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Age, Gender, Blood Glucose, and Disease Duration in Relation to Cognitive Function in People with Type 2 Diabetes Mellitus

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Abstract

Background: Individuals with diabetes have a 2–6 times higher risk of developing blood clots, which can contribute to cognitive dysfunction. Elevated blood sugar levels can lead to complications in the blood vessels, including those in the central nervous system.
Objective: This study aimed to examine the relationship between age, gender, blood sugar levels, and duration of illness with cognitive function in people with Type 2 Diabetes Mellitus (T2DM).
Methods: This was an observational analytic study using a cross-sectional design.
Results: Statistical analysis showed a significant relationship between age and cognitive function in T2DM patients (p = 0.001, r = –0.859), indicating a very strong negative correlation. No significant relationship was found between gender and cognitive function (p = 0.850, r = –0.037), indicating a very weak correlation. Blood sugar levels were significantly associated with cognitive function (p = 0.001, r = –0.637), reflecting a strong negative correlation. Duration of illness was also significantly related to cognitive function (p = 0.001, r = –0.843), indicating a very strong negative correlation.
Conclusion: here is a significant negative correlation between age, blood sugar levels, and duration of illness with cognitive function in T2DM patients, while gender shows no significant relationship. Further studies with additional variables, larger samples, and different methodologies are recommended to strengthen the evidence and provide more comprehensive insights.

Keywords: Age; blood sugar levels; cognitive function; duration of illness; gender; type 2 diabetes mellitus

Introduction

Diabetes mellitus (DM) remains a major global health challenge, contributing significantly to mortality and reduced quality of life, with prevalence continuing to rise. According to the International Diabetes Federation (IDF, 2019), there were 463 million people living with DM worldwide in 2019. The highest prevalence was reported in the Western Pacific region (163 million cases), followed by Southeast Asia (88 million cases) and Europe (59 million cases). The World Health Organization (WHO, 2020) notes that the majority of DM cases occur in low- and middle-income countries. By 2021, Indonesia ranked fifth globally in the number of DM cases, with 19.5 million individuals aged 20–79 years affected, and sixth in diabetes-related mortality, recording 236,000 deaths (IDF, 2021).

In Indonesia, South Sulawesi ranks second among provinces for DM prevalence, accounting for 15.79% of non-communicable disease cases after heart and vascular disease (South Sulawesi Provincial Health Office, 2018). The highest prevalence of DM diagnosed by physicians was reported in Tana Toraja Regency (6.1%), followed by Luwu (5.2%), Makassar (5.3%), and North Luwu (4.0%). Additional data show lower but notable prevalence in Pinrang

(2.8%), North Toraja (2.3%), Palopo (2.1%), and Makassar (2.5%) (South Sulawesi Health Office, 2018).

One contributing factor to the increasing number of DM cases is that three out of four people with DM are unaware of their condition and fail to control their blood glucose levels (Ministry of Health, 2021). Chronic hyperglycemia can lead to various complications, including peripheral neuropathy, macrovascular conditions such as coronary heart disease and ischemic stroke, and microvascular conditions such as retinopathy, nephropathy, and neuropathy (Nanda et al., 2022). Microvascular complications and prolonged disease duration have been linked to an elevated risk of cognitive dysfunction. Epidemiological studies indicate that chronic hyperglycemia and diabetic microangiopathy characterized by capillary basement membrane thickening are key pathological features found in the brains of individuals with DM (Kim, 2019). MRI studies further show that Type 2 DM is associated with brain atrophy, with rates of global brain atrophy being three times higher than those observed in normal aging.

Cognitive dysfunction in DM, including mild cognitive impairment (MCI), has significant implications for self-care, such as medication management, blood glucose monitoring, and adherence to diet and exercise regimens. Impaired cognitive function can lead to treatment-related complications, acute hyperglycemia, cardiovascular events, and even mortality (Biessels & Whitmer, 2020). Nugroho et al. (2021) found a significant relationship between disease duration, glycemic control, and cognitive decline among patients with Type 2 DM in Central Lampung. Similarly, a study conducted at Dr. Soedarso Hospital, Pontianak, reported associations between education level, employment status, blood glucose status, duration of illness, and cognitive dysfunction (Faisyal, 2019). Another study found that age and blood glucose levels were significantly related to cognitive decline in patients with Type 2 DM (Sriwahyuni & Wahyuni, 2021).

Preliminary observations at Tamalanrea Health Center in September revealed 111 patients with Type 2 DM, five of whom had experienced cognitive decline after approximately five years of disease duration. Cognitive dysfunction in DM is a complication that remains underrecognized and undertreated, despite its impact on patient independence, quality of life, and daily functioning. Therefore, this study aims to investigate the factors associated with cognitive function in patients with Type 2 DM.

Methods

Study Design

This study employed a quantitative analytical observational design with a cross-sectional approach.

Samples

The study population consisted of patients with Type 2 Diabetes Mellitus attending the Tamalanrea Makassar Health Center. Sampling was conducted using a purposive sampling technique, with sample size determined by the Slovin formula. Inclusion criteria were: (1) diagnosed with Type 2 DM, (2) able to communicate verbally, and (3) willing to participate as evidenced by signing informed consent. Exclusion criteria included: history of stroke, heart disease, kidney failure, or intracranial lesions; vision, hearing, or speech impairments; and illiteracy.

Instruments

Respondent data were collected using a structured questionnaire covering demographic characteristics (name, age, gender), blood glucose levels, and duration of illness. Blood glucose was measured with the Nesco Multi Check digital device following the SOP for capillary testing, and cognitive function was assessed using the Mini-Mental State Examination (MMSE), which evaluates orientation, registration, attention and calculation, recall, and language. The MMSE demonstrated acceptable reliability in this study, with a Cronbach's Alpha value of 0.724 (Irawati & Madani, 2019).

Data Collection
Primary data were obtained directly from respondents via interviews and measurements using MMSE sheets. Secondary data were retrieved from the Tamalanrea Health Center records. Prior to data collection, researchers explained the study's objectives, procedures, duration, and potential benefits, and obtained informed consent from participants.

Data Analysis
Univariate analysis was used to describe the distribution of respondent characteristics (age, gender, blood glucose level, duration of illness, and cognitive function). Bivariate analysis was conducted to test the relationships between independent and dependent variables. The Chi-square test was applied for nominal variables, while the Gamma correlation test was used for ordinal variables because it is appropriate for assessing the strength and direction of association between two ordinal-level variables, accounting for tied ranks and providing more robust estimates in small to moderate sample sizes. For numerical variables, Pearson or Spearman correlation tests were employed depending on data normality. A significance level of $p < 0.05$ was considered statistically significant.

Ethical Considerations
This study was reviewed and approved by the Research Ethics Committee of the Muslim University of Indonesia (UMI), as evidenced by the issuance of an ethics approval letter confirming that the research met ethical standards.

Results

The characteristics of respondents are presented in Table 1. The mean age was 60.70 years (±9.376), with a predominance of females (71.7%). The mean blood glucose level was 226.23 mg/dL (±59.230), mean duration of diabetes was 7.06 years (±3.091), and the average cognitive function score was 23.74 (±2.411).

Table 1. Distribution of Respondents by Characteristics

Variable	Mean ± SD / n (%)
Age	60.70 ± 9.376
Gender	Male: 15 (28.3%), Female: 38 (71.7%)
Blood Sugar Level (mg/dL)	226.23 ± 59.230
Duration of DM (years)	7.06 ± 3.091
Cognitive Function Score	23.74 ± 2.411

Source: SPSS Processed Data, 2024

A significant, very strong negative correlation was found between age and cognitive function ($r = –0.859$, $p < 0.001$), indicating that older participants tended to have lower cognitive scores (Table 2).

Table 2. Correlation of age with cognitive function in Type 2 DM sufferers at the Tamalanrea Health Center

	Cognitive Function Score
Age Score	*r* = - 0.859
	p = < 0.001
	n = 53

Source: SPSS Processed Data, 2024

No significant correlation was observed between gender and cognitive function ($\gamma = –0.037$, $p = 0.850$), suggesting that sex differences did not influence cognitive performance in this sample (Table 3).

Table 3. The relationship between sex and cognitive function in patients with Type 2 DM at the Tamalanrea Health Center

	Cognitive Function Score
Gender Score	*r* = -0.037 *p* = > 0.850 *n* = 53

Source: SPSS Processed Data, 2024

Blood glucose levels were significantly correlated with cognitive function (r = –0.637, p < 0.001), with higher glucose levels associated with lower cognitive scores (Table 4).

Table 4. Correlation of Blood Sugar Levels with Cognitive Function in patients with Type 2 DM at the Tamalanrea Health Center

	Cognitive Function Score
Blood Sugar Score	*r* = -0.637 *p* = < 0.001 *n* = 53

Source: SPSS Processed Data, 2024

Similarly, duration of diabetes showed a very strong negative correlation with cognitive function (r = –0.843, p < 0.001), indicating that longer disease duration was linked to greater cognitive decline (Table 5).

Table 5. Long-term correlation of DM with cognitive function in patients with Type 2 DM at the Tamalanrea Health Center

	Cognitive Function Score
Old score suffers from DM	*r* = -0.843 *p* = < 0.001 *n* = 53

Source: SPSS Processed Data, 2024

Discussion

The discussion for each variable is based on the results of the data analysis that has been carried out as follows.

Age and cognitive function in people with Type 2 DM

Based on the results of research that has been carried out on 53 patients with Type 2 DM, it was found that the results of the spearman correlation test with the value of $p = 0.001 < 0.05$ which means that there is a correlation between age and cognitive function in people with Type 2 DM and the value of r = -0.859 which means that the direction of negative correlation with the correlation strength is very strong which shows that the older the person with DM is, the more cognitive function decreases. The results of this study are in line with the results of research conducted by Susilawati, (2016) which states that there is a significant relationship between the age of DM patients and the decline in cognitive function in the Working Area of the Pringapus Health Center, Pringapus District with the test results *Kendall Tau* Obtained *p* value 0.000≤0.05.

This is also in line with research conducted by Wiratman & Cahyati, (2021) which states that there is a significant relationship between the age of the respondents and the decline in cognitive function with the value of the *p* Value =*0.048 < 0.05. Thing* This is also in line with research Siman et al., (2016) which states that the age group experiences a lot of cognitive function impairments with the age group of 50-59 years. As a person ages, it is closely related to a decline in cognitive function which can not only occur in old age. Based on the results of the study *Whitehall II Prospective Cohort* report that a decline in cognitive function can occur from the middle age of 45 years of age which will result in changes in cells, tissues, and functional decline in anatomy and physiology (Wiratman & Cahyati, 2021). The increase in age in people with Type 2 DM can affect cognitive status, which if the age increases, the status of cognitive function decreases.

The results of the study on cognitive function in respondents over the age of 54 who suffer from Type 2 DM experienced many failures in the aspects of attention, calculation, and *recall*. A decline in cognitive function can occur due to the ability of brain functions to concentrate, focus, calculation, decision-making or logic. Decreased central nervous system function is said to be a major contributor to the decline in cognitive function. There are several other factors that increase the decline in cognitive function, namely stress, genetics, lifestyle, environment, and disease. Based on the description above, the researcher concluded that age is related to the decline in cognitive function caused by increasing age accompanied by *degenerative* changes in the body or metabolic factors that can cause a decline in a person's cognitive function. So researchers suggest doing physical activities that can trigger brain function to stay active by exercising (brain exercises), reading books, newspapers and the Qur'an and eating healthy foods to inhibit neural degeneration in brain tissue which has an impact on cognitive function.

Sex and cognitive function in people with Type 2 DM

No significant relationship was found between gender and cognitive function ($p = 0.850 > 0.05$, $r = –0.037$). This aligns with previous findings (Wiratman & Cahyati, 2021; Lutski et al., 2017; Faiza & Syafrita, 2020), which also reported no significant gender differences in cognitive decline among Type 2 DM patients. However, some studies (Susilawati, 2016) have suggested that women may be more vulnerable to cognitive impairment post-menopause due to decreased estrogen levels. Estrogen supports nerve cell growth, synapse density in the hippocampus, and cerebral blood flow, acting as an antioxidant and promoting memory-related brain structures (Torindatu et al., 2020). While our study did not find gender differences, both men and women with poorly controlled blood glucose remain at risk for cognitive decline, particularly with advancing age.

Blood sugar levels and cognitive function

There was a significant negative correlation between blood glucose levels and cognitive function ($p = 0.001 < 0.05$, $r = –0.637$), meaning higher blood sugar levels were associated with lower cognitive scores. This supports findings from Faisyal (2019), Nugroho et al. (2021), and Salim & Hasibuan (2016), who found that hyperglycemia accelerates cognitive impairment in DM patients. The mechanism may involve the accumulation of advanced glycation end-products (AGEs), which cause oxidative stress and endothelial dysfunction, disrupting brain function (Salim & Hasibuan, 2016). Other contributing factors include insulin resistance, depression, genetics, and lack of family support (Meloh et al., 2015). Regular blood sugar monitoring, dietary control, and appropriate treatment are essential to prevent long-term cognitive decline in this population.

Duration of Diabetes and cognitive function

A very strong negative correlation was found between the duration of diabetes and cognitive function ($p = 0.001 < 0.05$, $r = –0.843$), indicating that the longer a person has Type 2 DM, the greater the decline in cognitive ability. This finding is consistent with Faisyal (2019), Nugroho et al. (2021), and Kartika et al. (2015). Patients with DM for ≥5 years were more likely to have impaired working memory, slower processing speed, and reduced executive function (Mouse, 2017). Long-term hyperglycemia may lead to microvascular complications such as retinopathy

and nephropathy, both of which are associated with mild cognitive impairment (Nugroho et al., 2016). While disease duration is a risk factor, adopting a healthy lifestyle and maintaining glycemic control can help reduce the risk of cognitive decline and improve quality of life.

Conclusion

Based on the results of the research conducted at the Tamalanrea Health Center, it can be concluded that age, blood sugar levels, and duration of illness are significantly correlated with cognitive function in patients with Type 2 Diabetes Mellitus, while sex shows no significant correlation. These findings suggest that older age, higher blood sugar levels, and a longer duration of illness are important risk factors for cognitive decline in this population. Future studies should involve larger and more diverse samples and utilize additional cognitive assessment methods to validate and compare results, ensuring higher accuracy and generalizability. Clinically, routine cognitive screening should be integrated into diabetes management, and interventions focusing on blood sugar control, healthy aging, and early prevention of complications should be prioritized to maintain cognitive health in patients with Type 2 DM.

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