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Evaluation of RehaCom cognitive rehabilitation on different aspects of visual attention in patients with middle cerebral artery ischemia: A nonblinded randomized clinical trial

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Original Article

Abstract

BACKGROUND: Cerebral ischemia or stroke is the second leading cause of death in the world, and most surviving patients suffer from long-term physical and cognitive disabilities, which create many social and economic problems for them and society. Visual attention impairment is a common cognitive complication among patients with cerebral ischemia, especially in the Middle Cerebral Artery (MCA). One way to improve attention in these patients is cognitive rehabilitation. RehaCom software is one of the computer-based tools to rehabilitate visual attention in these patients. The purpose of this study was to evaluate RehaCom cognitive rehabilitation on different aspects of visual attention in patients with middle cerebral artery ischemia.

METHODS: In this single-blind randomized clinical trial, 30 patients with cerebral ischemia in MCA territories were selected and randomly divided into control (n=15) and intervention (n=15) groups. Visual attention of both groups was assessed before the treatments using the Integrated Visual-Auditory test (IVA). Then the intervention group was rehabilitated for 8 sessions of 45 minutes each with RehaCom cognitive software, according to our selected modules, while the control group was only under intervention by non-targeted computer games. After applying the treatments, visual attention in the two groups was assessed using the IVA test.

RESULTS: There were no significant differences in visual focus attention between the intervention and control groups before the intervention (29.20±30.06 and 49.53±29.69, P value >0.05). In addition, there were no significant differences in visual selective attention in both groups before the study (23.07±24.73, 39.27±27.08, P value >0.05). However, significant differences were found in visual sustained attention, visual alternating attention, and visual divided attention at baseline (P value <0.05). After the intervention, visual focus attention in the intervention group was significantly higher than in the control group (84.67±26.51, 57.20±31.44, P value <0.05). RehaCom cognitive software intervention increased visual divided attention in the intervention group (88.40±14.85 versus 72.70±25.73, P value <0.05).

CONCLUSION: These results demonstrate that using RehaCom cognitive software can improve focus attention and visual attention in the intervention group. Cognitive rehabilitation with RehaCom was able to improve visual attention deficits in patients with middle cerebral artery ischemia.

Keywords: Cerebral Ischemia; RehaCom; Cognitive Rehabilitation; Visual Attention; Medial Cerebral Artery

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Introduction

Based on statistics from the worldwide Burden of Disease (GBD), the estimated worldwide future risk of stroke for those 25 years of age or older was 24.9% in 2016, an increase from 22.8% in 1990. 2016 Stroke Collaborator Lifetime Risk. There are several forms of strokes, including thrombotic, ischemic, and embolic strokes[1]. Unexpectedly, Stroke continues to be the second leading cause of death worldwide, resulting in 5.5 million losses of life in 2016. Stroke killed fewer females (2.6 million) than males (2.9 million)[2]. Ischemic stroke deaths were a little less common than hemorrhagic stroke deaths. Stroke continues to be the second leading cause of death worldwide.

However, central Latin America had the lowest rates of stroke incidence, while East Asia and Eastern Europe had the highest rates. Age-specific occurrences were equal for men and women up to the age of 55, but for males, they increased between the ages of 55 and 75, and then leveled out beyond that age[2]. In cerebral ischemia of the middle cerebral artery, visual attention disorders are common[2] and are among the most significant cognitive skills compromised after a stroke[3]. Attention applied internally is harmonized by the dorsal attention network (DAN), while attention acquired externally is harmonized by the ventral attention network (VAN), which are the two attentional networks in the brain[4]. This type of top-down, intentional activity is known as endogenous attention because it comes from within—that is, from your own understanding in this particular case[5]. It is possible to override the other type of goal-driven or top-down attention, in which strong and noticeable triggers can divert attention from the task at hand[5]. Visual attention is affected by the DAN, which is why tasks are mostly designed for DAN[5]. Cerebral ischemia causes major structural and biological alterations in the brain, which have a significant impact on brain function[6]. These changes affect the motor cortex, neuroplasticity, and recovery[6]. The DAN network seems to have an important effect in setting attention and is an effective network for cognitive rehabilitation after stroke[7]. Although there are several techniques available for cognitive rehabilitation, a recent meta-analysis of 146 publications revealed norms of practice for: (1) attention shortages following a traumatic brain injury or stroke; (2) visual inspection for neglect after a stroke in the right hemisphere; (3) compensatory techniques for minor memory losses; (4) language impairments following a left-hemisphere stroke; (5) social-communication difficulties following a traumatic brain injury; (6) training in metacognitive strategies to address executive functioning deficiencies; and (8-9) comprehensive and thorough neuropsychological therapy to reduce cognitive and functional impairment after a stroke or traumatic brain injury[8]. All these methods have pros and cons, so we propose that using RehaCom, as an updating software, could be used for cognitive rehabilitation with significant effects on cognitive functions[9].

Treatment professionals for middle cerebral artery ischemia are considering mental rehabilitation as a means of improving the complications and the patients' quality of life because of the problems that mental and cognitive disorders, particularly visual disturbances, cause in these patients. So far, no comprehensive and practical study in this regard has been conducted in the country.

These obtained results could affect different cognitive areas of the brain that need rehabilitation[10]. The impact of RehaCom on brain-damaged patients' memory and attention has been demonstrated by earlier research[11]. We aimed to evaluate how the structural and functional communication network of different areas of the brain is affected by RehaCom[12]. Also, RehaCom cognitive rehabilitation regulates the function of different areas of the brain by designing different tasks, which improves cognitive function[13]. The aim of this study was to evaluate how RehaCom cognitive treatment affected different aspects of visual attention in patients with middle cerebral artery ischemia.

Materials and Methods

Participants

In total, 30 patients with distinguished ischemic stroke, damage to the middle cerebral arteries, and visual attention disorder, who referred to the Neurology Clinic of Al-Zahra Hospital (Isfahan, Iran) from November 2019 to September 2020, were selected for this study. The study procedure was explained to the study participants and one of their family members, and in case of agreement and signing informed consent, patients were enrolled in the study. The ethical committee of Tehran University approved the study by number IR.UT.IRICSS.REC.1399.003.

Sample size

The minimum sample size was determined to be 30 patients (15 in the placebo group or control group and 15 in the intervention group). In this estimate calculation, we considered an α error of 0.05, a β error of 0.20, and a difference in progression risk of 50%.

Inclusion criteria: Patients with MCA stroke based on MRI and history in the acute phase (the first 6 months after ischemia), age less than 70 years, patient's willingness to participate in rehabilitation sessions, having a score of 6-14 according to the National Stroke Health Institute (NIHSS) scale according to the opinion of a neurologist, occurrence of visual impairment after stroke.

Exclusion criteria: Age over 70 years, hemorrhagic stroke, severe metabolic disorders, Alzheimer's, having pre-stroke vision disorders, having bleeding stroke.

Allocation Ratio: Patients were divided randomly into (1:1) control (n=15) and intervention (n=15) groups.

Outcomes: Visual attention of both groups was assessed before and after the treatments using the Integrated Visual-Auditory test (IVA). This test lasts 13 minutes and assesses two main factors: reaction control and attention. The sensitivity is 0.92 and power is 0.89, and it is used for evaluating attention deficiency.

Intervention: RehaCom software was used in the intervention group for cognitive rehabilitation. RehaCom cognitive rehabilitation software is a computer software used for cognitive rehabilitation. This software has a large number of modules to perform cognitive rehabilitation in various cognitive fields, which is available in 21 different languages. Its therapeutic modules are categorized into eight main groups, each of which has a number of subgroups that are selected and used according to the needs of the participant. RehaCom has the auto-adjusting property; therefore, its complexity and difficulty of the task are automatically increased or decreased, depending on the patient's function and response to questions. It allows the evaluator to monitor a person's online performance while working with this cognitive software. The evaluator is able to take into account the information obtained from the evaluation of the sessions and, based on it, provide modules to strengthen the brain's cognitive functions, which increases the degree of difficulty with the development of the treatment. The results of the intervention group were compared with the results of the control group before (pre-test) and after (post-test) using RehaCom software.

In the control group, patients were asked to do simple computer games as a placebo.

Randomization: All patients, after meeting inclusion and exclusion criteria, were randomly assigned into two groups using a simple randomization method, done by a nurse who was not aware of the study procedures.

Study endpoints: The study endpoint was to compare the changes in the clinical situation of the patients based on the physician's diagnosis.

Intervention: Before the study, the IVA-2 test was conducted for all participants, and visual and auditory responses, as well as cognitive factors such as control and attention, were evaluated. The IVA-2 test runs in four stages: warm-up, training, main test, and cool-down. The warm-up stage is divided into two separate periods: one minute for visual warm-up and one minute for auditory warm-up. Next, the training stage starts, where the goals and visual and auditory errors are presented in combination for 90 seconds. The main test is performed after the training stage, where visual and auditory goals are presented in combination for 13 minutes. The last two minutes of the test assess the validity of the test, which is called cool-down. The main test consists of five hundred visual and auditory stimuli. The task of the test is to respond or not respond to five hundred visual and auditory stimuli. Each stimulus is shown for only one and a half seconds. Hence, good performance requires persistent and constant attention. During the IVA-2 test, the person is encouraged to press a key upon hearing or seeing the number one. If the person presses the key after hearing or seeing the number two (which is not the target), it indicates impulsiveness, and if the person responds less after hearing or seeing the number one, it indicates attention deficit. This test is designed for people aged 6 years and older.

Experimental procedure: After holding a briefing and receiving written consent, 30 patients

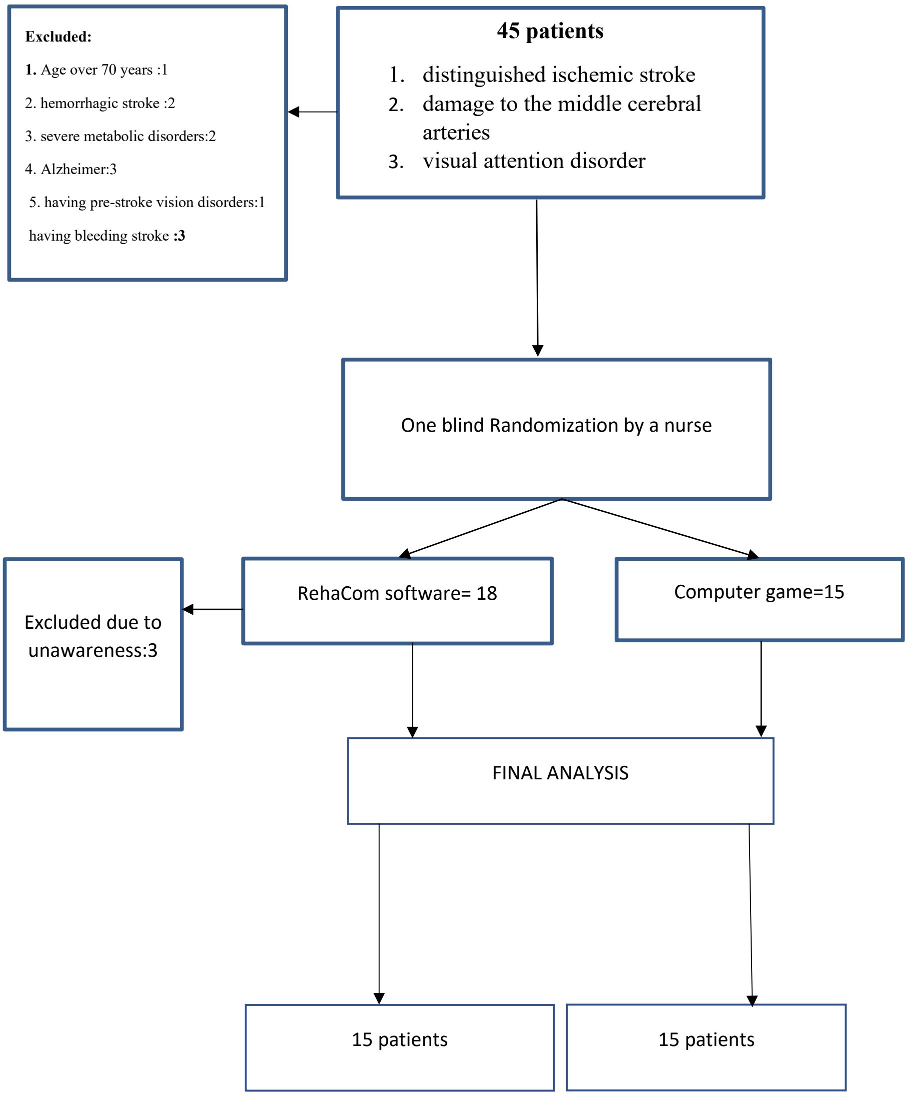

Figure 1. CONSORT Diagram for study

with stroke in the middle cerebral artery were selected for this study, according to the mentioned criteria for entering the research. Next, the patients were randomly divided into two groups: control (n=15) and intervention (n=15). A briefing session was held to inform patients about how to conduct the study. After that, participants' visual attention was evaluated using the IVA test. Then the intervention group was rehabilitated for 8 sessions of 45 minutes each with RehaCom cognitive software, according to our selected modules, while the control group was only under intervention by non-targeted computer games. After completing the treatment, the experimental group and the control group were subjected to a post-test, and then the results were analyzed using SPSS software.

Statistical analysis

All statistical analyses were performed using SPSS version 22 (SPSS Inc., Chicago, IL, USA). The distribution normality was analyzed using the Kolmogorov–Smirnov test. Quantitative data were expressed as mean and standard deviation (SD). Student t-test and Mann-Whitney U-test were used to evaluate differences between groups as parametric and non-parametric tests for normal and non-normal data, respectively. Analysis of covariance (ANCOVA) was used to evaluate the effect of cognitive rehabilitation on visual attention in MCA stroke patients compared with the control group between evaluation stages (post-test, follow-up). Paired t-test or Kruskal-Wallis test were used to evaluate the differences between stages (post-test, follow-up) for normal and non-normal variables, respectively. P < 0.05 was considered statistically significant.

Results

All participants in this study were male, and the mean age of the intervention and control groups was 58.87±9.66 and 57.33±10.31 years, respectively. There is no significant difference between the ages of participants. Table 1 shows the demographic data of the study participants.

Table 2 displays the cognitive rehabilitation methods in the intervention group compared to the control group. There are no significant differences in visual focus attention between the intervention and control groups before the intervention (29.20±30.06 and 49.53±29.69, P value >0.05). In addition, there are no significant differences in visual selective attention in both groups before the study (23.07±24.73, 39.27±27.08, P value >0.05). However, significant differences could be found in visual sustained attention, visual alternating attention, and visual divided attention at the baseline (P value <0.05). After the intervention, visual focus attention in the intervention group was significantly higher than in the control group (84.67±26.51, 57.20±31.44, P value <0.05). Our intervention had no significant effect on visual sustained attention and visual alternating attention in the intervention and control groups (P value >0.05). RehaCom cognitive software intervention could increase visual divided attention in the intervention group (88.40±14.85 versus 72.70±25.73, P value <0.05). These results demonstrate that using RehaCom cognitive software is able to improve focus attention.

Discussion

We assessed the impact of RehaCom cognitive rehabilitation software on the improvement of visual attention in MCA stroke patients, to the highest standard of our knowledge, for the first time in Iranian history. Our results revealed that RehaCom rehabilitation significantly enhanced visual attention in MCA stroke patients, but it had no significant positive effect on visual sustained attention. In this study, patients with MCA arterial ischemia were selected due to the role of the artery and its branches. These vessels are responsible for the nutrition of the occipital and temporal parts of the brain, which are responsible for attention control, especially visual attention. Unfortunately, the lack of blood supply to these parts disrupts the rehabilitation protocol. We expected RehaCom software to increase cognitive brain function through mechanisms involving neuroplasticity, mirror neurons, and the enhancement of neuronal pathways that rehabilitate visual attention. In previous studies using this software, either the patients were not stroke patients, or attention was generally examined as a minor aspect

Table 1. Distribution of educational in patients it's chronic stroke in the studied group

Demographics	Intervention (n=15)	Control (n=15)	p-value
Male(%)	15(100)	15(100)	>0.999
Age(years)	57.87±9.66	57.33±10.31	0.56
Age range(years)	40 - 70	30 - 70	
Education(%)			0.08
Elementary	1(6.7)	0(0)	
Under diploma	5(33.3)	3(20)	
Diploma degree	3(20.0)	6(40.0)	
Associate degree	2(13.3)	2(13.3)	
Bachelor's degree	4(26.7)	4(26.7)	
Socioeconomic condition (%)			0.12
Under normal	3(20.0)	2(13.3)	
Mediocrity	7(46.7)	6(40.0)	
Upper normal	15(33.3)	7(46.7)	

Data were reported as mean±SD and number (percent)
Student t-test and chi-square test were used for continuous and categorical variables.

Table 2. Comparison the effect of intervention versus placebo in the intervention and control

Variable	Before intervention	Control	P Value*	After intervention	Control	P Value*	P difference**
Visual Focus Attention	29.20±30.06	49.53±29.69	>0.05	84.67±26.51	57.20±31.44	<0.05	<0.001
Visual Selective Attention	23.07±24.73	39.27±27.08	>0.05	77.20±27.06	49.73±32.71	<0.05	<0.001
Visual Sustained Attention	42.87±42.48	79.60±24.41	<0.001	83.40±12.53	74.93±23.39	>0.05	<0.001
Visual Alternating Attention	38.40±38.04	66.93±23.39	<0.05	80.93±13.06	69.07±24.46	>0.05	<0.001
Visual Divided Attention	40.30±40.39	66.27±25.09	<0.05	88.40±14.85	72.70±25.73	<0.05	<0.001

Data were reported as mean ±SD
*paired t-test
**student t-test

of the study. However, we focused specifically on the middle cerebral artery and visual attention, which is impaired in ischemia of the middle cerebral artery.

Cognitive disorders, as one of the major complications of stroke, affect about 32% of patients after a stroke[14]. Many cognitive disorders can occur after a stroke, but the most important one is often overlooked, while sensory and motor disorders are considered second-level disabilities[15]. Furthermore, studies have shown that stroke significantly impairs a variety of attention-related domains. Prior research has shown that almost one-third of stroke victims have cognitive impairments, such as attention deficiency, especially in visual attention[16-18]. Any defect in the perfusion of the midbrain artery, which is responsible for blood supply to the parietal, occipital, and especially the temporal lobes, causes damage to these parts (one of the functions of which is the rapid processing of visual stimuli) and leads to defects in the cognition process[19]. Directed attention is mediated in large part by the Dorsal Attention Network (DAN)[20]. DAN is also regarded as a crucial network for stroke patients undergoing cognitive rehabilitation[21]. Attention effectiveness is correlated with interhemispheric connection[22]. However, attention deficit disorder in subcortical stroke patients has an unclear etiology[23]. Liu et al. have shown that in individuals with right subcortical stroke, disruption of the right thalamic-prefrontal and right caudate-prefrontal circuits is associated with attention disorders[24]. Two brain attention networks-the right-dominant cortical and sub-cortical attention networks-have their functionality disturbed in right-hemisphere stroke patients[25]. Two decades ago, it was noted that individuals with brain injuries who underwent computerized cognitive rehabilitation showed improvement in their cognitive impairments[26]. Former studies have indicated that attention process training reduces attention deficit disorder after stroke[27]. In another study, Tacchino et al. declared that the range of useful vision of patients with stroke increased with the training of visual attention-enhancing skills, using useful field of view (UFOV) computer software[28]. Research by De Luca et al. concluded that computerized cognitive reconstruction may be a promising approach to improving post-traumatic brain injury[29]. Using RehaCom cognitive rehabilitation software for the first time showed its positive effects on attention in patients with Multiple Sclerosis (M.S.)[29].

Several years ago, various methods were suggested to improve cognitive performance in patients with stroke. For example, patients who had strokes saw increased cognitive performance when they combined RehaCom with acupuncture[30]. Another study was performed on brain injury patients with mild to moderate impairment in memory, attention, and aphasia. The cognitive software RehaCom carried out the intervention. The results indicated a significant improvement in patients' attention and memory[31]. A study was conducted on people with chronic brain damage who had impaired memory and attention. After computerized cognitive rehabilitation, the results showed a significant improvement in memory and attention[32]. Additionally, research on both functional and structural imaging found that RehaCom software has better impacts on attention[33]. Moreover, verbal memory, visual memory, and processing speed are all enhanced with RehaCom[34]. As previously stated, the DAN network serves as the primary network for stroke patients undergoing cognitive rehabilitation[19]. Following cognitive rehabilitation, functional connectivity and microstructural changes have been noted[35]. Thus, it appears that RehaCom rehabilitation might alter the brain's attention networks and cognitive processes. In acute stroke patients, it may also have an impact on how well the DAN network functions[36].

Conclusion

Our results indicated that cognitive rehabilitation via RehaCom improved different aspects of visual attention, except sustained attention, in cases with MCA stroke in the acute phase. It seems that RehaCom achieves this by influencing brain activities associated with attention, leading to visual attention improvement. The effect of cognitive rehabilitation was not the same for all patients; however, it did provide a level of cognitive improvement. Thus, it is possible to conclude that RehaCom's impact on the anatomical and functional network connections in the brain might result in cognitive rehabilitation.

Limitation

This study is limited to the sample size to find patients who meet inclusion and exclusion criteria but are strangled to the first experience in Iran.

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Conflict of interests

The authors declare no conflict of interest.

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Author's Contributions

All authors contributed to conducting the research, drafting the manuscript, and reviewing and approving the final version.

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