International Journal of Current Pharmaceutical Research

ISSN- 0975-7066 Vol 17, Issue 3, 2025

Original Article

STUDY OF ASSOCIATION BETWEEN COGNITIVE IMPAIRMENT AND GLYCEMIC CONTROL IN TYPE 2 DIABETES PATIENT AND MOCA (MONTREAL COGNITIVE ASSESSMENT) AS A PREDICTIVE TOOL FOR GLYCEMIC CONTROL IN DIABETIC PATIENTS WITH COGNITIVE IMPAIRMENT: A CROSS-SECTIONAL STUDY

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Received: 20 Jan 2025, Revised and Accepted: 10 Mar 2025

ABSTRACT

Objective: India has the second highest number of type 2 diabetes mellitus (T2DM) cases, with several known complications, including heart disease, stroke, hypertension, atherosclerosis, neuropathy etc. In a considerable number of diabetics, cognitive impairment is found. This prevalent complication is an alarming one. There has been insufficient research data to conclusively comment on cognitive impairment in diabetic patients with poor glycemic control. This study was therefore designed to assess the cognitive impairment using MoCA test (Montreal Cognitive Assessment) and its association with glycemic control in T2DM and utility of MoCA test as a predictive tool for glycemic control in patients with cognitive decline over period of time.

Methods: 30 points MoCA test was conducted in 150 T2DM patients.

Results: In present study, significant cognitive impairment (MoCA score<26) was found in diabetic patients with HbA1c % >7.5 and a resounding majority of diabetic patient also showed cognitive impairment with greater preponderance towards the uneducated subjects and those with co-morbid conditions.

Conclusion: The diabetics with strict glycemic control have lesser incidence of cognitive impairment over period of time. MoCA test could be used as early predictive tool for glycemic control in patients with cognitive decline.

Keywords: MoCA. Glycemic control, Cognitive decline

DOI: https://dx.doi.org/10.22159/ijcpr.2025v17i3.55061 Journal homepage: https://innovareacademics.in/journals/index.php/ijcpr

INTRODUCTION

Diabetes Mellitus (DM) is a complex metabolic disorder characterized by elevated blood glucose levels due to insulin resistance, impaired insulin secretion, or both. It is associated with a range of complications that can significantly affect an individual's quality of life [1].

Diabetes Mellitus, particularly type 2 diabetes (T2DM), has been associated with a range of cognitive impairments and memory disorders. Research has consistently shown a strong correlation between diabetes and an increased risk of cognitive decline and dementia. Studies indicate that T2DM can lead to deficits in various cognitive domains, including memory, psychomotor speed, visuospatial skills, executive functions, processing speed, verbal fluency, attention, and complex motor tasks [2-6].

The brain's dependence on glucose for metabolic function and neuronal survival highlights the potential impact of hyperglycemia and insulin resistance, two hallmark features of T2DM. These metabolic disturbances can contribute to cognitive dysfunction, potentially through mechanisms like impaired insulin signaling, oxidative stress, and systemic inflammation that can impact brain health.

Furthermore, diabetic encephalopathy has emerged as a significant risk factor for cognitive decline, dementia, and particularly Alzheimer's disease. Evidence from brain imaging studies has revealed structural alterations in the brains of individuals with diabetes, such as hippocampal injury, reduced gray matter density, changes in white matter micro-structure, and atrophy. Such changes suggest that individuals with diabetes are at an elevated risk for neuro-cognitive dysfunction [7-9].

Current management strategies for T2DM primarily focus on glycemic control and do not adequately address the cognitive consequences of the disease. Given the rising prevalence of diabetes and the aging population, it is crucial to further investigate the relationship between diabetes and cognitive decline. Understanding these connections can guide the development of more comprehensive management strategies that also take cognitive health into consideration.

Studies also claimed to have confirmed the fact that changes in the brain in the early stages of diabetes can be rectified using rehabilitation methods like cognitive training or therapeutic physical training [10] if detected early. An analysis in India also came to the conclusion that Diabetic patients display an increased burden of oxidative stress and inflammation, which puts them at an increased risk for cognitive impairment and neuro-degeneration [11]. Hence, test like MoCA [12] may be useful in early detection of diabetes-associated cognitive impairment and if found association between cognitive impairment and glycemic control it may serve as an effective tool for predicting poor glycemic control in diabetic patients.

Thus, the main focus of this study is to determine whether cognitive impairment is associated with glycemic control of patients suffering from T2DM and to ascertain if glycemic control reduces the extent of cognitive impairment in such patients.

MATERIALS AND METHODS

After taking Institutional Ethics Committee approval (SKNMC/Ethics/App/2022/983), this cross-sectional study was carried out for 6 mo at a tertiary care hospital in India. Written Informed Consent of the subjects was taken. One hundred fifty patients of either sex between 45-65 y of age suffering from diabetes for over 5 y duration, without any prior mental illness were included in the study. Socio-demographic characters like age, gender, education, habits, co-morbidities were recorded. Their latest HbA1c

report was considered for detecting glycemic control. The MoCA a standardized and rapid tool to assess cognitive abilities, was given to the patients and score was assessed at once. The MoCA test [maximum score: 30 points] in which points were allotted for the following abilities: (i)Visuospatial/Executive [0-5 points] (ii)Identification[0-3 points] (iii)Memory[no points] (iv) Attention [0-6 points] (v)Language [0-3 points] (vi)Abstraction [0-2 points] (vii)Delayed recall [0-5 points] (viii)Orientation [0-6 points]. Cognitive Impairment was defined as MoCA score<26.

Data was collected in MS Excel sheet and analyzed using analysis of variance (ANOVA) followed by post hoc Tukey's statistical test and chi-square test for correlation of the MoCA score with co-morbidities in Diabetic patients, Fisher exact probability test with Freeman-Halton extension for correlation of the MoCA score with HbA1c in Diabetic patients (non-parametric tests) using the OpenEpi, version 2.3 (Andrew G. Dean and Kevin M. Sullivan, Atlanta, GA, USA) and online VassarStats: Website for Statistical Computation, (Richard Lowry, USA), respectively. $p<0.05$ was considered significant.

RESULTS

Table 1 lists the socio-demographics of 150 study participants. The mean age of participants was 54.87+0.8 and 51.72+0.5 in Diabetics with co-morbidities and without co-morbidities respectively; 81 were males and 69 females. Among the 150 participants, only 36 held a postgraduate degree. Based on HbA1c levels, diabetes was controlled in less than one-third of the patients (HbA1c<7.5). Additionally, over half of the sample had been living with diabetes for at least 10 y. Self-reported co-morbidities exceeded 60% for both renal and cardiac conditions. A review of hospital records indicated that respiratory issues affected more than 20% of the participants, while neurological problems, at just over 10%, were the least common co-morbidities.

Table 1: Socio-demographics of participants in the study groups (N=150)

Demographics	Study group	
	Diabetic with co-morbidities	Diabetic without co-morbidities
mean age	54.87	51.72
Age group		
45-55 y	51	33
55-65 y	45	21
Gender		
Male	51	30
Female	45	24
Education		
Non-graduate	33	24
Graduate	42	15
Postgraduate	21	15
Habits		
Smoking	6	3
Tobacco	55	6
Alcoholic	3	0
Nil	72	45
Diet		
Vegetarian	30	27
Non-vegetarian	3	3
Mixed	63	24
HbA1c		
<7.5	42	18
>7.5	54	36

The mean total cognitive score showed a clear and significant negative association with glycemic control and co-morbidities suggestive of evident cognitive impairment (p=0.012). This relationship is consistent across the mean scores of the seven sub-domains but was significant (p=0.003) only in the visuospatial/executive domain (table 2).

Table 2: Mean MoCA score in T2DM patients for total cognitive function and each subdomain (N=150)

Cognitive domain	Highest score	Diabetic with co-morbidities mean score (SD)	Diabetic without co-morbidities mean score (SD)	Diabetic with HbA1c<7.5	p-Value
Total Score on MoCA	30	21.8±3.7	21.9±4	25±1.7	0.012*
Visuospatial/Executive Function	5	2.42±1.7	2.78±1.7	3.95±1.2	0.003*
Naming	3	2.78±0.7	2.83±0.4	2.95±0	0.214
Attention	6	4.67±1.5	4.67±1.3	5.33±1.2	0.454
Language	3	1.97±0.9	2.00±0.8	2.45±1.2	0.083
Abstraction	2	2.00±0	2.00±0	2.05±0	0.262
Delayed Recall	5	2.36±1.2	1.89±1.7	2.85±1.5	0.083
Orientation	6	5.61±0.7	5.72±0.6	5.65±1.2	0.843

P values by analysis of variance (ANOVA) followed by post *hoc* Tukey's statistical test

When association between cognitive impairment, HbA1c was studied by Fisher exact probability test with Freeman-Halton extension, we found a significant association between them; p= 0.0218 (table 3). We also studied association between cognitive impairment and co-morbidities by chi-square non-parametric test; table 4 shows that there was significant association (p= 0.0003).

Table 3: Association of the MoCA score with HbA1c in T2DM patients

MoCA score	No. of patients	HbA1c mean (SD)	No of patients with HbA1c>7.5	p Value
0-25	108	8.67 (2.2)	81	
Above 26	42	7.48 (0.9)	09	0.0218*

P Value by fisher exact probability test with freeman-halton extension

Table 4: Association of the MoCA score with co-morbidities in diabetic patients

MoCA score	No. of patients	Mean score (SD)	p Value
0-25	84	23.06 (1.48)	0.0003*
Above 26	12	28 (1.87)	

P Value by chi-square non-parametric test

DISCUSSION

The MoCA is a commonly used instrument for evaluating cognitive impairment and is mainly used to identify patients who may be experiencing cognitive decline [1]. The MoCA scale was employed in this study to evaluate the cognitive function of people with T2DM, taking into account their overall cognitive capacities and performance in a range of cognitive areas. In order to detect any cognitive impairment in them and compare it with the cognitive function of diabetic persons with and without co-morbidities and glycemic control, we used this standardized test to assure consistent and objective assessment of cognitive performance. A MoCA score of 26 or higher is defined as normal cognitive abilities. Present study demonstrated that more than 70% of participants had cognitive impairment (MoCA<26). A recently performed study in Saudi Arabia [13] assessing cognitive function among elderly patients (60 y) and above revealed that the prevalence of cognitive impairment was 46% based on the standard MoCA cutoff point. While in a middle east study, it was reported more than 80% [14].

The difference between our results and these results regarding the MoCA score is mostly due to the selection criteria as our patients are all T2DM over 5 y between 45-65 y, which is considered as a risk factor for development of cognitive impairment. In present study, we have included younger patients also as we wanted to check utility of MoCA test in early detection of cognitive decline, since earlier few studies in this regard have confirmed the fact that changes in the brain in the early stages of diabetes can be rectified using rehabilitation methods like cognitive training or therapeutic physical training [10] if detected early. However, results of this study are in accordance with few studies that have reported significant cognitive decline in diabetics with co-morbidities and with poor glycemic control [15, 16]. Interestingly in this study, we found an impact of educational status and lifestyle on glycemic control and hence, cognitive decline. Which we need to take into consideration while exploring therapeutic options for treatment of diabetes.

The T2DM patients demonstrated apparent impaired performance across various subdomains of the MoCA tool, especially visuospatial/executive function (p=0.003), though in other subdomains such as naming, attention, abstraction, delayed recall, language, orientation and this impairment was not statistically significant (p>0.05). This impairment was more in T2DM with co-morbidities and those with poor glycemic control. Our results suggest that all cognitive domains are not affected equally.

The visuospatial/executive domain was the worst affected followed by delayed recall and language. Whereas attention and orientation were the least impacted areas. Deficit percentages for naming and abstraction were identical. In present literature review on the association studies between diabetes and cognitive function conducted in India, the authors concluded that verbal memory and processing speed were the most domains affected with preservation of functions in other areas including visuospatial function, attention, semantic memory, and language [17]. These results are in line with our findings except visuospatial function and language, which were also affected, and was confirmed by another study which revealed impairment of executive function in diabetic individual at baseline and had more pronounced impairments in executive function(Stroop color/word interference test) and language (phonemic verbal fluency) tests than people without diabetes. The findings corroborate earlier research showing notable variations in language, executive function, and psychomotor speed/attention [1, 18, 19]. According to the affected domain of the MoCA score, a Japanese study identified three types of cognitive impairment: a temporal lobe impairment group with impaired recall domain, a frontal lobe impairment group with attention, language, and abstraction domain impairment, and a mixed type [20]. Remarkable decline in MoCA scores in the areas of naming and delayed recall was reported in few studies [21, 22]. In a study, the domains of MoCA, orientation, delayed memory, and attention/calculation, found that older individuals with hyperinsulinemia with poor glycemic control performed worse on cognitive tests [23]. In our study also comparable impairment was observed in patients with poor glycemic control.

Etiopathogenesis of cognitive decline in diabetes is multifaceted, and risk of cognitive decline escalates progressively with advancing age; duration and poor glycemic control in also play a role in this cognitive decline. Neuroimaging and neuropathological studies have confirmed the role of diabetes in neurodegeneration. MRI research indicates a strong link between T2DM and brain atrophy, with the rate of global brain atrophy in T2DM being up to three times faster than in normal aging [24, 25]. Poor glycemic control and a longer duration of diabetes raise the risk of hyper-glycemic episodes, which directly damage neurons by causing glucose and glutamate toxicity and oxidative stress. Hyperglycemia also raises the risk of microvascular problems, such as cerebral microangiopathy, which may worsen cognitive impairment [26].

It is crucial to determine which cognitive domains are most impacted by diabetes in order to target risk modification. This may involve implementing cognitive rehabilitation therapies, such as exercise and physical activity, which are necessary to improve executive functioning and lower the risk of cognitive impairment. MoCA test can be a useful tool in early prediction of poor glycemic control of diabetic patients, preventing cognitive decline as changes in the brain in the early stages of diabetes can be rectified using rehabilitation methods like cognitive training or therapeutic physical training [10] if detected early.

CONCLUSION

This study demonstrated that T2DM patients having poor glycemic control do suffer from significant cognitive impairment, than patients with strict glycemic control and patient with co-morbidities are at more risk of developing cognitive impairment Measures must be taken to control a patient's HbA1c level and treatment of co-morbidities in order to prevent cognitive decline and MoCA test can be useful tool in early prediction of poor glycemic control of diabetic patients.

ACKNOWLEDGEMENT

The authors are thankful to Dr. A. V. Bhore, Director SKNMC for providing facilities to carry out of the experiments of this work.

FUNDING

Nil

AUTHORS CONTRIBUTIONS

All authors have contributed equally

CONFLICT OF INTERESTS

Declared none

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