Activitas Nervosa Superior Rediviva Volume 66 No. 2 2024

ORIGINAL ARTICLE

DOI: https://doi.org/10.31577/ansr.2024.66.2.4

Efficacy of mindfulness-based stress reduction and cognitive rehabilitation training on executive functioning of stroke patients

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Submitted: 2024-05-18 Accepted: 2024-07-10 Published online: 2024-09-08

Key words: **Mindfulness-based Stress Reduction; Powell's Cognitive Rehabilitation; Executive Functions; Ischemic Stroke**

Act Nerv Super Rediviva 2024; **66**(2): 76–85 ANSR66224A04

Abstract

OBJECTIVES: This study aims to evaluate the efficacy of mindfulness-based stress reduction (MBSR) cognitive rehabilitation training (CRT) on executive functions in stroke patients.
METHODS: This semi-experimental study was based on the pre-test, post-test, follow-up design. The statistical population consisted of all the people with stroke who referred to Razi Hospital in Birjand City, Iran, from June 2018 to June 2021. Thirty-six eligible stroke patients were included in the study by purposive sampling method and randomly assigned to 3 groups of MBSR, CRT and control. The MOCA test was the instrument employed in this research; and MBSR and CRT sessions were held for 3 months (12 sessions, one 60-minute session each week). The data were analyzed using repeated measures ANOVA and Bonferroni post-hoc test in SPSS software (version. 26) at a significance level of $p < 0.05$.
RESULTS: The majority of participants were male. There wasn't a significant difference between the mean score of executive functioning among the three groups in the pre-test, while, in the post-test, a significant difference was observed which implies the MBSR and CRT groups outperformed the control group in Improving executive functions of patients. Finally, at the follow-up, all changes were stable. Repeated measurement analysis showed that both training methods were significantly effective on improving patients' executive actions($p < 0.05$), and its effectiveness was stable over time. Also, there was no significant difference between effectiveness of the MBSR and CRT methods. In addition, regarding the subscale of Visuospatial skills, attention and working memory, only the effectiveness of cognitive rehabilitation training was significant ($p < 0.05$) that its effectiveness was stable over time.
CONCLUSION: It is suggested that stress reduction treatments based on mindfulness and cognitive rehabilitation are used as complementary treatments along with other treatments to improve the cognitive and psychological problems of stroke patients.

Introduction

A stroke, also referred to as a cerebrovascular accident, is a sudden onset of a neurological condition that can be attributed to a specific vascular issue. Ischemic stroke is a prevalent vascular disorder that affects the brain(Abiodun 2018).

Langlois, Rutland-Brown, and Wald (2006) highlight that a traumatic brain injury (TBI) can have long-term or lifelong consequences, potentially leading to other health issues. Individuals who have experienced a brain injury may face various challenges that affect their daily lives and functioning. Emotional difficulties, such as depression and anxiety, are common among TBI survivors, with a significant percentage experiencing these mental health issues. Literature suggests that emotional issues after brain injury may develop due to difficulty adjusting to a different view of themselves and their life (Langlois *et al.* 2006).

Each year, more than 400,000 individuals are discharged from hospitals after experiencing acute stroke episodes, resulting in varying levels of cognitive and physical impairments. While about 30% of these individuals recover, approximately 40% are left with disabilities. Interventions, like Mindfulness-Based Stress Reduction (MBSR), have the potential to improve quality of life, speed up recovery, reduce hospital stays. MBSR, a consciousness-focused intervention, offers patients a deep awareness of their thoughts, emotions, and physical sensations. This mindfulness-based approach can positively impact psychological functions, promote self-management, and boost adaptability. Initially designed to enhance mental well-being through traditional mindfulness practices, MBSR has evolved to support individuals in managing their overall health and well-being (Kilkenny *et al.* 2020; Cadilhac *et al.* 2017; De Vibe *et al.* 2012).

Mindfulness-based interventions have been shown to reduce stress, increase psychological well-being and reduce mood symptoms. Completion of mindfulness-based interventions have been shown to reduce anxiety and depression symptoms and diagnosis (Zhang *et al.* 2021).

Mindfulness has also been shown to be effective in the treatment of generalized anxiety disorder by reducing symptomology of anxiety and depression (Burton *et al.* 2017).

Cognitive Rehabilitation Therapy (CRT) is a method aimed at improving psychological characteristics and restoring lost cognitive abilities through targeted stimuli and specific exercises. It addresses cognitive and psychological issues by focusing on repairing or compensating for impaired functions through rigorous training and practice (Huckans *et al.* 2013). This intervention includes a variety of techniques to enhance comprehension, attention, learning, memory, and problem-solving skills. CRT begins and ends with assessments covering self-awareness, orientation, attention, memory, organization, and problem-solving abilities (Renton *et al.* 2017).

Broomfield *et al.* (2014) identify four key predictors of depression following a stroke, including negative self-perception and anticipation of the future. Similarly, in anxiety research, there is a suggestion that negative emotions can be perceived as threatening, potentially resulting in individuals adopting avoidant coping mechanisms (Broomfield *et al.* 2014).

Executive functions, also known as cognitive control, encompasses top-down mental processes used when focus and autonomy are needed. This function is supported by the brain's frontal lobes, with three primary components: inhibitory control, working memory, and cognitive flexibility. These functions contribute to higher-order abilities like logic, problem-solving, and planning (Friedman & Robbins 2022).

Several studies have found that mindfulness-based interventions (MBIs) are effective in improving executive functions and reducing cognitive and behavioral issues in patients (Im *et al.* 2021). MBIs have also been identified as a promising approach for medical care, helping individuals improve their mindfulness skills like self-awareness, attention control, and emotion regulation. Participants in MBIs have shown more consistent and appropriate responses to various aspects of their condition, such as adherence to medication, diet, exercise, and stress management. Literature reviews indicated cognitive issues and executive function weaknesses in some patients (Pheh *et al.* 201). Meanwhile, most studies focus on the correlations and etiology, or variables related to problems of stroke patients, and ignore the effectiveness of treatments affecting the cognitive features of stroke patients (Sanchez-Lara *et al.* 2022). Furthermore, even though MBSR is among the well-received treatments for improving cognitive functions in various sample groups, its effect on the executive and cognitive functions of stroke patients has not been investigated, and the number of available studies is limited.

Contrary findings in studies by Askari *et al.* (2023) and Marciniak *et al.* (2020) have raised questions about the effectiveness of MBIs on patients' executive and cognitive functions (Askari *et al.* 2023; Marciniak *et al.* 2020), highlighting the importance of further research. Given these considerations, the current study aims to examine the impact of mindfulness-based stress reduction and cognitive rehabilitation training on the executive functions of stroke patients.

Materials and methods

A pre-test-post-test quasi-experimental study was conducted with a follow-up period. Three groups were considered in this study, namely MBSR, CRT, and control. The statistical sample was selected from ischemic stroke patients referred to the neurology department and clinic of Razi hospital in Birjand from June

Tab. 1. Summary of MBSR protocol sessions

Sessions	Content
1	Introduction and communication between members, administration of a pre-test, mindfulness training, mindful breathing and feedback, assignment of homework (meals to be taken mindfully), distribution of educational pamphlets and CDs
2	Homework review, explanation about stress, mindful breathing, mindful eating and feedback, homework (10-15 minutes of mindful breathing every day, mindfulness in daily activities: brushing teeth, showering, washing dishes), distribution of educational pamphlets and CDs
3	Homework review, explanation about anxiety, body scan meditation, mindfulness to sounds and thoughts, homework (taking notes of pleasant experiences, the way events happen, degrees of awareness, emotions, thoughts, and reactions), distribution of educational pamphlets and CDs
4	Homework review, explanation about depression, mindful walking meditation and feedback, STOP meditation, homework (taking notes of unpleasant experiences, the way events happen, degrees of awareness, feelings, thoughts, and reactions), distribution of educational pamphlets and CDs
5	Homework review, explanation of attention, mindful sitting and feedback, meditation to bring the eight attitudes to life, homework (engaging in the three-minute breathing space and body scan at least three times a day), distribution of educational pamphlets and CDs
6	Homework review, explanation of memory, mindful yoga and feedback, pain awareness meditation, homework (being mindful of daily activities: brushing, showering, washing dishes, and mindful breathing meditation), distribution of educational pamphlets and CDs
7	Homework review, explanation of executive functions, conscious self-questioning and feedback, RAIN meditation, homework (checking the conscious mind, practicing the three-minute breathing space), distribution of educational pamphlets and CDs
8	Homework review, loving-kindness meditation and feedback, habits awareness meditation, homework (practicing mindful sitting with awareness of breathing, body, sounds, and thoughts; integrating mindfulness into all daily activities), distribution of educational pamphlets and CDs

2018 to June 2021. 36 patients were selected by purposive sampling method and divided into three MBSR, CRT, and control equal groups by lottery.

The sample size was determined to be 12 per group using Cohen's table taken from Stevens, considering the minimum power of the test (74%), average effect size, and attrition probability. The inclusion criteria included the following: first ischemic stroke, diagnosis based on either MRI or CT scan, a period of at least six months but no more than three years since the stroke, an age range of 40 to 70 years, having at least a secondary education level, receiving the same drug treatment, confirmation of memory and attention disorder, absence of verbal, motor, or hearing disability, and absence of alcohol and drug addiction. The exclusion criteria included absence from more than three sessions, reluctance to undergo treatment, occurrence of severe stress, memory improvement prior to the completion of the intervention, and experiencing another stroke.

Before the interventions, the purpose and method of conducting the research and the confidentiality of information were explained for each patient. After providing informed consent, they completed the demographics form and the Montreal Cognitive Assessment (MoCA) scale. The MBSR and CRT interventions sessions were held for 3 months (12 sessions, one 60-minute session each week). The control group received drug treatment without any additional intervention. Two months after the completion of the interventions, a meeting was convened to conduct a general evaluation and assess the effectiveness of the interventions. Subsequently, the questionnaires were completed once again.

The Montreal Cognitive Assessment (MoCA)

OOne of the most practical cognitive screening tools available to geriatric forensic evaluators is the MoCA. Unlike the MMSE or the CDT, the MoCA is specifically designed to detect subtle cognitive impairments, known as Mild Cognitive Impairment (MCI). Originally developed for screening Mild Cognitive Impairment (MCI), MOCA has become widely used in clinical and research settings, often replacing the MMSE. It assesses various cognitive domains, including executive function skills. While not a replacement for comprehensive neuropsychological testing, the MOCA is well-correlated with more extensive formal testing (Nasreddine *et al.* 2005).

The MoCA test has been validated as a highly sensitive tool for early detection of MCI in many studies since 2000. It is widely used in clinical settings and in academic and non-academic research globally. The sensitivity of the MoCA for detecting MCI is 90%, which is significantly higher than the 18% sensitivity of the MMSE. The MoCA is a brief, well-validated, widely used cognitive screener which can flag the possibility of MCI and dementia to be verified with further evaluation (Lam *et al.* 2013). This test evaluates various fields of cognition, which include: Visuospatial, attention and working memory, language, delayed recall and orientation. People who get a score of 26 or more from

Tab. 2. Summary of Powell's protocol sessions

Exercises	Cognitive skills	Instruction
Memory Session 1	1- Remembering daily activities 2- Remembering arrangements 3- Assigning homework	1- Provide information about yourself for other members to remember at the end of the session. 2- Creating an alphabetical shopping list, recalling the sequence of movements or sounds, recalling the order of words in the form of a story, and creating a shopping list
2	1- Recalling pictures 2- Recalling people's names from their faces 3- Examining assignments	1. Examine the image for one minute; recall the details immediately and thirty minutes later. 2- Look at the pictures with names for a few minutes; then, recall the faces of people without names.
3	1- Segmentation 2- News report 3- Examining assignments	1- Memorize the set of pictures by dividing them into small groups or putting them into categories (immediately and 30 minutes later) 2- Read a paragraph and then tell about it.
4	1- Remembering numbers 2- Using memory aids 3- Examining assignments	1- Techniques to recall numbers: segmenting, relating, using rhythm, visualizing the pattern 2- Using educational aids: notepads, tagging, indexing, calendars, and messaging devices
Attention Session 1	1- Latent words 2- Examining assignments	Concentration enhancement exercise: Find the words in the list that have shared characteristics and mark them with underlines and crosses.
2	1- Counting of "s" 2- Examining assignments	Count the number of times the proposition "from" is used in the excerpt that is read aloud.
3	1- Remembering 2- Division and change of attention 3- Examining assignments	1- Exercise to improve the ability to think of two things or more at a time 2- Review the letters of the alphabet and consider names that begin with these letters.
4	1- Practicing several previous stimuli 2- Examining assignments	Exercise for sustained attention: Step one: preparation; step two: one return; step three: two returns

this test are considered normal; While scoring less than 26 is abnormal and suggests mild cognitive impairment. MoCA has high test-retest reliability (ICC = 0.92). MoCA has good internal consistency (Cronbach's alpha = 0.82). The convergent validity between MoCA and MMSE was high (r = 0.66) (Hoops *et al.* 2009; Ciesielska *et al.* 2016).

Demographic Characteristics Form

This form included variables such as age, gender, marital status, number of children, occupation, level of education, income, place of residence, housing status, duration of illness, and history of physical and mental illness.

Mindfulness-based Stress Reduction (MBSR)

Mindfulness-based stress reduction is an effective intervention in treating psychological complications associated with chronic diseases. It was developed by Kabat-Zinn to reduce stress and pain symptoms. It is a multi-component therapy delivered in groups. This intervention aims to help people accept and communicate with their inner experiences and increase their awareness of conscious behaviors (Santorelli *et al.* 2017). Mindfulness meditation has been shown to enhance an individual's attention, thereby fostering heightened awareness and emotional capacity. Sisk acknowledges that mindfulness can provide insight to assist individuals in anticipating and creating a new approach to life and a different way of living. In the present study, the intervention was carried out in accordance with the protocols of Kabat Zinn and Stahl and Goldstein (Table 1).

Powell's Cognitive Rehabilitation Training

The cognitive rehabilitation intervention is a therapeutic system that uses brain-behavior relationships to facilitate performance change. This is achieved through various processes, including the creation or reinforcement of previously learned behavioral patterns, the development of new cognitive patterns using compensatory cognitive mechanisms, the establishment of new activity patterns through external compensatory mechanisms, and the facilitation of individuals in compromising with their cognitive disability to enhance overall performance. The basis for improving cognitive deficits through CRT lies in the brain's neural flexibility property. The foundation of behavioral and structural changes in the brain is rooted in dendritic and synaptic fibers. The current study administered CRT following Powell's rehabilitation protocol (Table 2). (Powell 2017; Sahragard *et al.* 2018)

Statistical analysis

Mean±SD and frequency(percent) were used to describe data. To determine the normality distribution assumption of dependent variables, Shapiro-Wilk test was used. Chi-square test was used to compare qualitative

Tab. 3. Comparison of frequency distribution of demographic variables in the studied groups

Variables	Levels	Experimental CRT		Experimental MBSR		Control group		*p* value
		N	%	N	%	N	%	
Sex	Male	4	40	4	36.4	3	25	0.73
	Female	6	60	7	63.6	9	75	
Age groups	40-50	4	40	3	27.3	3	25	0.77
	51-60	2	20	5	45.4	5	41.7	
	61-70	4	40	3	27.3	4	33.3	
Educational level	High school	1	10	2	18.2	2	16.66	0.99
	diploma	4	40	4	28.2	5	41	
	Bachelor's degree	3	30	3	27.3	3	25	
	Master degree and higher	2	20	2	18.2	2	16.66	
Marital status	Married	10	100	10	90.9	10	83.3	0.40
	Single	-	-	1	9.1	2	16.7	

variables among the groups. Mauchly's test was used to check the sphericity or equality of variance of the differences among the variable's levels; also, the M-box test was used to check the assumption of homogeneity of the covariance matrices; and the Leven's test was used to check the equality of variances. To check the hypotheses, repeated measures analysis of variance (ANOVA) and Bonferroni post-hoc test were used. Data were analyzed in SPSS software version 26 at a significance level of 0.05.

Results

A total of 33 patients (10 in the CRT group, 11 in the MBSR group, and 12 in the control group) participated in the study. The frequency distribution of the participants by gender, age groups, education level, and marital status was no significant difference between the study groups according to the results of chi-square test (Table 3).

The findings showed that in the pre-test, there wasn't a significant difference in the MBSR, CRT and control groups, while in the post-test, a significant difference was found between the MBSR (24.63±2.11) and CRT (25.00±1.63) with the control group (22.08±1.50); which implies the MBSR and CRT groups outperformed the control group in increasing executive functions. Finally, at the follow-up, all changes were still stable in the MBSR group (24.27±2.24) CRT group (25.20±1.75) and the control group (22.25±1.42).

Results of Kolmogorov Smirnov test indicated the normal distribution of the variables ($p > 0.05$). The assumption of homogeneity of variance was met using Leven's test in the post-test and follow-up phase ($p > 0.05$). Considering the significance of the Mauchly's test result, which indicates the heterogeneity of covariance matrix between the groups, the epsilon correction was used. The observed interaction effect of group and time was significant for executive functions factor ($F = 7.764$, $p < 0.001$) indicating a significant difference between the groups at different times. Therefore, the results of each group were separately assessed over time. The results of pairwise comparison were shown in Table 5. In the experimental group, the mean difference between pre-test and post-test, and between the pre-test and the follow-up for each component reported as negative, indicates a significant increase in the score of that component of executive functions in the post-

Tab. 4. Mean±SD of the executive functions' variable in the experimental and control groups

Group	Mean±SD			*p* value
	Pre-test	Post-test	Follow-up	
Experimental CRT	22.20±2.35	24.70±2.36	24.90±2.60	<0.05
Experimental MBSR	20.64±2.94	23.00±3.22	23.18±3.66	<0.05
Control	20.67±2.71	20.67±2.15	21.17±2.37	>0.05
p value	0.035*			

* The average score of executive actions among the three studied groups has a significant difference over time.

Tab. 5. Bonferroni test to compare executive functions in the studied groups across time periods

Group	Course		MD	SE	*p* value
CRT	Pre-test	Post-test	-2.50	0.307	0.000*
		Follow-up	-2.70	0.423	0.000*
	Post-test	Pre-test	2.50	0.307	0.000*
		Follow-up	-0.20	0.249	0.999
MBSR	Pre-test	Post-test	-2.364	0.527	0.004*
		Follow-up	-2.545	0.545	0.003*
	Post-test	Pre-test	2.364	0.527	0.004*
		Follow-up	-0.182	0.377	0.999
Control	Pre-test	Post-test	0.00	0.369	0.999
		Follow-up	-0.50	0.379	0.643
	Post-test	Pre-test	0.00	0.369	0.999
		Follow-up	-0.50	0.261	0.246

test and follow-up stages compared to the pre-test in the experimental group ($p < 0.05$); while none of the mean differences in the control group were reported to be significant. Therefore, the MBSR training was effective in improving executive functions in stroke patients.

Result of repeated measures analyses showed a significant difference the average score of executive actions among the three studied groups over time ($p < 0.05$) (Table4).

Bonferroni test was used to check the stability of effectiveness and changes in each of the experimental groups and the control group during three periods of time (pre-test, post-test and follow-up) as pairwise comparisons of the executive functions' variable by the study groups in three stages. A *p*-value less than 0.05 indicates a significant difference between the averages in that time period (Table5).

Bonferroni's post hoc test was used to pairwise comparations of the mean of executive functions' components in the studied groups. A *p*-value less than 0.05 indicates a significant difference at that time stages (Table 6).

According to the confirmation of the assumption of Mauchly's sphericity Test, it can be seen that the significance level of the visuospatial skills for time * group is 0.044, so the mean score of this component is significantly different over time in the studied groups. But for other components of executive functions , the significance level were more than 0.05, which showed no significant difference in mean scores of studied groups over time (Table 7).

Discussion

The aim of this study was to explore the impact of mindfulness-based stress reduction (MBSR) and CRT on executive functions in the stroke patients. The findings revealed a significant enhancement in executive functions among patients undergoing MBSR. Specifically, MBSR led to an increase in the visuospatial skills scores in the experimental groups. These results align with previous studies (Eskandari *et al.* 2022; Shakib *et al.* 2020; Ahmed Aboalola 2023; Yousefi *et al.* 2023).

The results showed that only CRT training had a significant effect on improving the executive functions of stroke patients over time compared to the control group. In the comparison between the groups, the results showed that only the CRT training was able to show these significant changes over time compared to the control group, which include the attention and working memory and the recall delay subscale.

In general, both trainings have been effective on executive functions, but in some subscales (visuospatial skills, attention and working memory, recall delay), the effectiveness of CRT has become significant compared to the control group, unlike the MBSR intervention group, which indicates the importance of effectiveness of CRT training. These results are in line with the results of these studies (Doshi *et al.* 2021; Homam Zakere Langerode *et al.* 2021), and also in line with the results of Sharifi *et al.*'s study (Sharifi *et al.* 2019). Also, the results of studies (Sharifi *et al.* 2019; Khanjani *et al.* 2019; Salehian Boroujerdi *et al.* 2021) based on the effectiveness of cognitive rehabilitation on executive functions (working memory, attention) indicated the positive effect of this intervention which their results are in line with the results of the present study.

The effectiveness of MBSR on executive functions in stroke patients was investigated in this study. The findings showed that MBSR significantly improved executive functions score. These results are consistent with previous studies on (Duval *et al.* 2022; Marciniak *et al.* 2020; Sahragard *et al.* 2018).

Executive functions, also known as executive control or cognitive control, involve a set of high-to-low cognitive processes that allow the brain to organize and utilize

Tab. 6. Results of the Bonferroni test to compare the mean of executive functions' components in the studied groups

Variables	Group I	Group II	MD	SE	*p* value
Visuospatial skills	CRT	MBSR	0.43	0.41	0.913
		Control	0.27	0.40	0.999
	MBSR	CRT	-0.43	0.41	0.913
		Control	-0.16	0.39	0.999
Attention and Memory	CRT	MBSR	0.49	0.35	0.494
		Control	1.04	0.34	0.013
	MBSR	CRT	-0.49	0.35	0.494
		Control	0.55	0.33	0.321
Language	CRT	MBSR	-0.13	0.16	0.999
		Control	0.07	0.16	0.999
	MBSR	CRT	-0.13	0.15	0.999
		Control	-0.06	0.15	0.999
Delayed Recall	CRT	MBSR	0.11	0.31	0.999
		Control	0.98	0.31	0.010*
	MBSR	CRT	-0.11	0.31	0.999
		Control	0.87	0.30	0.021*
Orientation	CRT	MBSR	0.05	0.30	0.999
		Control	0.20	0.18	0.836
	MBSR	CRT	-0.05	0.18	0.999
		Control	0.15	0.18	0.999

* Significant difference

information. These skills enable individuals to plan, organize, memorize, prioritize, focus attention, and engage in tasks. Executive functions are essential for mental and physical health, success in life, cognitive, social, and psychological growth (Carruthers 2002). Furthermore, several studies regarding the support significant improvements in cognitive variables such as memory and attention in patients, aligning with the findings of the current study (Askari *et al.* 2023; Salehian Boroujerdi *et al.* 2021; Moynihan *et al.* 2013). However, a study demonstrated that short-term mindfulness training over a 4-week period did not result in significant cognitive changes in patients (Josefsson *et al.* 2014). These results contrast with the findings of the present study.

Ahmed Aboalola's (2023) demonstrated the potential for improving executive function skills in young individuals with attention deficit/hyperactivity disorder (ADHD) through mindfulness-based interventions(Ahmed Aboalola 2023). This finding was supported by Shakib *et al.* (2021) in a study involving children with ADHD (Shakib *et al.* 2020). Additionally, Yousefi *et al.* (2023) found that MBSR led to enhanced executive function n patients with rheumatoid arthritis (Yousefi *et al.* 2023), while Eskandari *et al.* (2022) illustrated the positive impact of mindfulness-based interventions on executive functions in individuals with multiple sclerosis (Eskandari *et al.* 2022). In contrast, Askari *et al.* (2023) and Marciniak *et al.* (2020) presented conflicting results, suggesting minimal cognitive improvement with MBSR and no significant difference in cognition. They attributed these results to participants' low compliance with home exercises (Marciniak *et al.* 2020; Askari *et al.* 2023).

The hypothesis discusses the neurological mechanisms behind the effects of MBIs, focusing on the role of the Fornix in cognition and memory recall. Studies have shown increased structural connectivity and axon diffusivity in individuals practicing MBIs, as well as activation of key brain regions such as the basal ganglia, entorhinal cortex, and medial prefrontal cortex during mindfulness training (Melis *et al.* 2023; Doshi *et al.* 2021). These regions play important roles in cognitive and emotional processes, including memory, inhibitory control, and self-awareness, which are key components of executive functions influenced by mindfulness therapy. The findings suggest that mindfulness practice can lead to changes in brain connectivity and activation of specific regions that are crucial for cognitive and emotional functions. The increased structural connectivity in the fornix-stria terminalis tract and thicker corpus callosum in meditators indicate improvements in cognitive processes and memory recall. Additionally, the activation of the basal ganglia, entorhinal cortex, and medial prefrontal cortex during mindfulness training

Tab. 7. Tests of between-subjects effects for patients' executive functions' components

Effects	Variable	Sum of squares	d.f	Mean of squares	F	*p* value	Eta squared index
Group	Visuospatial skills	2.892	2	1.466	0.555	0.580	0.036
	Attention and Memory	17.797	2	8.898	4.754	0.016	0.241
	Language	0.251	2	0.126	0.310	0.736	0.020
	Delayed Recall	19.623	2	9.811	6.399	0.005	0.299
	Orientation	0.716	2	0.354	0.674	0.517	0.043
Time	Visuospatial skills	2.112	2	1.056	4.111	0.021	0.121
	Attention and Memory	18.926	2	9.463	10.701	0.001	0.263
	Language	1.385	2	0.693	5.175	0.008	0.147
	Delayed Recall	6.720	2	3.360	7.518	0.001	0.200
	Orientation	2.682	2	1.341	3.527	0.036	0.105
Time*group	Visuospatial skills	2.690	4	0.673	2.619	0.044	0.149
	Attention and Memory	4.151	4	1.038	1.173	0.332	0.073
	Language	0.450	4	0.113	0.841	0.505	0.053
	Delayed Recall	3.782	4	0.945	2.115	0.09	0.124
	Orientation	3.392	4	0.848	2.230	0.076	0.129

supports the idea that mindfulness can enhance inhibitory control, mental state regulation, and emotional awareness. These findings highlight the potential of mindfulness therapy to improve executive functions and overall cognitive and emotional well-being.

A study found that Mindfulness-Based Interventions (MBIs) were linked to structural changes in the cingulate, specifically observing changes in white matter structure in the posterior cingulate cortex in experienced meditators (De la Torre *et al.* 2022). The connection between mindfulness practices and executive functions, emphasizing how MBIs can improve cognitive aspects related to self-care and treatment adherence in individuals with chronic conditions. By focusing on techniques such as body scans, breathing meditation, and sensory awareness exercises, participants can enhance their present-moment attention and strengthen their executive functions. Muller *et al.*'s suggestion that relaxation exercises can impact mood-regulating hormones and executive functions indirectly further supports the potential benefits of mindfulness practices in improving overall well-being. Despite some conflicting study results, the overall consensus indicates that MBSR can be effective in enhancing executive functions and cognitive abilities essential for managing chronic health conditions.

Conclusion

The research found that Mindfulness-Based Stress Reduction (MBSR) was beneficial for improving the executive functions of stroke patients, suggesting its use in medical settings to enhance cognitive activities in this population. However, the study faced limitations due to COVID-19 constraints, leading to a small sample size through purposive sampling. The short two-month follow-up period raises concerns about long-term effectiveness, and the lack of detailed information on participants' medication usage could also impact executive and cognitive function outcomes. Future studies should address these limitations for more conclusive results.

Acknowledgments

We express our gratitude to the esteemed officials of Islamic Azad University and Birjand University of Medical Sciences, as well as to the kind patients who assisted us in carrying out this research.

Authors' contribution

F. Sha was responsible for various tasks, including ideation, selecting the statistical sample, obtaining informed consent, conducting the research, collecting data, and drafting the article. The second author (F. Sh) supervised the implementation, conducted statistical analysis and interpretation, and contributed to drafting and revising the article. The third, fourth, and fifth authors (SMMM, M DF, and AA E) were involved in selecting the statistical sample and supervising the implementation and conceptualization. They also contributed to the final editing of the manuscript.

Ethical approval

The Ethics Committee of Birjand University of Medical Sciences approved this study under the ethical code of IR.BUMS.REC.1399.394.

Funding/support

This study was funded by personal sources. Informed Consent: The objectives of this study were explained to the participants, and they were assured that their participation was voluntary. Written consent for informed participation was obtained from all participants.

Conflict of interests

The authors declare no conflict of interest in the present study.

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