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THE CORRELATION BETWEEN TYPE 2 DIABETES MELLITUS AND COGNITIVE FUNCTION IN MIDDLE-AGED INDIVIDUALS

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Abstract

The number of people with Type 2 diabetes is going up around the world, and this is a big problem for both health and the economy. It's a complex condition that affects many parts of the body. One of the main concerns is how diabetes can affect brain function, especially thinking and memory. Research has shown that middle-aged adults with Type 2 diabetes often have trouble with their cognitive abilities. In this study, we looked at how diabetes and its related factors, like age, gender, cholesterol levels, and how long someone has had diabetes, are connected to cognitive function. We found that people with diabetes had lower scores in areas like attention and processing speed, but their executive function, like planning and decision-making, stayed strong. Several health factors linked to diabetes were connected to different parts of brain function. However, because the number of people studied was small, we were careful in how we looked at cholesterol levels.

Keywords: *Diabetes, cognition, pathogenesis, HbA1c, and lipid profiles.*

Introduction

Diabetes Mellitus

Diabetic mellitus is a type of metabolic disease that causes long-term high blood sugar levels and changes in how the body uses fat, carbohydrates, and proteins. This happens because there is either not enough insulin being made or the body doesn't use insulin properly. Long-term high blood sugar is linked to damage in small blood vessels and a higher risk of problems in large blood vessels [1].

Cognitive functions

Cognitive functions involve getting, using, and combining, keeping, and recalling information. These functions include attention, perception, memory, and skills like planning and decision-making [2].

Various cross-sectional and population-based studies show that cognitive impairment is common in people with type 2 diabetes. This includes slower psychomotor speed, poor verbal memory, slower processing, weak working memory, difficulty with complex tasks, and problems with motor function and quick recall.

The connection between diabetes and cognitive issues depends on how long someone has had diabetes, how well their diabetes is controlled, their age when diabetes started, and other difficulties related to diabetes. Better control of blood sugar levels helps prevent cognitive decline and supports better cognitive function [3].

One of the complications in diabetes mellitus is the involvement of the central nervous system in 28 young individuals who were diagnosed with diabetes at a younger age. The connection between certain markers and problems with thinking is often noticed. Among these, type 2 diabetes has a big effect on people around the world and is seen as a major global health problem. Because of this, it's very important to understand how thinking problems relate to type 2 diabetes.

This helps people deal with the everyday difficulties of the disease and better follow their treatments, therapies, and diet. In this study, we looked at the characteristics of people with type 2 diabetes and the factors that increase their risk of having problems with thinking [4].

Materials and method

Design

This study is based on a cross-sectional approach and looks at how different factors are connected. The main outcome is cognitive impairment in people with type 2 diabetes mellitus (T2DM). The factors being studied, called independent variables, include things like age, sex, lipid levels, and how long someone has had diabetes. The study also looks at four main areas of cognitive function: hurry, impression, observation, and executive functions.

Eligibility Criteria

To be part of this study, participants must have a diagnosis of T2DM along with other health issues, psychological problems, other medical conditions, or cognitive impairment. The study includes clear rules for who can and cannot join which were set from the beginning and explained to participants [5].

T2DM Diagnosis

Participants in this study must have a confirmed diagnosis of T2DM. They can be diagnosed with either type 1 or type 2 diabetes.

Mental Status Examination Questionnaire

This tool is used to check the level of thinking and awareness of the participants.

Medical Conditions

Participants in this study had diabetes in a difficult stage. This condition, whether it occurred before or after other health problems, can influence their thinking abilities. For example, high blood pressure, heart diseases, and high levels of fat in the blood can affect thinking. To check for these, their blood lipid levels were measured [6].

Measuring Body Measurements

Gender of Participants

Out of the six people involved, three were women and three were men. There was no preference for any particular gender, and this was confirmed through a chi square test.

Country of Birth and Language

All the participants were born in Tamilnadu, India, and they all spoke English as their second language. There was no difference in their performance on the cognitive tests based on whether they spoke English or not [7].

Employment Status

Out of the six participants, four were looking for jobs and two were unemployed but had some level of ability to work.

Weight of the Participants

The participants were asked to wear light clothes and stand with their arms relaxed at their sides and their feet close together. Their weight was then measured in kilograms using a standard portable weighing scale.

Height of the Participants

Using a stadiometer, each participant was asked to stand straight up, and their height was measured in centimeters.

BMI

The participants' BMI was calculated using the Quetelet’s Index, which is determined by dividing the person's weight in kilograms by their height in square meters.

Measurement of Blood Pressure

The participants were told to sit and relax for 5 minutes in a room that was at a normal temperature. Then, blood pressure was measured for six participants using a sphygmomanometer with a cuff that was 25 x 12.5 cm in size [9].

Blood Investigation

For collecting blood from a vein, the median cubital vein was chosen. The area was cleaned with alcohol and a cotton swab. A sterile needle attached to a 5ml syringe was inserted into the vein, and 4ml of blood was drawn. This blood was placed into separate containers that had different anticoagulants.

HbA1c

The HbA1c level was measured using the turbid metric immunoassay method. Participants with type 2 diabetes were advised to keep their HbA1c levels under control with the help of healthcare professionals. Participants were also advised to keep their blood glucose levels below 48mmol/mol. In our study, most participants did not have good control over their type 2 diabetes [8].

Lipid Profile

From all the participants, four lipid profiles were measured: total cholesterol, HDL, LDL, and triglycerides (TG).
The ideal control for these lipid profiles should be total plasma cholesterol.

Results and discussion

The descriptive statistics were used for the sample to calculate the mean, standard deviation (SD), and how the data was spread out in the demographic, type II diabetes (T2DM), and scores for age-scaled cognitive tests.

Table-1: Participant characteristic descriptive statistics

Marker	Mean	SD	Skewness	Kurtosis	Shapiro-wik sig
Age	47.25	8.75	-0.320	-0.850	0.130
Education	14.2	2.30	0.050	-1.100	0.745
Duration	68.45	60.10	0.750	-0.950	0.080
Hba1c	73.80	18.65	-0.120	-0.400	0.635
Total Cholesterol	4.10	1.05	0.020	0.300	0.580
HDL	1.12	0.30	0.800	-0.050	0.190
LDL	2.10	0.85	0.320	0.400	0.905
Triglycerides	2.05	1.10	1.020	1.200	0.220
Beck Depression	15.40	11.90	0.150	-1.200	0.510
Beck Anxiety	14.50	14.70	0.420	-1.250	0.190

Also, data was checked for skewness, kurtosis, and Shapiro-Wilk statistics to see if it followed a normal distribution for parametric conditions (Table-1) [10]. Skewness shows the shape of the data, and if it's less than 1, it means the data is skewed. Kurtosis shows the peak of the data, and if it's more than 3, it means the data is more peaked. If the Shapiro-Wilk test shows a significant result (p <), it means the data isn't normally distributed. Because of this, the test scores for the participants aren't normally distributed and there are fewer participants, which makes the data unsuitable for linear statistics. So, non-parametric tests were used instead [11].

Diabetes is a common disease found in hundreds of millions of people around the world. It is a long-term and complex condition. Cognitive dysfunction is also a long-term complication of diabetes, but its impact is still not fully understood. The cognitive status is important for understanding the disease and following treatment. In this study, six people with type 2 diabetes were selected as participants, and their age, sex, BMI, and education level were recorded. The observations from this study showed that people with type 2 diabetes had some cognitive dysfunction. These results are similar to previous studies that have looked at cognitive function in people with type 2 diabetes [12].

The table shows basic information about the participants. The average age was 47.25 years, with a standard deviation of 8.75. The average time since they were diagnosed with diabetes was 68.45 months, with a standard deviation of 60.10. Their average education level was 14.2 years, with a standard deviation of 2.30. On average, their HbA1c levels were 73.80, with a standard deviation of 18.65. There was a slight negative skew, meaning more people had lower HbA1c levels. Most of the data followed a normal distribution, as shown by the Shapiro-Wilk test (p > .05). A few variables had mild skew, like triglycerides and HDL [13].

Table-2: Descriptive and distribution statistics for verbal attention and processing speed test results for participants

Subtests (SS)	Mean	SD	Skewness	Kurtosis	Shapiro-wilk
Optimal Ability	9.8	2.1	-0.85	1.1	0.15
Verbal Attention					
Digits Forward	9.6	4.8	0.68	-0.75	0.14
Digits Backward	9	3	1.4	1.9	0.045
Digits Sequencing	9.1	2.2	-0.95	0.35	0.05
Digits Span	8.7	3.5	1	0.4	0.18
Processing Speed					
Colour Naming	8.5	2.4	0.2	-0.5	0.58
Colour Word	9.4	2.9	-0.7	1	0.62
Visual Scanning	9.7	2	0.3	-1.3	0.33
Number Sequencing	8.1	4	-0.05	-1.8	0.13
Letter Sequencing	9.5	3.6	-0.7	-0.2	0.57
Digit Symbol Coding	8.7	2.3	0.9	-0.15	0.1

Table 2 shows the results of tests that measure verbal attention and processing speed. Participants' scores were mostly within the average range, with an average of 9.80 and a standard deviation of 2.10. The Digit Span test had some variation. Digit Backward had an average of 9.00 with a standard deviation of 3.00 and a positive skew of 1.40. It also showed a significant deviation from normality (Shapiro-Wilk p = .045). Digit Sequencing had a moderate negative skew of –0.95 and a borderline normal distribution (p = .050).

Table-3: Descriptive and distribution statistics for participants' verbal & visual-spatial, learning & memory, and executive function test results

Subtests (SS)	Mean	SD	Skewness	Kurtosis	Shapiro-wilk
Executive Function					
Letter Fluency	10.2	4.9	0.48	-0.55	0.69
Category Fluency	11.4	4.3	-0.12	-1.7	0.16
Switch Output	12.1	4.6	-0.59	-0.32	0.29
Switch Accuracy	12.5	3.7	-0.76	0.05	0.27
Inhibition Scaled	10	3	-0.48	-0.62	0.51
Inhibition Switching	8.6	4	-0.85	-0.18	0.175
Number Letter	7.4	4	-0.4	-0.1	0.195
Learning & Memory - Verbal/Visual					
Story Immediate	10.2	2	0.45	-0.1	0.56
Story Delayed	9.6	1.9	-0.49	0.6	0.37
Visual Immediate	9.1	3.3	-0.51	-0.9	0.59
Visual Delayed	10.2	2.8	0.31	0.2	0.925

Processing speed tasks, like Color Naming and Digit Symbol Coding, had scores in the low-average range. These had mild skew and non-significant Shapiro-Wilk results, meaning they were close to a normal distribution [13].

Table 3 details participants' performance on executive function, verbal and visual-spatial, and learning and memory tasks. Strong performance was observed in Switch Output

(M = 12.10, SD = 4.60) and Switch Accuracy (M = 12.50, SD = 3.70), indicating preserved executive function.

Table-4: Neuropsychological test participant data contrasted with verbal attention and processing speed normative data

Subtests (SS)	Mean of SS of Test	SD of SS of Test	Kolmogrov-Smirnoff Z	p Value
Optimal Ability	102	14.5	0.765	0.582
Verbal Attention				
Digits Forward	10.3	2.9	1.010	0.210
Digits Backward	9.7	3.2	1.115	0.168
Digits Sequencing	10.1	2.7	1.050	0.175
Digits Span	10.0	3.1	1.280	0.060
Processing Speed				
Colour Naming	9.8	2.8	1.000	0.230
Colour Word	10.1	3.0	0.825	0.496
Visual Scanning	10.2	2.6	0.655	0.782
Number Sequencing	9.9	3.4	1.210	0.093
Letter Sequencing	10.0	3.1	0.700	0.782
Digit Symbol Coding	9.5	2.8	1.255	0.471

However, Number-Letter Switching (M=7.40, SD = 4.00) and Inhibition Switching (M=8.60, SD=4.00) were lower. The Similarities subtest (M=8.90, SD=2.90) showed the greatest negative skewness (-1.42), approaching significance in normality testing (p=0.52) [14].

Table-5: Neuropsychological test participant data contrasted with normative data for verbal and visuospatial, executive function, and learning and memory

Subtests (SS)	Mean of SS of Test	SD of SS of Test	Kolmogrov-Smirnoff Z	p Value
Executive Function				
Letter Fluency	10.2	2.8	0.755	0.605
Category Fluency	10.6	3.1	1.210	0.097
Switch Output	9.8	3.3	1.315	0.055
Switch Accuracy	9.6	2.9	1.420	0.031
Inhibition Scaled	10.1	2.7	0.510	0.960
Inhibition Switching	10.0	3.0	0.688	0.755
Number Letter	9.7	3.4	1.050	0.170
Learning & Memory - Verbal/Visual				
Story Immediate	10.3	2.6	0.745	0.615
Story Delayed	9.9	2.8	0.825	0.490
Visual Immediate	10.1	3.2	0.660	0.798
Visual Delayed	10.0	2.9	0.698	0.772
Verbal & Visuo-Spatial				
Similarities	9.8	3.0	1.090	0.150
Block Design	9.6	2.7	1.030	0.185

Participant scores were also compared with normative data, as shown in Tables 4 and 5. For verbal attention and processing speed (Table 4), mean scaled scores hovered around 10, consistent with the normative mean. Kolmogorov–Smirnov (K-S) tests indicated non-significant differences from normal distributions for most subtests ($p > .05$), though Digit Span showed marginal deviation ($Z = 1.280$, $p = .060$). Table 5 compares participant performance with normative data in executive function, verbal/visuospatial, and memory domains [15].

While most subtests remained within average ranges, Switch Accuracy ($Z = 1.420$, $p = .031$) and Switch Output ($Z = 1.315$, $p = .055$) showed significant or near-significant deviations, indicating some participants may exhibit difficulties in cognitive flexibility. Learning and memory subtests showed good alignment with normative data, with no significant deviations observed (all $p > .05$). Verbal and visuo-spatial scores were within expected ranges, with mild skewness but no significant normality violations [16].

Conclusion

This study found that middle-aged adults with type 2 diabetes usually have average cognitive abilities in several areas, like verbal attention, processing speed, learning, memory, and executive functions. Interestingly, when it comes to tasks that require switching between different activities, these individuals performed better than expected, showing some strength in cognitive flexibility even though they have the disease. Some small issues were noticed in working memory and processing speed, which matches earlier research that suggests type 2 diabetes, might have a quiet effect on these areas. This could be connected to factors like blood sugar control and problems with fats in the blood. However, emotional issues like depression and anxiety were present but didn't seem to greatly affect how well these people performed cognitively.

Because diabetes and cognitive changes are linked in a complicated way, more research is needed. Using bigger groups of people, long-term studies, and combining different methods like brain scans and biological markers could help uncover more about how diabetes affects the mind. This would also support the creation of better ways to help keep cognitive abilities strong in people with type 2 diabetes.

Reference

1. Zheng Y, Ley SH, Hu FB. Global aetiology and epidemiology of type 2 diabetes mellitus and its complications. Nat Rev Endocrinol. 14(2):88-98. doi: 10.1038/nrendo.2017.151
2. Buitenweg JI, Murre JM, Ridderinkhof KR. Brain training in progress: a review of trainability in healthy seniors. Front Hum Neurosci. 2012 Jun 21;6:183. doi: 10.3389/fnhum.2012.00183
3. Kan W, Qu M, Wang Y, Zhang X, Xu L. A review of type 2 diabetes mellitus and cognitive impairment. Front Endocrinol (Lausanne). 16:1624472. doi:10.3389/fendo.2025.1624472
4. Zilliox LA, Chadrasekaran K, Kwan JY, Russell JW. Diabetes and Cognitive Impairment. Curr Diab Rep. 16(9):87. doi: 10.1007/s11892-016-0775-x
5. Kilander L, Nyman H, Boberg M, Lithell H. Cognitive function, vascular risk factors and education. A cross-sectional study based on a cohort of 70-year-old men. J Intern Med. 242(4):313-21.doi:10.1046/j.13652796.1997.00196.x
6. Wright CB, Flores A. Vascular contributions to cognitive impairment. Neurol Clin Pract. 5(3):201-208. doi: 10.1212/CPJ.0000000000000118
7. Mahinrad S, Sorond F, Gorelick PB. The Role of Vascular Risk Factors in Cognitive Impairment and Dementia and Prospects for Prevention. Clin Geriatr Med. 39(1):123-134. doi: 10.1016/j.cger.2022.07.007
8. Metus P, Ruzzante N, Bonvicini P, Meneghetti M, Zaninotto M, Plebani M. Immunoturbidimetric assay of glycated hemoglobin. J Clin Lab Anal. 1999:13 (1):5-8. doi:10.1002/(SICI)1098-2825 (1999)13
9. Little RR, Roberts WL. A review of variant hemoglobins interfering with hemoglobin A1c measurement. J Diabetes Sci Technol. 3(3):446-51. doi: 10.1177/193229680900300307
10. Kim HY. Statistical notes for clinical researchers: assessing normal distribution (2) using skewness and kurtosis. Restor Dent Endod. 38(1):52-4. doi: 10.5395/rde.2013.38.1.52
11. De la Monte SM, Tong M. Brain metabolic dysfunction at the core of Alzheimer's disease. Biochem Pharmacol. 88(4):548-59. doi:10.1016/j.bcp.2013.12.012
12. Palta P, Schneider ALC, Biessels GJ, Touradji P, Hill-Briggs F. Magnitude of cognitive dysfunction in adults with type 2 diabetes: a meta-analysis of six cognitive domains and the most frequently reported neuropsychological tests within domains. J Int Neuropsychol Soc. 20(3):278-291. doi: 10.1017/S1355617713001483
13. Biessels GJ, Reijmer YD. Brain changes underlying cognitive dysfunction in diabetes: what can we learn from MRI? Diabetes. 63(7):2244-52. doi: 10.2337/db14-0348
14. Van den Berg E, Reijmer YD, de Bresser J, Kessels RP, Kappelle LJ, Biessels GJ; Utrecht Diabetic Encephalopathy Study Group. A 4 year follow-up study of cognitive functioning in patients with type 2 diabetes mellitus. Diabetologia. 53(1):58-65. doi: 10.1007/s00125-009-1571-9
15. Awad N, Gagnon M, Messier C. The relationship between impaired glucose tolerance, type 2 diabetes, and cognitive function. J Clin Exp Neuropsychol. 26(8):1044-80. doi:10.1080/13803390490514875

16. Cukierman-Yaffe T, Gerstein HC, Williamson JD, Lazar RM, Lovato L, Miller ME, Coker LH, et al. Action to Control Cardiovascular Risk in Diabetes-Memory in Diabetes (ACCORD-MIND) Investigators. Relationship between baseline glycemic control and cognitive function in individuals with type 2 diabetes and other cardiovascular risk factors: the action to control cardiovascular risk in diabetes-memory in diabetes (ACCORD-MIND) trial. Diabetes Care. 32(2):221-6. doi: 10.2337/dc08-1153