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Correlation Between Hypertension, Type 2 Diabetes Mellitus, Physical Activity, and Cognitive Function in Elderly Population at Primary Healthcare

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ABSTRACT

Background: Cognitive impairment is broadly connected as one of the factors that cause disability in the elderly. This study seeks to ascertain the correlation amidst hypertension, diabetes mellitus, physical activity, and cognitive function in the elderly.

Methods: A cross-sectional analytical study was carried out using a consecutive sampling method. The data were collected by interviewing elderly patients with Montreal Cognitive Assessment (MoCA) Indonesia and Rapid Assessment of Physical Activity (RAPA) while assessing patient Vascular Metabolism Factor (VMF) such as hypertension, type 2 diabetes mellitus (T2DM), and past history of heart disease**.** The Statistical Package for the Social Sciences (SPSS) was utilized to analyze the correlation between the aforementioned variables.

Results: A total of 277 elderly participants were recruited from February to July 2022. There was a significant correlation between hypertension (OR= 4.8; 95% CI: 2.5-9.1; $p < 0.001$) and cognitive impairment as well as physical activity (OR= 1.7; 95% CI: 1.3-2.4; $p < 0.001$). Despite no meaningful correlation amidst diabetes status and cognitive impairment (OR= 1.7; 95% CI: 0.8-3.8; $p = 0.14$), the number of participants with impaired cognitive function was elevated in the diabetes group (80.7%). Further analysis revealed that the interaction between diabetes, hypertension, and physical activity has a significant correlation with cognitive impairment ($p < 0.001$; $r^2 = 0.216$).

Conclusion: This study demonstrated a notable correlation amidst hypertension status, physical activity intensity, and cognitive function in the elderly population at Hative Kecil Public Health Center.

KEYWORDS: cognitive function, diabetes mellitus, hypertension, physical activity

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INTRODUCTION

A multitude of mental processes such as problem-solving and decision-making, attention, memory, learning, verbal memory, concentration, as well as reasoning, were involved in cognitive function. Cognitive impairment becomes a health problem in the elderly that is affiliated with Dementia, Alzheimer and Parkinson's. Cognitive impairment ranges from a reduced cognitive function without affecting daily functions delineated as Mild Cognitive Impairment (MCI) whilst dementia is portrayed as a cognitive impairment that adversely affects daily functions.[1,2]

Cognitive impairment in the elderly is common during the aging process. According to World Health Organization (WHO) in 2008, there were around 121 billion older adults suffering cognitive impairment.[3] Indonesia had around 23,68 billion elderly population in 2017 representing 9,03% of the total population, the number will be growing to 33,69 billion in 2025,[4] suggesting a prominent incidence of dementia and cognitive impairment. The 2010 World Alzheimer Report provided an estimation that the process of aging within the global population will result in the economic impact of dementia surpassing cancer, heart disease, and stroke combined.[5]

MCI is considered to be an intermediary step between normal cognitive function and dementia. There are numerous risk factors that can cause a decline in older adult's cognitive

functions. The Vascular Metabolism Factors (VMF), encompassing hypertension, coronary artery disease (CAD), hyperlipidemia, type 2 diabetes mellitus (T2DM), obesity, and other cardio-cerebrovascular diseases, possess the potential to instigate vascular dementia and potentially even yield Alzheimer's disease.[6,7]

Hypertension, diabetes mellitus, physical activity, and cognitive function were linked in several previous studies in the elderly. The massive number of elderly populations will increase the number of neurodegenerative cases which will eventually cause disability in the elderly. This study endeavors to establish the association between hypertension, type 2 diabetes mellitus, physical activity, and cognitive function within the elderly population residing in the Hative Kecil Public Health Center work area.

PATIENTS AND METHODS

A cross-sectional analytical study was carried out employing a consecutive sampling technique located at the Hative Kecil Public Health Center during the period of February to July 2022. Due to the low number of patients and 2nd peak of the SARSCOV-2 wave in Indonesia, the data were collected using two different methods, interviewing elderly outpatients and visiting elderly patients at their houses. Briefly, respondents who live in the Hative Kecil Public Health Center work area, with a minimum age of 60 years or above and a 6-year educational level or above were included in this study. Patients younger than 60, refused to be a respondent, had a visual and/or hearing impairment, had a past history of stroke, or past history of severe traumatic brain injury will be excluded.

The Bahasa version of the Montreal Cognitive Assessment (MoCA) was utilized to assess the participant's cognitive function. With a robust sensitivity ranging from 83% to 97%, the MoCA is considered to be the optimal screening tool for Mild Cognitive Impairment (MCI) in primary care settings. The MoCA evaluates various cognitive domains through a 30-point assessment, including executive function, visuospatial ability, language proficiency, delayed recall, attention, abstraction, and orientation. A score below 26 on the MoCA confirms the presence of MCI in the participant.[8,9]

The assessment of the respondent's physical activity was conducted through the utilization of the Rapid Physical Activity (RAPA) questionnaire. The RAPA questionnaire, which is designed for implementation within clinical practice involving older individuals, serves as a valid and user-friendly measure of physical activity. Comprising a total of nine items, the RAPA questionnaire presents respondents with the option of responding with either a yes or no, thereby encompassing a wide range of exercise levels including sedentary behavior, regular vigorous physical activity, as well as strength training and flexibility exercises. The instructions accompanying the questionnaire provide a succinct depiction of the three levels of physical activity (light, moderate, and vigorous) through the inclusion of both visual and textual representations of the various activities that fall within each respective category. The cumulative score derived from the initial seven items ranges from 1 to 7 points, which subsequently enables classification of the respondent's level of physical activity into one of five distinct categories: 1 = sedentary; 2 = underactive; 3 = regular underactive (light activities); 4 = regular underactive; and 5 = regular active. Notably, responses to the strength training and flexibility items are evaluated independently, with a score of 1 assigned to strength training, a score of 2 assigned to flexibility, and a score of 3 assigned to both activities..[10]

The respondent's Vascular Metabolism Factor (VMF) such as hypertension, type 2 diabetes mellitus (T2DM), and past history of heart disease was assessed by examining blood pressure and after meal blood glucose levels. The diagnosis of hypertension was determined by inquiring about whether a physician had ever informed the individual of having elevated blood pressure within the past five years or if they were currently or previously taking medication for blood pressure. Afterward, a medical professional evaluated the individual's Blood Pressure (BP) following a period of quiet sitting lasting five minutes, if the first systolic and diastolic BP results were more than 140 and 90 mmHg, the patient was rescheduled for the second examination. After two BP measurements, average systolic and diastolic BP (SBP and BP) were obtained. SBP and BP more than 140 and 90 mmHg indicated hypertension diagnosis according to The Eight Report of the Joint National Committee (JNC 8).[11] Type 2 diabetes mellitus (T2DM) is diagnosed by asking the patient "Has a medical practitioner ever informed you that you have diabetes??" or using the question for T2DM classic symptoms "Do you experience an increased thirst, increased hunger, frequent urination at night, and/or unintended weight loss?" A physician then assessed the patient after meal blood glucose. According to the American Diabetes Association, patients presenting the classic T2DM symptoms with after meal blood glucose levels of more than 200 mg/dl are diagnosed as T2DM.[12] The collected data were then analyzed using SPSS Software.

RESULTS

The following table provides information related to the characteristics of the subject in this study (Table 1). Amidst the 277 individuals who took part in this study, a significant majority consisted of individuals aged 75-90 years, totaling 85.2% (236) of the total participants. The remaining 41 participants, accounting for 14.8% of the total, were individuals aged above 90 years. Regarding the gender character, male and female participants respectively stands at 101 (36.5%) and 176 (63.5%). Of all the subjects, 44 (15.9%), 81 (29.2%), 120 (43.3%), and 32 (11.6%) reported the stratification of subject education respectively for elementary, junior, senior, and higher education. In this study,

just over a fifth of subjects were diagnosed with diabetes mellitus and hypertension was seen in 123 (44.4%) participants. Regarding their physical activity level, persons with a history of sedentary, underactive, and underactive regular light amounted around nearly a third of the subjects, while persons with underactive regular activity were seen in 19 (6.9%) of participants. Importantly, around three-quarters of the subjects belonging to have a cognitive impairment compared to 27.8% of subjects were associated with normal cognitive conditions.

Table 1. Characteristics of subjects

Sample Characteristic	Total (N) (%)
Age	
Elderly	236 (85.2%)
Old	41 (14.8%)
Gender	
Male	101 (36.5%)
Female	176 (63.5%)
Education	
Elementary	44 (15.9%)
Junior High School	81 (29.2%)
Senior high schol	120 (43.3%)
Higher Education/University	32 (11.6%)
Diabetes Melitus	57 (20.6%)
GDS (Mean)	155.19 ± 79.2
Hypertension	123 (44.4%)
Physical Activity	
Sedentary	92 (33.2%)
Underactive	84 (30.3%)
Underactive reguler light	82 (29.6%)
Underactive reguler	19 (6.9%)
Cognitive Function	
Cognitive impairment	200 (72.2%)
Normal	77 (27.8%)

In terms of generating correlation among the participants, two groups were proposed in this study, subjects with cognitive impairment and normal cognitive status. Three factors associated with the level of education, hypertension status, and type of physical activity have a significant correlation statistically between cognitive impairment and normal groups ($p < 0.05$) (Table 2). The occurrence of individuals displaying cognitive dysfunction was frequently observed in individuals diagnosed with hypertension. We observed a significant correlation between hypertension and cognitive dysfunction, as well as physical activity ($p < 0.001$). No noteworthy disparity was identified between cognitive dysfunction and the control group regarding from their blood glucose level profile. (Table 2). Among the 57 samples with diabetes mellitus, 46 patients (80.7%) were noticed to have a cognitive impairment, however, there is no significant correlation between diabetes status to the incidence of cognitive disturbances ($p = 0.108$). Additionally, the cognitive status of subjects in this study appeared to be unaffected by age and gender statistically ($p = 0.199$ and $p = 0.983$, respectively).

Table 2. Correlation of Participant's Characteristics to Cognitive Impairment

Characteristic	Cognitive Status				Total	P
	Cognitive Impairment (n=200)		Normal (n=77)			
	n	%	n	%		
Age						
Elderly	167	70.8%	69	29.2%	236	0.199
Old	33	80.5%	8	19.5%	41	
Gender						
Male	73	72.3	28	27.7	101	0.983
Female	127	72.2	49	27.8	176	
Education						

Elementary	38	86.4	6	13.6	44	0.002
Junior High School	66	81.5	15	18.5	81	
Senior High School	74	61.7	46	38.3	120	
Higher Education/University	22	68.8	10	31.2	32	
Diabetes Mellitus						
DM	46	80.7	11	19.3	57	0.108
Non-DM	154	70	66	30	220	
Blood Glucose Level						
GDS (Mean ± SD)	155.22±77.99		152±82.83			0.729
Hypertension						
Hypertension	108	87.8	15	12.2	123	<0.001
Non Hypertension	92	59.7	62	40.3	154	
Physical activity						
Sedentary	76	82.6	16	17.4	92	<0.001
Underactive	64	76.2	20	23.8	84	
Underactive reguler light	52	63.4	30	36.6	82	
Underactive reguler	8	42.1	11	57.9	19	

Since this study aims to underpin the remarkable correlation between diabetes, hypertension, and physical activity to our dependent variable, we then question whether amidst those three conditions might impose sufficient cognitive impairment in the subject of study. To achieve this objective, logistic regression analysis was employed to ascertain the importance of the interaction between the variables. People with hypertension have a 4.8 fold increased risk of cognitive impairment than non-hypertension subjects (Table 3). In relation to their PA intensity, this logistic regression model reveals that people with different intensity of PA has a significant association with their cognitive function. Furthermore, the interaction between diabetes, hypertension, and physical activity has a considerable potential to be an indicator of deteriorating cognitive status in the subject population ($r^2 = 0.216$; $p < 0.001$).

Table 3. Multivariate Logistic Regression Assessing the Interaction Effect on Cognitive Impairment

Risk Factor	Cognitive Impairment					
	p	OR	95% CI		p	R^2
			Lower	Upper		
Diabetes	0.147	1.764	0.819	3.800		
Hypertension	<0.001	4.778	2.508	9.102	<0.001	0.216
Physical Activity	<0.001	1.752	1.292	2.376		

After conducting an analysis of the independent variables in relation to cognitive impairment, our next step is to leverage our research in order to obtain a comprehensive understanding of the cognitive domain as it pertains to diabetes, hypertension, and the status of physical activity. (Table 4). What have depicted here in the table below displays diabetes patients addressed to have poor delayed recall ($p = 0.008$) and orientation ($p = 0.007$). We also confirmed that delayed recall and attention disturbance have been associated with patients with hypertension ($p = 0.002$ and $p = 0.01$, respectively). Of note, a distinct level of physical activity rules out the possibility of the sample having a lack of abstraction skill ($p < 0.001$), delayed recall ($p < 0.001$), and bad orientation.

Table 4. Multivariate Analysis of Interaction Effect on Cognitive Domain

Domain	Score (Total)	Diabetes Status			Hypertension status			Physical activity				
		Diabetes (n=) Mean (SD)	Non Diabetes (n=) Mean (SD)	P value	Hypertension (n=) Mean (SD)	Non Hypertension (n=) Mean (SD)	P value	Sedentary Mean (SD)	Underactive Mean (SD)	Underactive reguler light Mean (SD)	Underactive reguler Mean (SD)	P value
Visuospatial	0-5	3.18 (1.2)	3.42 (1.1)	0.14	3.24 (1.21)	3.48 (1.043)	0.073	3.18 (1.35)	3.39 (0.91)	3.44 (0.99)	3.89 (1.19)	0.086

Naming	0-3	2.19 (0.78)	2.3 (0.69)	0.27	2.2 (0.75)	2.36 (0.68)	0.06 20	2.32 (0.69)	2.10 (0.73)	2.37 (0.73)	2.63 (0.49)	0.006 *
Attention	0-6	4.49 (1.2)	4.55(1.3)	0.73	4.33 (1.35)	4.71 (1.14)	0.01 0*	4.5 (1.24)	4.52 (1.25)	4.57 (1.26)	4.68 (1.25)	0.955
Language	0-3	1.93 (0.65)	1.85 (0.66)	0.39	1.85 (0.68)	1.87 (0.64)	0.83 7	1.85 (0.75)	1.82 (0.58)	1.89 (0.58)	2.00 (0.82)	0.770
Abstraction	0-2	1.28 (0.72)	1.22 (0.69)	0.55	1.22 (0.66)	1.24 (0.73)	0.80 7	0.93 (0.71)	1.36 (0.65)	1.38 (0.66)	1.47 (0.61)	<0.0 01*
Delayed recall	0-5	2.3 (1.51)	2.9 (1.55)	0.00 8*	2.46 (1.51)	3.03 (1.54)	0.00 2*	2.12 (1.63)	3.12 (1.37)	3.06 (1.45)	3.26 (1.45)	<0.0 01*
Orientation	0-6	5.35 (0.97)	5.65 (0.67)	0.00 7*	5.59 (0.7)	5.59 (0.79)	0.95 1	5.41 (0.97)	5.55 (0.73)	5.79 (0.44)	5.74 (0.45)	0.022 *

DISCUSSION

This study set out to define the correlation between diabetes, hypertension, and physical activity in cognitive impairment (CI). To understand the association of those factors in CI, we collected 277 samples comprising different statuses of their cognitive measured by Montreal Cognitive Assessment (MoCA) then we defined specific features of the sample including their history of diabetes, hypertension, and type of physical activity, also other complementary characteristics like age, gender, education, and their blood glucose level. Taken together, this study suggests that CI incidence was elevated in the female group compared to the male group, and elderly people predominantly had CI which accounted for 167 persons. Those differences, however, were not significant statistically. To date, several studies have investigated that CI is predominantly found in the female group,[13,14] while in fact, gender implication on CI remains thus far unknown. Previous studies have indicated that cognitive decline in the female population may be linked to various factors, such as genetics, socioeconomic status, lifestyle choices, hormonal influences, psychological aspects, and neurobiological elements.[15] In this study, we have found that most of the female group had lower education compared to the male group, and it will be related to personal income. Low economic and educational status might imply poor dietary intake, difficulty in accessing healthcare, and quite challenging to build social interaction which leads to cognitive impairment.[16,17] Participating in a larger social circle is also thought to potentially diminish the likelihood of cognitive decline.[18]

Our study comparing diabetes status with cognitive impairment depicts a statistically non-significant correlation. However, the etiology of cognitive impairment in diabetes remains incompletely comprehended; nevertheless, hyperglycemia, vascular impairment, hypoglycemia, and insulin resistance have prominent roles. In spite of this, diabetes is renowned for inducing structural deterioration and functional disturbances in diverse tissues and organs over time. Moreover, diabetes has been documented to give rise to an array of cerebrovascular, neurochemical, and electrophysiological modifications in the central nervous system, thereby resulting in cognitive dysfunction.[19]

Moreover, our study also demonstrated a significant correlation between patients hypertension status with cognitive impairment, interestingly. This finding in line with previous studies demonstrated that alterations in BP are linked to cerebral perfusion and metabolism changes. Additionally, it has been observed that the influence of BP on white matter volume is more pronounced in the frontal lobes compared to the occipital, parietal, and temporal lobes.[20] Meanwhile, recent evidence suggests that human frontal lobes were associated with executive function and cognitive ability. Numerous additional investigations have likewise demonstrated a substantial quantity of extensive white matter hyperintensities in the frontal region among patients with hypertension, which have been linked to diminished performance on cognitive assessments evaluating memory (in the form of matching pairs), executive functioning (in the context of reorganizing towers), and reasoning abilities (in the context of discerning patterns in a matrix).[20,21]

Our analysis also demonstrated a statistically meaningful correlation between physical activity (PA) and cognitive impairment. Regardless of the PA intensity, a higher percentage of normal cognitive functions was seen in elderly people with a higher intensity of the PA group. The latest literature implied that physical activity may be expected to protect mobility and cognitive function in elderly people as the brain retains plasticity.[22,23] Exercise could potentially serve as a powerful and secure substitute for pharmaceutical drugs when it comes to decelerating cognitive decline. This is achieved through the stimulation of the brain-derived neurotrophic factor (BDNF) and insulin-like growth factor-1 (IGF-1), which in turn facilitate the restructuring and interconnectivity of various key brain regions. These regions include the hippocampus, temporal lobe, frontal areas, and corpus callosum, all of which are known to be activated during tasks that require executive function, attention, processing speed, and memory.[24]

Delayed recall becomes the same cognitive domain that is disrupted in diabetes, hypertension, and poor physical activity groups. In the diabetes group, the cognitive areas that have

been linked to diabetes have shown a lack of consistency. Nevertheless, a preliminary investigation that observed 1,290 participants over a period of 12 years as part of the Maastricht Aging Study revealed that diabetes was linked to the most substantial decreases in the ability to process information quickly, executive functioning, and the ability to recall words after a delay.[25,26] Meanwhile in the hypertension group, contrary to other studies that found a statistically significant difference for all cognitive domains of MoCA, the current study only found a statistically significant difference in attention and delayed recall domain amidst hypertension and non-hypertension groups. This occurrence could arise due to the varying susceptibility of distinct cerebral tissues to fluctuations in blood pressure levels, hence warranting further extensive investigation into the impact of blood pressure classification on cerebral tissue.[20,27] Furthermore, in the physical activity group, patients with mild cognitive impairment (MCI) were believed to have a decrease in cerebral blood flow (CBF), including the precuneus, hippocampus, and posterior cingulate gyrus.[28] Exercise has the ability to regulate the cerebrovascular structure, thereby enabling improved perfusion, oxygen and nutrient delivery, neurotrophin circulation, and other factors that have the potential to enhance brain function. Meanwhile, a crucial brain locus for learning and memorizing namely the hippocampus exhibits a positive correlation between increased fitness levels and greater hippocampal volume, resulting in enhanced performance on memory assessments.[29]

CONCLUSION

The correlation between hypertension, physical activity, and cognitive function in the elderly population was found to be statistically significant. Although there was no substantial correlation observed between diabetes and cognitive function, a greater proportion of patients with diabetes exhibited unfavorable results on the Montreal Cognitive Assessment (MoCA) compared to those without diabetes. These results point up the need for a better understanding in the community about maintaining blood pressure and blood glucose level, as well as increasing daily exercise, especially for elderly people to protect their cognitive function that could help them achieve a good quality of life.

ETHICAL STATEMENT

Approval from the Research Ethics Commission of the Faculty of Medicine, Pattimura University, Ambon has been received for this research.

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