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Original Article

The Effect of Working Memory Rehabilitation on Visual Memory and Memory Span

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Introduction: Age-related cognitive decline or cognitive aging is largely the result of structural and functional decline in specific areas of the brain, but lifestyle also contributes to this cognitive decline. The aim of this study was to investigate the effect of working memory rehabilitation on visual memory and memory span in ageing.

Methods: This was a quasi-experimental study with pretest-posttest design and a control group. The study population included all elderly people who lived in Bukan Nursing Home from April to July 2019 (N = 120). Among these individuals, 30 elderly people were selected by convenience sampling method and then randomly assigned to two experimental and control groups (two groups of 15 people). Kim Karad Visual Memory Test and Wechsler Memory Span Test were taken from the groups in pretest. The working memory rehabilitation was performed in 18 sessions (each sessions 60-minute) and after which the test was performed again. The data were analyzed by multivariate covariance test according to its assumptions.

Results: The results showed that after the rehabilitation of working memory, in the experimental group, the mean of short, medium and long components of visual memory were 12.00, 10.8 and 12.33, respectively, and the direct and inverse of memory span were 11.66 and 9.66, respectively. In the control group, the average of short, medium and long components of visual memory is 7.00, 6.70 and 9.00, respectively, and direct and inverse of memory span is 8.33 and 6.46, respectively. The difference in the mean scores between the two groups in the components of visual memory and memory span after the intervention was significant ($p < 0.001$).

Conclusion: The results showed that working memory rehabilitation can improve visual memory and memory span, and it is recommended that this rehabilitation method be used to improve the cognitive functions of the elderly.

Keywords: Rehabilitation, Cognition, Memory Span, Visual Memory, Aged

Introduction

Our understanding of aging and its effects on cognition has improved significantly over the past 50 years. In the next decade, for the first time in human history, the number of people over the age of 60 will be more than children (1). The most common cognitive complaint among the elderly is memory problems. It is estimated that 56% of elderly who visit clinical centers, complain of memory problems (2). Memory is divided into sensory, short-term, working, and long-term memory in terms of information retention period and in terms of the type of information that enters and stores in memory, it is divided into spatial, visual, olfactory, auditory, haptic, and taste (food) memory (3). Also, the types of memory differ in terms of information storage capacity and memory span, and the term memory span is more commonly used for short-term memory (4).

One type of memory that has been studied in the present study is visual memory. Visual memory contains visual representations that store information about the perceptual characteristics of the observed stimuli (5). Active visual memory declines from about age 21 onwards, and its capacity is halved at age 75. Age-related decline in visual memory has been observed in various features (such as color, location, and orientation) and during encryption (6). Numerous different studies, including, Brockmole & Logie (7), Pardhan et al. (8), have shown a decline in visual memory function with age.

Another dependent variable of the present study was memory span. According to the American Psychological Association, memory span means the number of things that can be remembered immediately after a presentation. Items usually include letters, words, numbers, or syllables that participants must reproduce in order (9). Many studies have been done on the memory capacity in the elderly, including Wiliams & Kemper (10), Gordon-Salant & Cole (11), Keating et al. Affleck-Brodie (12), and the results of all of them have shown that aging affects memory capacity and reduces it.

So far, many interventions have been made to improve visual memory and memory span in the elderly, including Computer-Based Visual Training (13), Stroboscopic Visual Training (14), and Transcranial direct current stimulation (15). The intervention in the present study is working memory rehabilitation. Baddeley defines working memory as the brain system that provides temporary storage and manipulates information needed to perform complex cognitive tasks such as language, perception, learning, and reasoning (16). Memory rehabilitation is one of the results of cognitive rehabilitation. Memory rehabilitation includes instructions and exercises on memorization, organization, and extensive processing strategies used during encryption. Various studies have shown that memory rehabilitation has positive effects on cognitive functions in old age (17). Memory rehabilitation programs are based on the principle that cognition can be changed in the elderly, and memory rehabilitation interventions facilitate the flexibility of the brain through the teaching of various strategies that help to better encrypt and retrieve information (18). The performance of working memory tasks can be improved through training (19). Working memory training can be a credible way to help the elderly to maintain some of their daily abilities and functions (20). Various studies have shown that working memory rehabilitation improves memory capacity and memory span (21). The results of Russi et al. study (22) showed that the elderly with memory problems benefit from memory rehabilitation, and this rehabilitation enhances their memory span. The results of a study by Kihoon et al. (23) showed that rehabilitation programs are effective on elderly visual memory. Various studies on the effect of memory rehabilitation on visual memory have shown that memory rehabilitation affects the visual memory of the elderly (24).

Improving the quality of life and health, increasing life expectancy has led to a high prevalence of the elderly population and increasing this class of the population, consequently will increase the physical and cognitive problems caused by increasing age and cause great concern about this group of has created crowds (25). Research shows that memory rehabilitation is an effective way to improve cognitive functions, and given that not much research has been done on the effectiveness of this method on memory functions in the elderly, and due to population growth in recent years, the inevitability of age-related cognitive problems and its high prevalence in old age, research in this field seems necessary and the purpose of this study was to answer the question: Does working memory rehabilitation affect visual memory and memory span in the elderly?

Methods

Study design and participants

This was a quasi-experimental study with pretest-posttest design and a control group. Working memory rehabilitation was considered as an independent variable and visual memory and memory span were considered as dependent variables. The study population included all elderly people who lived in Millad Bukan Nursing Home from April to July 2019 (N = 120). Among these individuals, 30 elderly people were selected by convenience sampling method and then randomly assigned to two experimental and control groups (15 people each) (26).

The inclusion criteria included: completion of consent form, age range 65 to 85 years, ability to read and write, being male, absence of acute and chronic psychological disorders (such as schizophrenia, depression, bipolar disorder, obsessive-compulsive disorder, Post-traumatic stress disorder, severe anxiety disorder, dementia) based on an interview by a psychologist, absence of significant physical illness based on a physical examination by a physician, and absence of vision and hearing problems based on optometrist and audiometrist examinations. The exclusion criteria were including: incomplete answering to the questions, participating in other psychotherapy sessions at the same time, and refusing to continue participating.

Instrumentation

Wechsler Memory Span Test: Wechsler developed his Intelligence Scale in 1939, which consisted of two parts: the verbal scale and the functional scale and digit span subtests is a part of the verbal scale of the Wechsler Intelligence Test. This test is used to measure instant parrot-like memory, focus and accuracy, displacement (the ability to move thought patterns from direct to reverse digits), sequencing or listening chains, and parrot-like learning. Digit span is a test for short-term memory and attention. The examiner read a list of three to nine digits calmly and aloud. The examinee should remember and repeat the auditory information in order. High scores on inverted digits indicate a person's ability to be flexible, focused, patient with stress, and to make, maintain, and check visual mental images. Direct digits indicate parrot-like memory (27). The test is performed in such a way that if the examinee is not successful in the first attempt, the second attempt digits are performed. If the examinee fails in both attempts, the test is stopped. The score of the examinee is equal to the successful repetition of the numbers of the last series of the first and second attempts. The maximum score is 7 for direct numbers and 7 for reverse numbers. The reliability of the test with the test-retest method for Iranian women and men was reported to be 0.90 and 0.92, respectively (28). In Iran, Sadeghi et al. reported that the split half reliability coefficient of the test was 0.95 and the reliability coefficient of its subscales was 0.71 (29). Also, in some studies, Cronbach's alpha for the test was 0.96 and for all subscales was higher than 0.87 (30). In the present study, Cronbach's alpha of this questionnaire was 0.65.

Kim Karad Visual Memory Test: The test was developed in 1945 by Kim Karad. This test is part of the visual memory function measurement test. This test contains of a 16-cell cardboard sheet that has a picture in each cell (the main sheet of the test), a blank 16-cell sheet, and 16 cardboard pieces, each with a picture of the main test sheet. The way to do the Kim Karad test is that the main cardboard sheet is shown to the participants for 1 minute, and then the person has to remember and place the pieces he has, as he saw them. The examinee is then asked to correct his or her work compared to the main sheet, then this step is repeated a second time, and the person has to correct his or her work again. In the last step (which is the main step and the score is calculated), the participants are asked to set the blank sheet of the test as before, without seeing the main sheet. The examiner calculates the test score in the last step. This test can assess short-term, medium-term and long-term visual memory. The reliability coefficient of this test is acceptable (0.81) (31). Also, other studies have estimated the validity of this test using the retesting method, which reported the criterion-related validity coefficient of 0.5 and the validity coefficient of 0.62 at the significance level of 0.01 (32).

Working Memory Rehabilitation: working memory rehabilitation is a program designed based on Dehn's working auditory memory intervention program and includes 4 major techniques includes: elaborative rehearsal, semantic rehearsal, chunking, and paraphrasing (33). The program designed in 18 sessions (each sessions 60-minute), which are shown in Table 1.

Data collection

Initially, in the pretest phase, both the Wechsler Memory Span Test and Kim Karad Visual Memory Test were performed on both groups. Then, the working memory rehabilitation was performed on the experimental group in 18 sessions (each sessions 60-minute) over 6 weeks but control group received nothing. After the rehabilitation sessions, posttest was held. In the posttest phase, the experimental group and the control group performed the Wechsler Memory Span Test and Kim Karad Visual Memory Test again.

Ethical considerations

This research has a code of ethics from Urmia University of Medical Sciences with the ID of IR.UMSU.REC.1398.142 and the clinical trial code of IRCT201909100447737N1. In this study, ethical considerations such as professional competence, respectful and honest treatment, individual rights, human dignity, confidentiality, non-exploitation of participants, avoidance of harming others and non-distortion of information were regarded.

Data analysis

The data were analyzed using descriptive (mean and standard deviation) and inferential statistics (multivariate analysis of covariance or MANCOVA) by SPSS 22.00.

Results

The study included 30 elderly people whose mean age was 75.3 ± 5.2, 77.7% were single (without a spouse, divorced or deceased), 22.2% married (with a live spouse) and their education was as follows: 85% middle school, 15% high school diploma and undergraduate.

As Table 2 shows, the mean and standard deviation of posttest visual memory of the working memory rehabilitation group in the short-term was 12.00 (1.2), in medium-term was 10.80 (1.03) and in the long-term was 12.33 (0.93).

As table 3 shows, the mean and standard deviation of the posttest memory span of the working memory rehabilitation group was 11.66 (1.44) in direct span and 9.66 (1.24) was reverse span.

The results of table 4 showed that the value of the Wilks 'lambda test was 0.034 for the visual memory variable and 0.088 for the memory span, which were significant at the level of 0.001 ($p < 0.001$). The smaller the value of the Wilks 'lambda test than 1, the more significant the difference between the groups is.

Homogeneity of variances

The results of Levene's test showed that the difference in variances between the two groups in the score components of the consistent card, inconsistent card and interference from the variable of the Stroop test and response error, deletion response, correct response and reaction time from the Continuous Performance Test were not significant. Based on these results, the assumption of homogeneity of variances in the above variables in the studied groups was confirmed. This test was not significant for any of the variables, in other words, the variances were equal in both population. As a result, the use of parametric tests was unrestricted.

The results of table 5 showed that there was a significant difference between the elderly in the experimental and control groups in visual memory at the level of 0.001 ($p < 0.001$). In other words, the visual memory of the experimental group differed after performing the working memory rehabilitation. There was also a significant difference between the elderly in the experimental and control groups in memory span at the level of 0.001 ($p < 0.001$). In other words, the memory span of the experimental group differed after performing working memory rehabilitation

Table 1. Treatment protocol in each working memory rehabilitation session

Session	Topic	Purpose
1st	Pretest	Introduction- purpose expression- performing pretest
2nd	Auditory memory	Learning to remember- remembering a few letters, simple words and numbers after a few seconds- remembering the first or last letter, number or word
3rd	Visual memory	Learning to hide one of the objects- identifying deleted objects- Remembering seen objects- Learning to remember seen objects- Remembering faces- repeating patterns
4th	Practice	Repeating auditory and visual memory exercises, training remembering in reverse order
5th	Play with pictures	Images and photos are shown to the participant and then asked to retell the colors and directions after 15 seconds.
6th	Follow the instructions	At the same time, several orders are given to the participant and he or she must follow them in order
7th	Show movie	A short film is shown to the participant, and after the film is over, the person has to say in colloquial language what she/he has seen.
8th	Recognition memory	Images of animals, fruits, objects and landscapes are shown to the person and she/he must recognize them after a few seconds.
9th	Practice	An overview of the training content of previous sessions
10th	Recall memory	A short story is read to the person in a few minutes (maximum of 3 minutes) and she/he has to tell that story.
11th	Long-term Memory	The person is asked to restate the events of the previous 24 hours in full detail.
12th	Auditory perception	A polynomial phrase is read to a person and he/she must express its meaning in colloquial language. Then we do the same exercise with two phrases and the person has to express the concepts in order.
13th	Learning list	The person is asked to learn a list of words that have already been prepared and then to remind them. The person must also repeat the sentences given by the instructor (examiner).
14th	Practice	An overview of the training content of previous sessions, playing with word cards and recognizing the word provided among all the cards
15th	Mental review technique	Teaching mental review technique (repeated reading and writing)
16th	Mental review technique	Continuing teaching mental review techniques
17th	Practice	An overview of the training content of previous sessions, playing with word cards
18th	Posttest	Thank and performing posttest

Table 2. Mean and standard deviation of the experimental and control group in visual memory in pretest and posttest

Size	Experimental group				Control group			
	Pretest		Posttest		Pretest		Posttest	
	M	SD	M	SD	M	SD	M	SD
Short	7.00	1.29	12.00	1.20	7.13	0.89	7.33	0.97
Medium	6.70	0.94	10.80	1.03	7.00	1.11	7.30	0.84
Long	9.00	0.96	12.33	0.93	9.50	0.88	9.30	1.11

Table 3. Mean and standard deviation of the experimental and control group in memory span in pretest and posttest

Memory span	Experimental group				Control group			
	Pretest		Posttest		Pretest		Posttest	
	M	SD	M	SD	M	SD	M	SD
Direct	8.33	1.23	11.66	1.44	8.46	1.24	9.33	1.58
Reverse	6.46	1.18	9.66	1.34	6.33	1.29	7.00	1.50

Table 4. Results of MANCOVA on visual memory and memory span

Test	Variable	Value	F	Hypothesis df	Error df	Sig	Eta
Pillai's Trace	Visual memory	0.966	219.054	3	23	0.001	0.966
	Memory span	0.912	129.019	2	25	0.001	0.912
Wilk's Lambda	Visual memory	0.034	219.054	3	23	0.001	0.966
	Memory span	0.088	125.019	2	25	0.001	0.912
Hotelling's Trace	Visual memory	28.57	219.054	3	23	0.001	0.966
	Memory span	10.322	125.019	2	25	0.001	0.912
Error Largest	Visual memory	28.57	219.054	3	23	0.001	0.966
Root	Memory span	10.322	125.019	2	25	0.001	0.912

Table 5. Results of MANCOVA on variables in experimental and control groups

Variables		Sum of Squares	df	Mean Squares	F	Sig	Eta Squared
Visual Memory	**Short**	157.928	1	157.928	229.511	0.001	0.902
	Medium	91.091	1	91.091	181.908	0.001	0.879
	Long	78.7	1	78.7	104.353	0.001	0.835
Memory Span	**Direct**	71.079	1	71.079	131.734	0.001	0.835
	Reverse	68.206	1	68.206	93.772	0.001	0.783

Discussion

The main purpose of the present study was to investigate the effect of working memory rehabilitation on visual memory and memory span of the elderly. The results of present study showed that working memory rehabilitation is effective on memory functions, and the experimental group was significantly different from the control group in terms of posttest. Elderly participated in the experimental group gained significant improvement in visual memory and memory span.

The first finding of the present study was that working memory rehabilitation improves the visual memory of the elderly, which was in line with the results of previous research (34). Memory rehabilitation programs train people to memorize information with their images, such as the names of people with their faces or the names of streets with the images associated with them, enabling people to better link between verbal and visual information and to better recall them (34). Memory rehabilitation also improves learning and makes easier recall with fewer errors, and improves visual memory by teaching you how to create a mental and cognitive map. Another strategy is to use signs strategies to store information, and signs engage the visual senses, thereby enhancing visual memory (34). Various studies have linked occipital lobe, midbrain and posterior temporal lobe to visual memory and suggesting that neural connections in these areas is impaired in the elderly (35-38). Brown and Wesley argue that visual memory is improved through combined cognitive strategies, semantic coding, and elongation, thus improving spatial visual pads and semantic knowledge of visual working memory when storing the use of verbal codes and phonetic nodes (39).

The next finding of the present study was that working memory rehabilitation improves memory span in the elderly. This finding is consistent with previous studies (40). Various studies have shown that memory rehabilitation can improve memory span by training older people to control irrelevant information and distraction control (41-43). Another strategy that is taught in memory rehabilitation is to break down information into meaningful pieces, which saves more data and improves memory span (44). Explaining the findings from neurological studies, the researchers found that working memory rehabilitation altered the structure of the white matter of the brain and improved working memory function, including memory capacity and memory span (45). Cassetta and Goghari believe that working memory rehabilitation increases the capacity of working memory through its effectiveness on fluid intelligence. The results of their study showed that working memory rehabilitation will improve fluid intelligence by affecting the mechanisms of executive attention, control of information input and control and interference strategies, and this ability in turn will improve the capacity of working memory (46).

Conclusion

The findings of this study emphasize the effectiveness of the memory rehabilitation method on the functions of visual memory and memory span. It seems that according to this finding and using the working memory rehabilitation method, memory span and visual memory of the elderly can be improved.

Study limitations

One limitation of the present study male-subject limited to the Bukan Nursing Home. Therefore, others should be careful in generalizing the present results to female elderly and non-resident elderly in care centers and the elderly in other cities. It is suggested that this research be conducted to obtain more evidence and credibility in other cities with older people of both sexes as well as non-resident elderly in care centers.

Conflict of interest

The authors declare no conflicts of interest.

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Authors' contributions

Data collection and preparation of draft manuscript :MMA
Conception of idea , data extraction and analysis: ES
Data interpretation and review: AIZ

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