

Research Paper

Investigating the Effectiveness of Neuropsychological Rehabilitation on Stroke Patients



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ABSTRACT

Objectives: This study aimed to investigate neuropsychological rehabilitation's effectiveness on stroke patients' cognitive status.

Methods: This quasi-experimental study examined 22 adults with ischemic stroke of the left hemisphere (with an average age of 64.31 years) before and after the intervention. The patients had fluent aphasia (10 people) and non-fluent aphasia (12 people), along with cognitive disorders such as memory or attention disorder. Medical examination and para-clinical diagnosis of magnetic resonance imaging (MRI) with different causes, along with the Persian diagnostic aphasia battery bedside version (P-DAB-AQ1, 2016), were conducted. The severity of language disorder and type of aphasia were investigated using the Persian diagnostic aphasia battery (P-DAB-1) and Persian picture naming battery tests. Also, the mini-mental state examination (MMSE) test checked the cognitive dimensions. Verb network strengthening therapy, treatment of underlying forms, Persian verb, and sentence production protocol, and semantic feature analysis (SFA) for patients were also used.

Results: Findings show that the participants' average aphasia quotient (AQ1) score increased from 74.80 to 80.12, and the average MMSE score increased from 17 to 22.59. The main variables do not follow a normal distribution ($P < 0.05$), but the difference between scores before and after the intervention follows a normal distribution ($P < 0.05$). Both the AQ1 and MMSE variables significantly differ before and after the intervention, according to the Wilcoxon test. The non-fluent aphasia group has a higher increase in MMSE scores than the fluent aphasia group.

Discussion: Neuropsychological rehabilitation interventions can effectively improve AQ1 and MMSE. In addition, further research on neuropsychological rehabilitation interventions with two intervention and control groups and the treatment methods used during this study can be suggested for the treatment of stroke patients.

Keywords:

Stroke, Aphasia, Neuropsychological rehabilitation, Persian speaking

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Highlights

- An important issue is investigating the effectiveness of neurological rehabilitation on stroke patients' cognitive status.
- Neurological rehabilitation interventions in aphasia can effectively improve aphasia quotient and mini-mental state examination (MMSE) scores.
- The non-fluent aphasia group has a higher increase in MMSE scores than the fluent aphasia group.

Plain Language Summary

This study investigates the effect of neurological rehabilitation interventions on the cognitive status of people after a stroke. The results show that these interventions positively affect stroke patients' recovery. Gender, employment status, marital status, income level, and age had no effect; only the patient's education level and number of children affected the results.

Introduction

In a stroke, an artery supplying blood to the brain is blocked by a blood clot (ischemic stroke), or a blood vessel in the brain bursts and cuts off blood flow to a portion of the brain (hemorrhagic stroke). Aphasia most frequently results from strokes, which sometimes is associated with dysarthria and dyspraxia. Every year, over 15 million people worldwide suffer from some degree of stroke and experience various complications, such as sensory-motor, cognitive, and language disabilities [1]. According to several studies, 23%-36% of stroke survivors experience various degrees of language-cognitive damage (aphasia) [2]. Aphasia is an acquired defect in language usage (expressive and perceptive language), which results from damage to specific language areas in the brain. Language impairment in aphasia depends on the type of damage, the location of the damage in the brain, and the severity of the problem, leading to different degrees of language comprehension and expression [3]. It also causes problems in naming, discussing, understanding concepts, repeating numbers and sentences, verbal fluency, verbal explanations, issues in defining words, and ambiguity in interpreting words and metaphors, especially metalinguistic disorders. Usually, communicating requires the ability to speak and use the appropriate language. Naturally, such injuries will destroy various aspects of a person's life, such as communication, participation in daily activities, individual independence, economic status, and quality of life (QoL) [4, 5]. Therefore, these individuals are damaged to varying degrees in daily communication, meeting personal needs, and participating in society, depending on the effects of symbolic communication (including speaking, listening,

reading, and writing) in aphasia patients [6, 7]. Word-finding defects are considered the main symptom of aphasia [8, 9].

Therefore, the most common language deficits in stroke patients are anomia or disorder in word retrieval, where word retrieval defects may be observed to express all concepts, including noun, verb, adjective, and adverb, and aphasia patients may have more difficulty in retrieving some grammatical concepts than other groups [10-12]. Studies have reported different morphological, phonological, gestural, and semantic methods for treating word retrieval impairments in aphasia caused by brain damage. The results of these treatments are not the same, but the improvement achieved in most treatments is specific to trained cases [13-15]. However, the provision of rehabilitation services based on the individual needs of stroke patients requires extensive screening and evaluation of the severity and type of language injuries.

Many standard tests have been developed in Western countries to evaluate different aspects of language, such as syntax, semantics, word search, listening comprehension, and reading. Some of these tests include the Western aphasia battery and Boston diagnostic aphasia examination [16]. In Iran, Dr. Nilipour et al. developed the clinical version of the Persian diagnostic aphasia battery bedside version (P-DAB-AQ1, 2016) to screen and assess the severity of acquired language disorders in Persian-speaking adults with brain injuries [17].

In neuropsychological rehabilitation, the neuropsychological principles that are effective in the severity of a stroke and aphasia include the severity of the disorder, type of stroke, extent of the lesion, location of the stroke,

and whether it is unilateral or bilateral. A CT scan should determine whether a stroke is present, and other individual factors like age, sex, hand side, whether the patient is monolingual or bilingual, and length of hospital stay should also be considered. This study investigated all the cases of stroke patients receiving advanced rehabilitation in the speech therapy and neurology departments. The results of the clinical-linguistic evaluations of the patients were compared by a neurologist and a speech and language pathologist (SLP) in two stages: 1) Initial admission in the mentioned departments and 2) After discharge from the hospital. Notably, the comparative evaluation was based on an internationally standardized valid aphasia test for the Persian language (P-DAB-AQ1, 2016) and medical and paraclinical examination. This assessment comprises the severity of aphasia disorder, each patient's recovery rate based on the treatment methods used, and the effect of various individual factors [17].

The World Health Organization (WHO) predicts that the number of strokes in the European Union, Iceland, Norway, and Switzerland will rise from 1.1 million in 2000 to 1.5 million by 2025. Also, according to a systematic review conducted in South America, the crude score of stroke prevalence varies from 1.74 to 6.51 per 1000 people, and its annual incidence rate is 0.35 to 1.83 per 1000 people [2]. Numerous studies on aphasia treatment have been conducted and are ongoing. Falconer et al. subjected four aphasic patients to the treatment of semantic feature analysis (SFA) with continuous speech tasks. It was hypothesized that retrieving words during discourse would be more efficient and significantly impact communication. The results show that using SFA in group therapy can improve an individual's communication performance [18]. Wambaugh et al. studied the effect of SFA treatment on verb naming performance in four English-speaking aphasic patients. Verbs were categorized into four groups of ten without semantic connection. After 12 therapy sessions, an increase in the accuracy of naming educational verbs was observed in 3/4 of the participants, no improvement in control verbs, and an increase in speech content was observed for one participant [19]. Kristensson et al. performed the intensive SFA treatment to increase speech and communication function content in three people with chronic aphasia. This treatment completed the naming task for 21 nouns and 21 verbs. The results showed that two participants had an increase in speech performance and an increase in self-correction. However, they did not show significant improvement in naming [20].

Mehri et al. investigated and compared the effect of semantic and phonetic guidance on facilitating the naming process in patients with aphasia and Alzheimer disease, considering the common impairments of comprehension and naming, as well as temporal and temporal lobe defects. The study was conducted cross-sectionally on seven patients with fluent aphasia and seven patients with Alzheimer disease. The study results showed that both types of patients benefited from semantic and phonetic guidance. Still, fluent aphasia patients benefited more from phonetic guidance. Alzheimer patients benefited more from semantic guidance, which shows that the damage of semantic representation in Alzheimer patients is more than in other patient groups [21]. Sadeghi et al. investigated and compared the effect of SFA and promoting aphasia communication efficacy (PACE) methods on the ability to name aphasia patients. A 2-week study was conducted on four patients with dyspraxia; after the intervention, the ability to name therapeutic words increased significantly in both methods, except for one participant with damage to the left basal ganglia, in whom the SFA method was ineffective. The observed changes in the PACE method were greater than those in SFA, and the ability to name control words, generate semantic coordinates, and transfer the message improved. One week after the interventions, the performance of the patients in naming therapeutic words was still above the baseline despite a slight decrease [22]. Parhoon et al. conducted a study on the effectiveness of cognitive rehabilitation on the executive functions of stroke patients. The cognitive rehabilitation program has re-learned mental actions, and based on brain flexibility, it has improved the patients' functional memory and selective attention [23].

In investigating the effectiveness of computer-based cognitive rehabilitation on enhancing the working memory of stroke patients in Tabriz, Ghorbanian et al. asserted that cognitive problems are one of the most prevalent issues among stroke patients. Also, the findings showed that computer-based cognitive rehabilitation improves working memory in stroke patients [24].

Considering the lack of research in this area, conducting related but underappreciated research seems essential. On this basis, the current study examined the efficacy of neurological rehabilitation for stroke patients with language and cognitive disorders. We emphasized the prevention and control of confounding factors, such as blood pressure and reducing mental stress in the cause of stroke, referring patients to neurologists after brain injuries, accurate diagnosis of the disorder, and prompt referral to speech therapy. Also, providing treatment-rehabilitation services, particularly during the first 6 months

Table 1. Frequency distribution of aphasia type involved in participant

Aphasia Type	No. (%)
Fluent aphasia	10(45.45)
Non-fluent aphasia	12(54.55)

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of a patient's illness, and fostering family participation is essential. This study aimed to investigate the effectiveness of neurological rehabilitation on the cognitive status of stroke patients.

Materials and Methods

This research is a quasi-experimental study before and after the intervention. The study was conducted on 22 adult Persian-speaking stroke patients with an average age of 64.31 years. They were selected from 41 patients who visited [Rofiedeh Rehabilitation Hospital](#) between March 2020 and October 2021. These patients with various cognitive disorders, fluency, and non-fluent aphasia were chosen based on the inclusion criteria: Speaking Farsi language, lacking history of previous stroke, being adult patients with left hemisphere stroke, having fluent and non-fluent aphasia caused by stroke, starting treatment 2 to 8 months after the complication, being stroke patients with cognitive disorders based on the MMSE test with a score below 23, taking up to 75% correct answers in clinical questionnaire of Persian picture naming battery test, being conscious during evaluation and therapeutic interventions, having minimum reading and writing literacy, and having normal hearing and vision. The data collection tools and methods included an acceptance questionnaire, personal information of an adult stroke patient with aphasia, and the Iranian version of

the Farsi aphasia diagnostic test (P-DAB-1 record form, AQ1). The method of execution and scoring of the P-DAB is based on the scores obtained from the execution of different versions of the test: Four different quantitative indicators can be calculated to determine the severity and type of linguistic-cognitive disorders. These quantitative indicators are as follows:

- Clinical prescription severity index for aphasia quotient screening (AQ1),
- Aphasia quotient (AQ2) severity index of oral language disorders,
- Aphasia quotient (AQ3) severity index of oral language disorder, and
- Aphasia cortical quotient (CQ1) severity index of oral and written language and cognitive disorders [17].

The components of this tool (P-DAB-1 record form, AQ1) include continuous speech content quality (4 items), fluency of speech (6 items), listening comprehension (10 items), comprehension of continuous commands (4 items), ability to repeat words (6 items), and naming ability (20 items). Dr Nilipour et al. checked and confirmed the validity and reliability of this tool in Iran [17].

Table 2. Descriptive indices of research variables and Shapiro-Wilk test results

Variables	Min	Max	Mean±SD	P*
Before AQ1 score	27.32	74.80	58.37±12.97	0.135
After AQ1 score	31.12	80.12	64.52±13.67	0.050
AQ1 difference before and after	3.32	9.18	6.15±1.69	0.445
MMSE before	13	19	17±1.75	0.036
MMSE after	16	26	22.59±2.75	0.040
MMSE difference before and after	3	8	5.59±1.29	0.121

AQ1: Aphasia quotient; MMSE: Mini-mental state examination.

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*Shapiro-Wilk test.

Table 3. Comparing Mean±SD research variables before and after treatment

Variables	Mean±SD	Wilcoxon Test Statistic	P
Before AQ1 score	58.37±12.97	4.107	>0.001
After AQ1 score	64.52±13.67		
MMSE before	17±1.75	139	>0.001
MMSE after	22.59±2.75		

AQI: Aphasia quotient; MMSE: Mini-mental state examination.

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The Persian picture naming battery clinical questionnaire contains 50 clear and distinct nominal images designed on a separate page. By presenting a picture, the therapist asks the patient to say the name of that picture. The answer sheet contains four options: No guidance, semantic guidance, phonetic guidance, and type of error. The severity of the disorder is mild, moderate, and severe. Up to 75% of correct answers are mild disorder severity, 50% to 75% are moderate, and less than 50% represent severe disorder severity.

The mini-mental state examination (MMSE) contains questions with 30 points that determine cognitive problems, especially memory in adults. In scoring, 0 is given for wrong answers and 1 for correct answers. Therefore, scores of 24 to 30 indicate a normal condition, and below 23 indicate a disorder and the need for psychiatric consultation. In internal studies by Kazazi et al., the degree of confidence and ability to do it are 95% and 80%, respectively [25].

The diagnostic tools for stroke patients include CT scans, MRI, and fMRI. In this study, the cause of the disease was determined solely by MRI findings. Also, after the patient's visit and the neurologist's diagnosis of a stroke, according to MRI findings and based on the referral form, aphasia patients were referred to a SLP to determine the cause of the complication. The treatment methods used in this study include treatment programs based on the damage mapping hypothesis, verb network strengthening therapy, treatment of underlying constructions, treatment of underlying forms, melodic intonation therapy, SFA, and treatment around cognitive components such as perception, attention, memory, language, and thinking. Neurological rehabilitation is a medically controlled process to heal a damaged part of the nervous system. Neurological rehabilitation often reduces disease symptoms, strengthens or stabilizes new behavioral patterns, and rehabilitates and empowers the damaged functions of the patient's nervous system.

Each patient began treatment between 2 and 8 weeks after sustaining a brain injury. An SLP provided rehabilitation services four times weekly (one 30-minute daily session) for one year and seven months. Due to the nature of aphasia, this treatment period did not affect the spontaneous recovery of the disorder. The treatment of patients varied according to severity, disorder type, and individual requirements. After the treatment, the patients' AQ1 and MMSE questionnaires were reviewed and completed. Finally, the collected data were analyzed. Data analysis was done using the SPSS software version 19. The characteristics of the study participants were summarized using the Mean±SD or number and percentage. The Shapiro-Wilk test was used to check the normal distribution of research variance. The Mann-Whitney and the Kruskal-Wallis non-parametric tests were applied to compare the means of the research variables in background variables with two groups, respectively. Wilcoxon's non-parametric test was used to compare research variance before and after the intervention.

Results

According to the results, 54.5% of the participants are male, 45.5% female, 72.7% employed, 72.7% married, 31.8% educated, and 77.3% had an average economic status. Table 1 shows that 10 patients (equivalent to 45.45%) had fluent aphasia and 12 of them (equivalent to 54.55%) had non-fluent aphasia.

Table 2 shows that the average AQ1 score of the participants has increased from 74.80 to 80.12, and the average MMSE score has increased from 17 to 22.59.

The main variables do not follow a normal distribution ($P<0.05$), but the difference between scores before and after the intervention follows a normal distribution ($P<0.05$).

Table 4. Comparing Mean±SD research variables according to the type of aphasia

Variables	Mean±SD		Test Statistic	P
	Fluent Aphasia	Non-fluent Aphasia		
Before AQ1 score	57.07±10.10	59.68±15.73	0.375	0.401
After AQ1 score	63.41±10.93	65.63±16.44	0.375	0.401
AQ1 difference before and after*	6.34±1.77	5.96±1.64	0.518	0.610
MMSE before	16±1.84	18.00±89	0.011	0.010
MMSE after	20.91±2.77	24.27±1.42	0.003	0.002
MMSE difference before and after*	4.91±1.14	6.27±1.10	2.855	0.010

AQ1: Aphasia quotient; MMSE: Mini-mental state examination.

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*T-test of two independent groups.

According to Table 3, the results of the Wilcoxon test, the mean score of AQ1, and MMSE before and after treatment had a significant difference.

According to the Mann-Whitney test in Table 4, the average score of AQ1 before and after treatment is not significantly different in the two types of aphasia. Still, MMSE recognition before and after treatment significantly differs in the two types of aphasia. The t test of two independent groups shows no significant difference in the AQ1 score in the fluent and non-fluent aphasia groups. Still, there is a significant difference in the MMSE score in the fluent and non-fluent aphasia groups. The MMSE increase was higher in the non-fluent aphasia group.

According to the Spearman correlation coefficient in Table 5, there is no significant association between research variables with age and the number of children. According to the Pearson correlation coefficient, the difference between the AQ1 score before and after treatment has no significant relationship with age and number of children. Still, a significant relationship exists between MMSE score before and after treatment and the number of children.

Discussion

As mentioned previously, the communication and pathological problems of these patients become more and more severe in the advanced stages of stroke, so the reduction of social participation due to existing communication problems endangers the emotional and mental health of

Table 5. Correlation coefficient of research variables with age and number of children

Variables	Age		Number of Children	
	Coefficient	P	Coefficient	P
Before AQ1 score	0.214	0.353	0.099	0.668
After AQ1 score	0.167	0.470	0.077	0.739
AQ1 difference before and after*	0.102	0.650	0.241	0.279
MMSE before	0.046	0.844	0.053	0.820
MMSE difference	0.199	0.388	0.317	0.161
MMSE difference before and after*	0.237	0.288	0.443	0.039

AQ1: Aphasia quotient; MMSE: Mini-mental state examination.

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*Pearson correlation coefficient and Spearman correlation coefficient.

the patient. The pathology and language deficit in aphasia, depending on the type of damage, the location of the damage in the brain, and the severity of the problem, leads to different degrees of language comprehension and expression problems. Since the current study aimed to examine the efficacy of neurological rehabilitation in stroke patients, the findings are compared to those of similar research. In this study, it was found that the average research variables of the type of individual factors, such as gender, occupation, marital status, place of residence, income level, education level, cause and location of the complication, and the number of children before and after treatment did not differ significantly among the participants. Also, based on the MMSE test, the education level affects patients' cognitive performance before and after treatment. This finding means that patients with a higher level of education had better performance in cognitive dimensions such as understanding, sustained attention, general memory, working memory, language, and thinking, which is in line with the study by Rahmani et al. [26]. According to this study, all participants showed functional improvement in continuous speech development and vocabulary retrieval. Thus, continuous speech and vocabulary retrieval are more efficient and possess a more meaningful communication aspect. This finding indicates that all participants showed improved performance in continuous speech tasks using SFA, and the results were consistent with Wambaugh and Falconer [15, 20]. The results of this study indicate that the average AQ1 score before and after treatment in two types of fluent and non-fluent aphasia is not significantly different. Based on the MMSE test before and after treatment, there is a significant difference in the treatment of two types of aphasia, and this variable is significantly less in the fluent aphasia group. It has been determined that word naming, language processing, word recall, working memory, and sustained attention are related to stroke patients' performance. In addition, word-finding difficulties are a widespread symptom attributed to many factors. In fatigue, great stress, and taking many medications, healthy speakers can also experience difficulty recalling vocabulary.

At the end of the section, as a clinical point, it can be acknowledged that referring stroke patients to a neurologist and providing services during treatment-rehabilitation services by neurologists and SLPs would benefit these patients. The advantages of this teamwork include organization and familiarization with spatial-temporal position (orientation) and strengthening of respiratory support, awareness of the coordination of the breathing system and vocalization, strengthening of the facial and mouth muscles, increasing the phonological-semantic awareness of names and training to retrieve words with fluent expression and strengthening of functional memory and other cognitive dimensions in-

crease linguistic and cognitive performance in stroke patients. In addition to being consistent with similar research, the important results of the research had innovations that include the effect of a regular and targeted treatment program on the rate of recovery of the patient's speech and cognitive aspects, as well as the impact of early rehabilitation services (up to 6 months after the onset of stroke) on all-round progress of the patient.

Conclusion

The research results about the objectives of "the effectiveness of neurological rehabilitation in stroke patients" for 22 adult participants are only presented in the two fields of changes resulting from the AQ1 and MMSE tests. The mean scores of AQ1 and MMSE before and after treatment significantly differed. The average score of AQ1 before and after treatment is not significantly different in the two types of aphasia. Still, cognitive dimensions according to the MMSE test before and after treatment are significantly different in the two types of aphasia. Results indicate that gender, employment status, marital status, income level, and age have no significant relationship with changes in AQ1 and MMSE scores and the effect of the intervention on these two variables. In addition, it was observed that the changes in MMSE caused by the intervention significantly correlate with education level and the number of children.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of [University of Social Welfare and Rehabilitation Sciences](#) (Code: IR.USWR.REC.1400.049).

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Authors' contributions

Conceptualization and study design: Mojtaba Azimian, Morteza Farazi and Reza Nilipour; Data acquisition: Morteza Farazi, Mohammad Sayad Nasiri, Marzieh Amrevani, and Zahra Valitabar Kerati; Data analysis and interpretation: Mojtaba Azimian, Morteza Farazi, Reza Nilipour and Mohammad Sayad Nasiri; Statistical analysis: Samaneh Hosseinzadeh; Initial draft preparation: Morteza Farazi; Review, editing and final approval: All authors.

Conflict of interest

The authors declared no conflict of interest.

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