Bali Medical Journal (*Bali MedJ)* 2023, Volume 12, Number 1: 249-254
P-ISSN.2089-1180, E-ISSN: 2302-2914

Bali Medical Journal

The frequency and determinants of executive dysfunction among patients with subacute phase of ischemic stroke in West Nusa Tenggara, Indonesia

CrossMark

Muhammad Akbar[1], Jumraini Tammasse[1], Andi Kurnia Bintang[1], Herpan Syafii Harahap[2*]

[1]Department of Neurology, Faculty of Medicine, Universitas Hasanuddin, Makassar, Indonesia;
[2]Department of Neurology, Faculty of Medicine, Universitas Mataram, Mataram, Indonesia;

*Corresponding author:
Herpan Syafii Harahap;
Department of Neurology, Faculty of Medicine, Universitas Mataram, Mataram, Indonesia;
herpanharahap@unram.ac.id

Received: 2022-11-10
Accepted: 2022-12-15
Published: 2023-01-11

ABSTRACT

Background: Executive dysfunction is a common form of intellectual weakening that interferes with the functional activity of the stroke survivors. Detection of executive dysfunction in the subacute segment of ischemic stroke allows the patients to receive appropriate interventions for optimal clinical outcomes. This study aims to investigate the frequency and determinants of executive dysfunction among subacute ischemic stroke patients in West Nusa Tenggara.

Methods: This study involved 192 subjects divided into two groups: ischemic stroke (n=96) and control groups (n=96). Categorical data collected from both ischemic stroke and control subjects were age, gender, education level, occupation, hypertension, diabetes mellitus, Trail Making Test Part B, verbal fluency test, backward digit span scores and executive function status. Besides the data previously mentioned, clinical data that were also collected in ischemic stroke subjects was infarct size. The significant difference in the frequency of executive dysfunction between ischemic stroke and control groups was analyzed using chi-square test. The association between the determinants of executive dysfunction and the frequency of this executive dysfunction was analyzed using logistic regression.

Results: This study discovered that the frequency of executive dysfunction among subjects with subacute phase of ischemic stroke was 52.1% and it was significantly higher compared with controls ($p<0.0001$). Further, lower education level was the only determinant significantly correlated with the increased risk of executive dysfunction in the subjects (Odds ratio [OR] =3.47; 95% confidence interval [CI] = 1.47 – 10.26).

Conclusion: There was high frequency of subacute ischemic stroke-associated executive dysfunction associated with lower education level.

Keywords: cognitive reserve, education level, executive dysfunction, risk factors, stroke.
Cite This Article: Akbar, M., Tammasse, J., Bintang, A.K., Harahap, H.S. 2023. The frequency and determinants of executive dysfunction among patients with subacute phase of ischemic stroke in West Nusa Tenggara, Indonesia. *Bali Medical Journal* 12(1): 249-254. DOI: 10.15562/bmj.v12i1.3789

INTRODUCTION

Cognitive impairment is an vital value of ischemic stroke. Its prevalence is in the range of 25 – 80% in stroke patients involving one or more cognitive domains.[1,2] In the subacute phase of ischemic stroke, the prevalence of ischemic stroke-associated cognitive impairment is found to be higher, up to 91% and 64% of them are found in the form of executive dysfunction.[3] In general, cognitive impairment, including executive dysfunction, which occurs in the subacute segment of ischemic stroke is subtle and difficult to be recognized by the patients and their relatives. However, the subacute phase of ischemic stroke is the most important phase for the improvement of cognitive function associated with neural plasticity in the brain.[4] Thirty-seven percent of stroke patients obtain optimal improvement on intellectual role in the subacute segment,[5] while in the chronic phase, those who obtain optimal improvement on cognitive function are only 7.8%.[6] In addition, ischemic stroke-associated cognitive impairment that becomes more severe will lead to permanent dependence of the patients on their caregivers to carry out their daily functional activities and this in turn increases the health, social, and economic burden on patients, their relatives and the healthcare system.[7] Therefore, detection and management of cognitive impairment, including executive dysfunction in the subacute segment of ischemic stroke is likely to benefit in stabilizing its clinical course.

Ischemic stroke-associated cognitive impairment may involve one or more subsequent cognitive fields, namely attention, executive function, delayed memory, language, and constructional praxis.[8] Among them, executive function is the domain mostly affected in ischemic stroke.[9] Since several brain structures, including prefrontal and parietal cortices, basal ganglia, thalamus, and cerebellum carry out executive function, ischemic stroke involving these structures as well as their white matter connections will lead to executive dysfunction.[10]

Executive dysfunction after an ischemic stroke causes patients to struggle with planning, concept modification, and decision-making.[11] Accordingly, it causes loss of their productivity and higher functional dependence on their caregivers compared to those with impairments in other cognitive domains.[12] However, the available data regarding the prevalence and the risk factors of executive dysfunction among ischemic stroke patients is still scarce. According to earlier research, 39 to 64 percent of stroke survivors exhibit executive impairment.[3,13] However, these data have not been updated. In addition, to our knowledge, similar data regarding the frequency and determinants of executive dysfunction among Indonesian ischemic stroke survivors are not available. Growing older, being a woman, having a low level of education, being unemployed, having a lacunar infarct, having high blood pressure, and having diabetes mellitus are some factors linked to an increased risk of executive dysfunction in ischemic stroke patients.[14] Intervention with these identified risk factors helps these individuals' executive dysfunction from progressing.[15]

Early evaluation of cognitive function allows the patients to obtain early intervention and optimal clinical outcomes.[12] Regarding the determination of the critical period for evaluation of cognitive function, some studies performed this evaluation in the acute segment.[5,16] The others performed it in the subacute phase.[3,17] Since up to 75% ischemic stroke patients may have delirium in the acute phase, which can be associated with the involvement of ischemic lesion in right hemisphere and this condition interfere the results of the evaluation of executive dysfunction.[18] It is wise to consider that the critical period for cognitive evaluation is in the subacute rather than acute segment of ischemic stroke.

West Nusa Tenggara is one of the provinces in Indonesia with a low Social Sustainability Index (SSI) characterized by the lack of access to education and healthcare services for its population.[19] This area has the potential to be studied, thus it provides updated epidemiological data. This initial investigation on executive dysfunction in patients with subacute ischemic stroke in West Nusa Tenggara, Indonesia, sought to determine its prevalence and determinants.

METHODS

Study design and sample

This is a case-control study involving subacute ischemic stroke and control subjects recruited from three main hospitals in Mataram City, West Nusa Tenggara Province. This study was conducted from August 2019 to May 2021. The sample size was calculated using formula of $n_1=n_2= [(Z_\alpha\sqrt{2PQ} + Z_\beta\sqrt{(P_1Q_1 + P_2Q_2)}):(P_1-P_2)]$.[2] By using the prevalence data of ischemic stroke-associated executive dysfunction in the previous study was 39%, $\alpha=0.05$, $Z_\alpha=1.96$, $\beta=0.2$, and $Z_\beta=0.84$, the sample size needed for each group was 96.[20] The inclusion criteria for subjects in subacute phase of ischemic stroke were ischemic stroke patients (confirmed by head CT scan examination), beyond 2 weeks to 12 weeks from stroke onset, aged 18-70 years old, fully conscious, and having a minimum of 6-year-education attainment. Control subjects were recruited from couple or relatives of the patients or subjects with other medical condition visiting the hospitals. The inclusion criteria for control subjects were subjects without prior history of stroke, aged 18-70 years old, fully conscious, and having a tiniest six years education attainment. The exclusion criteria for both groups were significant hearing and visual loss that could not be modified, history of cognitive impairment and psychiatric disorders prior stroke event, currently taking antidepressant, antipsychotic, and anti-anxiety drugs at the time of executive function assessment.

Data collection

Socio-demographic, clinical, and outcome data collected from study sample included categorical data of age group, gender, education level, occupation, hypertension, diabetes mellitus, Trail Making Test Part B (TMT-B) score, animal category of verbal fluency test (VFT) score, backward digit span (BDS) score, and executive function status. Age was categorized into young adults (<60 years old) and older adults (≥60 years old). Gender was categorized as male and female. Education level was categorized into low (≤12 years) and higher (>12 years) educational levels. Occupation was categorized into workers and non-workers. Data on hypertension and diabetes mellitus were collected based on information provided in their medical records.

In TMT-B, the subjects were instructed to connect circles containing numbers or letters randomly printed on a piece of paper in an alternate number/letter sequence and the result was categorized into normal (test completion time ≤180 seconds) and impaired (test completion time >180 seconds). In animal category of VFT, the subjects were directed to generate the names of animals as many as possible within 60 seconds and the result was categorized into normal (able to generate ≥14 animal names) and impaired (able to generate<14 animal names). In BDS test, the subjects were requested to reverse the sequence of numbers mentioned by the examiner and the result was categorized as normal (able to reverse ≥4 number sequences) and impaired (able to reverse <4 number sequences). Based on the results of these three tests, the status of executive function was categorized into normal (2 out of 3 tests showed normal results) and executive dysfunction (<2 tests showed normal results), as described in previous study.[21]

The socio-demographic and clinical data derived only from subjects with subacute phase of ischemic stroke as the categorical variables comprising all of the categorical variables mentioned above and supplemented with the data of infarct size based on head CT scan examinations. Infarct size was characterized into small (<15 mm in diameter) and larger (≥15 mm in diameter) size.[3]

Data analysis

Socio-demographic, clinical, and outcome data from both subacute ischemic stroke and control subjects were presented as frequency (n) and percentage (%). The first analysis was performed to determine the differences in the frequencies of socio-demographic variables, clinical variables, and outcome variables between subacute ischemic stroke and control subjects. The differences in the frequencies of all variables mentioned above between the two groups were examined using chi-square test.

The second analysis was performed to determine the association between socio-demographic and clinical variables as well as the frequency of executive dysfunction in subjects with subacute phase of ischemic stroke. The association between categorical variables (independent variables), i.e age (older adults vs young adults), gender (male vs female), occupation (workers vs non-workers), education level (low vs higher), infarct size (small vs larger), hypertension, and diabetes mellitus and frequency of executive dysfunction (dependent variable) in subacute ischemic stroke subjects were observed with simple binary logistic regression analysis. The independent variables showing p<0.25 were recorded in a multiple logistic regression model in odds ratio (OR) with 95% confidence interval (CI). The analysis was accomplished using computer program and the cutoff for statistical significance was p<0.05.

RESULTS

The comparison in socio-demographic, clinical, and outcome characteristics between subacute ischemic stroke and control subjects showed in Table 1. Of the 192 study samples, 96 of them were subjects with subacute phase of ischemic stroke and the remaining 96 were control subjects. With comparable socio-demographic and clinical characteristics between the two subject groups, except hypertension, the frequency of executive dysfunction in the ischemic stroke group was significantly higher than in the control group (p<0.05). The frequency of executive dysfunction in ischemic stroke group was 52.1%.

The association between demographic and clinical variables and the frequency of executive dysfunction among subacute ischemic stroke subjects showed in Table 2. Gender, occupation, and education level were eligible variables for further analysis (p<0.25). Furthermore, the subjects with low education level (≤12 years) were the only variable associated with the increase risk of executive dysfunction in subacute phase of ischemic stroke patients (OR = 3.48, 95% CI = 1.36 – 8.90, p = 0.006), while female gender and workers were not significantly associated (p >0.05).

Table 1. Comparison of socio-demographic, clinical, and outcome variables between subacute ischemic stroke and control subject groups.

Variables	Frequency (%)		p-value
	Stroke subjects (n=96)	Control subjects (n=96)	
Socio-demographic variables			
Age			
Older adults (≥60 years)	23 (24.0)	19 (19.8)	0.485
Young adults (<60 years)	73 (76.0)	77 (80.2)	
Gender			
Female	27 (28.1)	37 (38.5)	0.126
Male	69 (71.9)	59 (61.5)	
Occupation			
Workers	67 (69.8)	65 (67.7)	0.755
Non workers	29 (31.2)	31 (32.3)	
Education level			
Higher (>12 years)	30 (31.2)	38 (39.6)	0.227
Low (≤12 years)	66 (68.8)	58 (60.4)	
Clinical variables			
Hypertension			
Yes	86 (89.6)	49 (51.0)	<0.001*
No	10 (10.4)	47 (49.0)	
Diabetes mellitus			
Yes	35 (36.5)	33 (34.4)	0.763
No	61 (63.5)	63 (65.6)	
Outcome variables			
TMT-B score			
Normal	33 (34.4)	73 (76.0)	<0.001*
Impaired	63 (65.6)	23 (24.0)	
Animal category of VFT score			
Normal	34 (35.4)	53 (55.2)	0.006*
Impaired	62 (64.6)	43 (44.8)	
BDS test score			
Normal	79 (82.3)	75 (78.1)	0.469
Impaired	17 (17.7)	21 (21.9)	
Executive function status			
Executive dysfunction	50 (52.1)	20 (20.8)	<0.001*
Normal	46 (47.9)	76 (79.2)	

*Significant difference (p<0.05); OR=odd ratio; TMT-B=Trail Making Test B Part B; VFT=verbal fluency test; BDS=backward digit span

DISCUSSION

This is an preliminary study designed at investigating the frequency of executive dysfunction in subacute ischemic stroke patients living in West Nusa Tenggara and identifying its determinants. This study found that with comparable socio-demographic characteristics but not with almost all clinical characteristics, excluding hypertension, there was a high frequency of executive dysfunction in subacute ischemic stroke patients (52.1%) and it was significantly higher than controls. This result is constant with that of earlier research by Jaillard et al. and Nys et al.[3,13] Since the data on the prevalence of executive dysfunction from the two studies are quite old and there is currently no recent similar data, The findings of this study provide an update to those of the earlier investigations. High prevalence of ischemic stroke-associated executive dysfunction indicates the high potential for disability in patients as well as the economic burden on patients and their families.

This investigation also exposed that education level was the only determinant

Table 2. **Multivariate logistic regression analysis showing variables associated with executive dysfunction in subacute ischemic stroke subjects.**

Variables	Executive function status [n (%)]		Crude odd ratio (95% CI)[a]	p-value	Adjusted odd ratio (95% CI)[b]	p-value
	Normal (n=46)	Executive dysfunction (n=50)				
Age						
Older adults	11 (47.8)	12 (52.2)	1.00 (0.39 – 2.57)	0.992	-	-
Young adults	35 (47.9)	38 (52.1)	Reference			
Gender						
Male	37 (53.6)	32 (46.4)	2.31 (0.91 – 5.86)	0.077	1.75 (0.63 – 4.86)	0.281
Female	9 (33.3)	18 (66.7)	Reference		Reference	
Occupation						
Non-workers	11 (37.9)	18 (62.1)	1.79 (0.74 – 4.36)	0.200	1.37 (0.51 – 3.69)	0.528
Workers	35 (52.2)	32 (47.8)	Reference		Reference	
Education level						
Low	25 (37.9)	41 (62.1)	3.83 (1.52 – 9.66)	0.004	3.48 (1.36 – 8.90)	0.009*
Higher	21 (70.0)	9 (30.0)	Reference		Reference	
Infarct size						
Larger	8 (53.3)	7 (46.7)	1.29 (0.43 – 3.90)	0.648	-	-
Small	38 (46.9)	43 (53.1)	Reference			
Hypertension						
Yes	41 (47.7)	45 (52,3)	1.10 (0.30 – 4.07)	0.889	-	-
No	5 (50.0)	5 (50.0)	Reference			
Diabetes mellitus						
Yes	17 (48.6)	18 (51.4)	1.04 (0.45 – 2.39)	0.923	-	-
No	29 (47.5)	32 (52.5)	Reference			

[a]Simple logistic regression analysis; [b]Multiple logistic regression analysis; *Significant association ($p<0.05$); BMI=body mass index

associated with the risk of executive dysfunction in subacute phase of ischemic stroke. This result is in line with the result of a study led by Levine et al.[22] The education level, together with occupation, are the main components of cognitive reserve needed to maintain the integrity of person's cognitive status against the presence of ischemic lesions in the brain.[23] Stroke patients with higher level of education will have better improvements in the efficiency of synaptic connectivity in the brain disrupted after ischemic stroke and are able to preserve proper executive function.[11]

Since West Nusa Tenggara is one of the provinces with low access to education and health services as well as limited availability of advanced diagnostic facilities but with a high frequency of subacute ischemic stroke-associated executive dysfunction based on our findings, detection and intervention of executive dysfunction associated with ischemic stroke is challenging. This is because the success of rehabilitation and intervention programs specifically designed for executive dysfunction for these patients is mainly determined by their ability to understand the instructions given to them.[12] Therefore, the active participation of family members as well as caregivers of the patients is important.

This study also showed that the prevalence of subacute ischemic stroke-associated cognitive loss was not substantially correlated with the vascular risk factors, such as hypertension and diabetes mellitus, that were found in patients with subacute ischemic stroke. Previous research also produced conflicting findings on the relationship between these stroke features, vascular risk factors, and the prevalence of executive dysfunction brought on by ischemic stroke. All of the vascular risk variables previously described were connected to the prevalence of executive dysfunction in ischemic stroke patients, according to research by Zulkifly et al.[14] Meanwhile, Qu et al showed no association about it.[1] The different results between the two studies and our findings were most likely due to differences in the sample size, the socio-demographic characteristics of the subjects, and the study methods. The reason for the study's somewhat limited sample size is primarily that the subjects were stroke patients who had completed at least six years of education within the first three months of their stroke's onset. Since the presence of these vascular risk factors may independently impair the integrity of the frontoparietal white matter resulting in executive dysfunction, their identification and management remains an important part of stroke-associated executive dysfunction prevention strategies.[24]

This study contains a number of restrictions. First, this study was conducted with a small sample size that could influence the significance of the findings. Further study with a larger sample size to better represent the population in West Nusa Tenggara is recommended. Second, due to limited availability of diagnostic facilities, identification of stroke characteristics was based only on head CT scan. This could also influence the significance of the findings. Third, due to unavailability of baseline data on the cognitive function of patients before stroke onset, information regarding the presence of a prior history of cognitive impairment in this study was based on information provided by the patients and/or their relatives. Therefore, the possibility that executive dysfunction detected in this investigation was a preexisting condition could not be ruled out. Due to the scarcity of data on the prevalence of subacute ischemic stroke-associated executive dysfunction and its correlates, especially among the Indonesian population, our findings are valuable as a basis for developing rehabilitation and intervention strategies by healthcare providers in West Nusa Tenggara and other provinces in Indonesia and other developing countries with similar income category.

CONCLUSIONS

This study discovered that the frequency of executive dysfunction among subjects with subacute phase of ischemic stroke was 52.1% and it was significantly higher than controls. Further, education level was the determinant of the high frequency of subacute ischemic stroke-associated executive dysfunction. It is important to develop an early intervention strategy specific for executive dysfunction among ischemic stroke patients with regard to their educational level.

CONFLICT OF INTERESTS

No conflicts of interest exist, according to the authors, with the publishing of this article.

FUNDING

All research funding is the responsibility of the authors, who have not received any funding from other sources.

ETHICAL CONSIDERATION

Universitas Mataram's Ethical Committee for Medical Research gave its approval to this study (registration number: 214/UN18.F7/ETIK/2019).

AUTHOR CONTRIBUTIONS

Every author contributes to the study in some way, from developing the conceptual framework to collecting and analyzing the necessary data to publishing the findings.

REFERENCES

1. Qu Y, Zhuo L, Li N, Hu Y, Chen W, Zhou Y, et al. Prevalence of poststroke cognitive impairment in china a community-based, cross-sectional study. PLoS One. 2015;10(4):e0122864. Available from: https://doi.org/10.1371/journal.pone.0122864
2. Lo JW, Crawford JD, Desmond DW, Godefroy O, Jokinen H, Mahinrad S, et al. Profile of and risk factors for poststroke cognitive impairment in diverse ethnoregional groups. Neurology. 2019;93(24):E2257–71. Available from: https://pubmed.ncbi.nlm.nih.gov/31712368
3. Jaillard A, Naegele B, Trabucco-Miguel S, LeBas JF, Hommel M. Hidden dysfunctioning in subacute stroke. Stroke. 2009;40(7):2473–9. Available from: https://pubmed.ncbi.nlm.nih.gov/19461036/
4. Coco D Lo, Lopez G, Corrao S. Cognitive impairment and stroke in elderly patients [Internet]. Vol. 12, Vascular Health and Risk Management. 2016. p. 105–16. Available from: https://pubmed.ncbi.nlm.nih.gov/27069366/
5. Obaid M, Flach C, Marshall I, Wolfe CDA, Douiri A. Long-term outcomes in stroke patients with cognitive impairment: A population-based study. Geriatr. 2020;5(2):32. Available from: https://pubmed.ncbi.nlm.nih.gov/32443398/
6. Del Ser T, Barba R, Morin MM, Domingo J, Cemillan C, Pondal M, et al. Evolution of cognitive impairment after stroke and risk factors for delayed progression. Stroke. 2005;36(12):2670–5. Available from: https://pubmed.ncbi.nlm.nih.gov/16254227/
7. Rohde D, Williams D, Gaynor E, Bennett K, Dolan E, Callaly E, et al. Secondary prevention and cognitive function after stroke: A study protocol for a 5-year follow-up of the ASPIRE-S cohort. BMJ Open. 2017;7(3):e014819. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5372058/
8. Al-Qazzaz NK, Ali SH, Ahmad SA, Islam S, Mohamad K. Cognitive impairment and memory dysfunction after a stroke diagnosis: A post-stroke memory assessment [Internet]. Vol. 10, Neuropsychiatric Disease and Treatment. 2014. p. 1677–91. Available from: https://pubmed.ncbi.nlm.nih.gov/25228808/
9. Rincon F, Wright CB. Vascular cognitive impairment [Internet]. Vol. 26, Current Opinion in Neurology. 2013. p. 29–36. Available from: https://pubmed.ncbi.nlm.nih.gov/23254555/
10. Rabinovici GD, Stephens ML, Possin KL. Executive dysfunction [Internet]. Vol. 21, Continuum (Minneap Minn). 2015. p. 646–59. Available from: https://pubmed.ncbi.nlm.nih.gov/26039846/
11. Povroznik JM, Ozga JE, Haar CV, Engler-Chiurazzi EB. Executive (dys)function after stroke: Special considerations for behavioral pharmacology. Behav Pharmacol. 2018;29(7):638–53. Available from: https://pubmed.ncbi.nlm.nih.gov/30215622/
12. Cumming TB, Marshall RS, Lazar RM. Stroke, cognitive deficits, and rehabilitation: Still an incomplete picture [Internet]. Vol. 8, International Journal of Stroke. 2013. p. 38–45. Available from: https://pubmed.ncbi.nlm.nih.gov/23280268/
13. Nys GMS, Van Zandvoort MJE, De Kort PLM, Jansen BPW, De Haan EHF, Kappelle LJ. Cognitive disorders in acute stroke: Prevalence and clinical determinants. Cerebrovasc Dis. 2007;23(5–6):408–16. Available from: https://pubmed.ncbi.nlm.nih.gov/17406110/
14. Mohd Zulkifly MF, Ghazali SE, Che Din N, Singh DKA, Subramaniam P. A Review of Risk Factors for Cognitive Impairment in Stroke Survivors [Internet]. Vol. 2016, Scientific World Journal. 2016. p. 3456943. Available from: https://doi.org/10.1155/2016/3456943
15. Willis KJ, Hakim AM. Stroke prevention and cognitive reserve: Emerging approaches to modifying risk and delaying onset of dementia. Front Neurol. 2013;4:13. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3604564/
16. Westerlind E, Abzhandadze T, Rafsten L, Persson HC, Sunnerhagen KS. Very early cognitive screening and return to work after stroke. Top Stroke Rehabil. 2019;26(8):602–7. Available from: https://doi.org/10.1080/10749357.2019.1645440
17. Nys GMS, Van Zandvoort MJE, De Kort PLM, Jansen BPW, Van Der Worp HB, Kappelle LJ, et al. Domain-specific cognitive recovery after first-ever stroke: A follow-up study of 111 cases. J Int Neuropsychol Soc. 2005;11(7):795–806. Available from: https://pubmed.ncbi.nlm.nih.gov/16519259/
18. Stokholm J, Steenholt JV, Csilag C, Kjær TW, Christensen T. Delirium Assessment in Acute Stroke: A Systematic Review and Meta-Analysis of Incidence, Assessment Tools, and Assessment Frequencies. J Cent Nerv Syst Dis. 2019;11:1–9. Available from: https://pubmed.ncbi.nlm.nih.gov/31908562/
19. M. Faruk F. Regional Social Sustainability Index in Indonesia 2017. J Perenc Pembang Indones J Dev Plan. 2020;4(1):40–53. Available from: https://doi.org/10.36574/jpp.v4i1.103
20. Conti J, Sterr A, Brucki SMD, Conforto AB. Diversity of approaches in assessment of executive functions in stroke: Limited evidence? [Internet]. Vol. 1, eNeurologicalSci. Elsevier B.V.; 2015. p. 12–20. Available from: https://doi.org/10.1016/j.ensci.2015.08.002
21. Harahap HS, Akbar M, Bintang AK, Tammasse J, Zainuddin AA. Methylenetetrahydrofolate reductase (MTHFR) C677T polymorphism rather than homocysteine increase the risk

of ischemic stroke-associated executive dysfunction. Bali Med J. 2022;11(1):443–50. Available from: https://doi.org/10.15562/bmj.v11i1.2503
22. Levine DA, Wadley VG, Langa KM, Howard G, Howard VJ, Cushman M. Risk Factors for Poststroke Cognitive Decline: The REGARDS Study (Reasons for Geographic and Racial Differences in Stroke). Stroke. 2019;49(4):987–94. Available from: https://pubmed.ncbi.nlm.nih.gov/29581343/
23. Kluwe-Schiavon B. b, Sanvicente-Vieira B. b, Viola TW. b, e Souza LSA., Rigoli MM. c, Fonseca RP. d, et al. Rehabilitation of executive functions: Implications and strategies. Av en Psicol Latinoam. 2013;31(1):110–20. Available from: http://www.scielo.org.co/scielo.php?script=sci_arttext&pid=S1794-47242013000100009&lng=en&nrm=iso
24. Veldsman M, Werden E, Egorova N, Khlif MS, Brodtmann A. Microstructural degeneration and cerebrovascular risk burden underlying executive dysfunction after stroke. Sci Rep. 2020;10(1):17911. Available from: https://doi.org/10.1038/s41598-020-75074-w