.9) ($p < 0.001$). The test group demonstrated notable deficiencies in

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every cognitive domain assessed by the MoCA, including delayed recollection, abstraction, language, naming, attention, and orientation. The test group shown significant difficulties in both delayed recollection (2.1 ± 1.3 vs. 3.8 ± 0.6, $p < 0.001$) and orientation (4.2 ± 0.6 vs. 5.0 ± 0.0, $p < 0.001$), as seen by their significantly lower scores.

In the test group, 65% of T2DM patients were classified as cognitively impaired based on MoCA scores below 26, compared to just 15% in the control group ($p < 0.001$). This indicates a significant increase in the prevalence of cognitive impairment. This sharp discrepancy draws attention to the negative effects of diabetes on cognitive function and emphasises the necessity of focused interventions to slow the rate of cognitive deterioration in this population.

A multivariate correlation analysis revealed significant relationships between cognitive decline and several variables. Higher BMI was associated with lower cognitive scores ($\beta = -0.65$, $p < 0.001$), indicating that obesity may exacerbate cognitive impairment in T2DM patients. Additionally, a negative correlation was found with smoking status, where current smokers had lower cognitive scores ($\beta = -1.20$, $p = 0.05$), suggesting that smoking may further contribute to cognitive decline. Conversely, a positive correlation was observed with education score ($\beta = 0.40$, $p < 0.01$), indicating that higher educational attainment is protective against cognitive impairment. Postprandial blood sugar levels also negatively correlated with cognitive performance ($\beta = -0.30$, $p = 0.03$), reinforcing the importance of glycemic control in managing cognitive health.

Overall, the results of this study indicate a significant prevalence of cognitive decline among individuals with T2DM, particularly linked to higher BMI, lower education levels, and poorer postprandial blood sugar management. These findings emphasize the need for comprehensive strategies that address lifestyle factors and enhance education to improve cognitive outcomes for diabetic patients. Further research is warranted to explore the long-term implications of cognitive impairment in T2DM and to identify effective interventions to mitigate its effects.

One longitudinal study reported that T2DM was linked to accelerated brain atrophy and a decline in verbal memory and fluency among older adults over a 5-year period. Interestingly, the effects of T2DM on brain atrophy were more pronounced in midlife, emphasizing the need for early detection and intervention to prevent cognitive decline in this population [9].

Another cohort study focusing on patients aged 40–75 years in Morocco revealed that nearly 47.5% of T2DM patients showed mild cognitive impairment (MCI). The study identified several factors linked to cognitive decline, such as increased age, diabetic retinopathy, dyslipidemia, and elevated creatinine levels. These findings highlight the multifactorial nature of cognitive decline in T2DM patients, urging healthcare providers to monitor these risk factors closely [10]. Similarly, a review demonstrated that

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around 45% of T2DM patients globally suffer from MCI, with a notably higher prevalence in Asia. The study underscored the urgent need for healthcare systems to incorporate regular cognitive assessments in diabetic care [11].

A cross-sectional study conducted in Mysuru, India, also reported that diabetic patients had significantly lower cognitive function compared to non-diabetics, as assessed using the Montreal Cognitive Assessment (MoCA). This study found that factors like age played a critical role in the degree of cognitive decline, with older patients showing worse performance across cognitive domains such as visuospatial abilities, attention, and language [12]. Supporting this, a German study found that insulin resistance, even more than elevated blood glucose levels, was a key predictor of cognitive decline, particularly affecting memory domains. This suggests that addressing insulin sensitivity in the prediabetic and diabetic populations may help mitigate cognitive decline [13].

Further, a case-control study comparing diabetics and non-diabetics reported a higher prevalence of cognitive impairment among T2DM patients, with deficits observed particularly in concentration and orientation. This study also found that age and disease duration were significant predictors of cognitive decline [14]. In a Chinese study, approximately 21.8% of T2DM patients had MCI, with depression emerging as a significant risk factor. The study also noted that higher educational levels appeared to be protective against cognitive impairment, emphasizing the potential benefit of cognitive reserve in mitigating the effects of T2DM on the brain [15].

Lastly, research from India showed a significant correlation between poor glycemic control and cognitive impairment. Patients with higher HbA1c levels and poor fasting and postprandial glucose levels had worse cognitive performance, suggesting that maintaining optimal glycemic control could reduce the risk of cognitive decline in diabetic patients [16].

CONCLUSION

The study discovered that among T2DM patients, cognitive deterioration was significantly more common and was linked to higher BMI, lower levels of education, and worse postprandial blood sugar control. These results highlight the significance of improving education and addressing lifestyle factors as viable strategies for promoting cognitive health in diabetic populations. It is advised that more study be done to determine the best ways to reduce cognitive damage and to investigate the long-term effects of cognitive deterioration in people with type 2 diabetes.

LIMITATION

The limitations of this study include a small sample population who were included in this study. Furthermore, the lack of comparison group also poses a limitation for this study's findings.

RECOMMENDATION

Healthcare providers should prioritize cognitive assessments in T2DM management and implement lifestyle interventions targeting obesity, smoking cessation, and educational support to mitigate cognitive impairment in this population.

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CONFLICT OF INTEREST

The authors have no conflicting interests to declare.

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No funding received.

LIST OF ABBREVIATION

T2DM - Type 2 Diabetes Mellitus

MoCA - Montreal Cognitive Assessment

BMI - Body Mass Index

PPBS - Postprandial Blood Sugar

MCI - Mild Cognitive Impairment

WHO - World Health Organization

HbA1c - Hemoglobin A1c

T1DM - Type 1 Diabetes Mellitus

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