Computer Aided Technology-Based Cognitive Rehabilitation Efficacy Against Patients' Cerebral Stroke

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ABSTRACT

Cognitive dysfunction caused by cerebral stroke in different degrees throws patients into troubles in daily life. It, therefore, has been a great challenge about how to develop a positive and accurate diagnosis and treatment program against cognitive impairments and in favor of rehabilitation of patients after cerebral stroke. This paper investigates 128 cases of stroke patients randomly chosen and included into the traditional rehabilitation and computer-aided training groups who respectively received routine drug and traditional cognitive rehabilitation therapies for 4 weeks, except that the computer-aided training group also underwent a computer-aided cognitive exercises. A Montreal Cognitive Assessment (MOCA) was introduced for rating both groups. After a comparative analysis was conducted on the results, it turns out that, after cerebral stroke of patients, whether the traditional cognitive rehabilitation therapy or the computer-aided cognitive therapy they received, the cognitive dysfunction can be relieved, but the computer-aided training process, as an adjuvant therapy, has a more significant efficacy against this symptom. It is proved that the Computer Aided Technology (CAT) has played a great role in the rehabilitation of patients with cognitive dysfunction after cerebral stroke, which attributes to its strong targeted therapy, practicality, time-saving and less effort, and good scientificity. Not only that, it also has a great practical significance for clinical cognitive rehabilitation.

Key Words: Computer Aided Technology, Cerebral Stroke, Cognitive Dysfunction

DOI Number: 10.14704/nq.2018.16.4.1212 **NeuroQuantology 2018; 16(4):*86-92***

Introduction

According to statistics (Go, 2013), there are about 25 million patients who suffer from cerebral stroke in the world, while the incidence of stroke in China (Ferrucci, 1996) is on the rise by more than 1 million cases per year. As a disease with the highest neurological morbidity, stroke not only impairs the patient's motor homeostasis but also hampers their language expression. Nearly 50% -75% of patients appears cognitive dysfunction in varying degrees (Tatemichi, 1994), especially within one year after they stroke (Tham, 2002), thus they are exposed to greater risk and danger.

The etiology of cognitive dysfunction (Patel, 2003) is that the brain injury or cerebral stroke disrupts brain tissue structure, further causing varying degrees of impairment to the cerebral cortex, so that some symptoms occur in the patients such as memory loss, inattention, language expression stagnation, etc. (Kauhanen, 2000). These impairments of cognitive function area (Sachdev, 2006) not only worsen the quality of patient's daily life, but also pose a heavy psychological and financial burden on the families of patients. It, therefore, is imperative to

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Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.
Received: 8 February 2018; **Accepted:** 2 April 2018

timely diagnose cognitive impairment of patients after stroke, and make a systematic, targeted post-rehabilitation treatment on ordinary patients for their cognitive and physical recoveries.

However, at present, doctors and patients' families mainly concern their clinical verbal and motor function recoveries, the impairment to the patient's cognitive function (Petersen, 2001) can not be timely perceived; or those patients with cognitive dysfunctions can not actively cooperate with treatment, even the efficacy of training therapy falls well short of the expected goal (Iwashyna, 2010); for the above reasons, the incidence of cognitive disorder and dementia within 3 months after cerebral stroke reaches as high as 56.8% and 23.5%. Currently, the top priority is to evaluate the extent of cognitive dysfunction in stroke patients in clinical treatment, which will not only help understand the patient's physical conditions but also develop a reasonable therapeutic regimen based on the diagnosis results (Nasreddine, 2005).

Additionally, cognitive rehabilitation (Kneebone, 2016) is such a process that patients continually re-learn to improve and regain impaired functions such as attention, memory, disturbance of thoughts and perceptions. Therapies include one-to-one manpower cognitive and computer-aided cognitive training treatments, while the latter (Cully, 2013) is widely applied in the cognitive rehabilitation for patients after stroke because of its strong pertinence, scientificity and systematicity.

Currently, the popularity of cognitive rehabilitation in China is much lower than that in developed countries such as Europe and the United States (Toglia, 2011). Most of medical institutions just concern the recoveries of patient's verbal and motor functions, thus dismiss the cognitive rehabilitation as the unimportant. This paper aims at the impact of cognitive training therapies on cognitive functions of patients after cerebral stroke, statistically analyzes the effect of computer-aided training therapy on cognitive improvement of randomly selected patients with stroke in relation to the manpower cognitive training therapy, while observing their performance before and after training with Montreal Cognitive assessment (Cumming, 2011).

Methods

Study objects

The objects in the study were those stroke (cerebral infarction and cerebral hemorrhage) patients in the neurology department of a hospital. There is no obvious difference in ages, genders, education levels and stroke types between the two groups, the experiment group and the control group, which are comparable. After admission, they have ever been received brain CT or MRI examinations. After each patient is scored with the Montreal Cognitive Assessment (MoCA), those who get a score of less than 20 are confirmed as patients with cognitive disorder or defect. On the principle of patient's voluntary, a total of 128 cases were randomly chosen for computer-aided training experiment group (62 cases) and the traditional rehabilitation training control group (66 cases), provided that they can do simple computer operations. MOCA is introduced for rating the two groups of patients before and after training, coupled with further investigation and statistical analysis conducted on these patients. The general conditions of two groups of patients are shown in the following table (1):

Criteria for case inclusion and exclusion

The standard conditions for case inclusion and exclusion are given in the following tables (1) and (2), respectively.

Training program

(1)Training therapy for All selected cases

In order to ensure the patient's stable condition, vital signs, all patients will first receive a regular drug therapy, and then a series of "one-to-one" rehabilitation training therapy such as placement of limbs, joint motion, teeter torture, strength training, etc. Experienced doctors in the rehabilitation section will design an individualized progressive training procedure according to actual conditions of each patient. The training therapy lasts for four weeks. To ensure the availability of the results, both groups of patients are trained by the one group of medical workers.

(2)Training methods for computer-aided training group

For computer-aided training group, in addition to the traditional rehabilitation training, they also accept the computer-aided cognitive training therapy for 30 minutes a day, six days a week, and four weeks as one course of treatment.

Table 1. The Basic Information of Two Groups of Patients

Group	Quantity	M/F (Qua.)	Age (Years, $\bar{x} \pm s$)	Years of Education (Years, $\bar{x} \pm s$)	Clinical Diagnosis	
					Cerebral Infarction	Cerebral Hemorrhage
Computer Training Group	62	40/22	61.50±12.34	10.50±2.45	48 (77.4)	14 (22.6)
Traditional Training Group	66	46/20	62.35±10.34	11.22±3.08	50 ((75.7)	16 (24.2)

Table 2. The Basic Information of Two Groups of Patients

Factors	Computer Training Group	Traditional Training Group	x^2/t	p Value
M/F	40/22	46/20	x^2=0.03	0.960
Age (Years)	61.50± 12.34	62.35± 10.34	t=0.578	0.565
Years of Education (Years)	10.50± 2.45	11.22±3.08	t=-0.115	0.908
Clinical diagnosis (CI/CH)	48/14	50/16	x^2=0.016	0.898

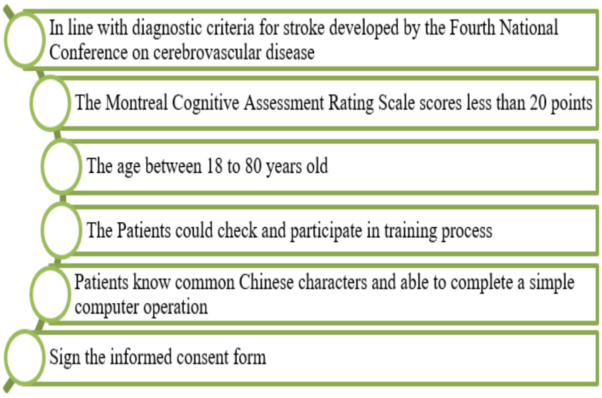

Figure 1. The Standard Constrain for Choosing Patients

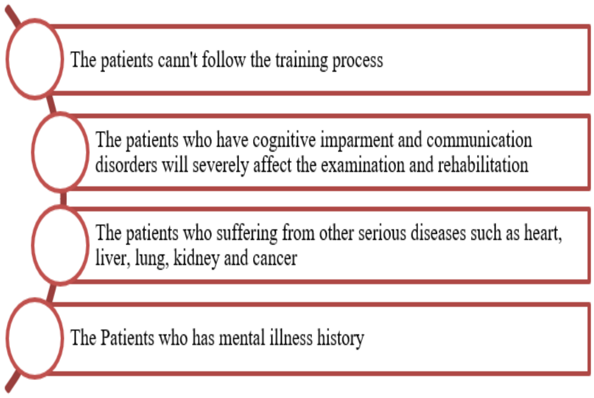

Figure 2. The Exclusion criteria for Choosing Patients

A special computer-aided cognitive training program is developed by a professional doctor for each patient based on the patient's scores rated with MOCA, and the training procedures should be consistent, and gradually completed from easy to difficult. It is mainly targeted to the following aspects as shown in Fig. 3.

Cognitive function assessment method

The MOCA is enabled for both groups before training, and repeat this process after 4 weeks. The scores of MOCA before and after training are compared. Those patients who have accepted an education of less than 12 years should be added 1 point.

Statistical method

A SPSS17.0 statistical software is used to analyze all data.

Measurement data are expressed as mean ± standard deviation; all tests, if P <0.05, have a statistical meaning, and the MOCA scores of two groups before and after training are tested with independent samples t and pared samples t.

Study results

Patient profiles

A total of 128 cases were included, including 42 females and 86 males, at the ages of 48 - 75. After statistical analysis of two groups of cases, the values p are all greater than 0.05, and there are no statistical deviations. The general conditions of the two groups of cases do not differ significantly. Data from comparison with each other is shown in the following table (2):

Figure 3. The Example of Training Process

Comparison of MOCA scores of two groups of cases before and after training

Prior to training, independent samples t test is conducted on both traditional rehabilitation and computer-aided training groups in accordance with several items in MOCA, and the P-values are greater than 0.05. This means there is no statistical difference. The MOCA scores for both groups are shown in Table (3) below, but their total score of MOCA is marked without significant deviation.

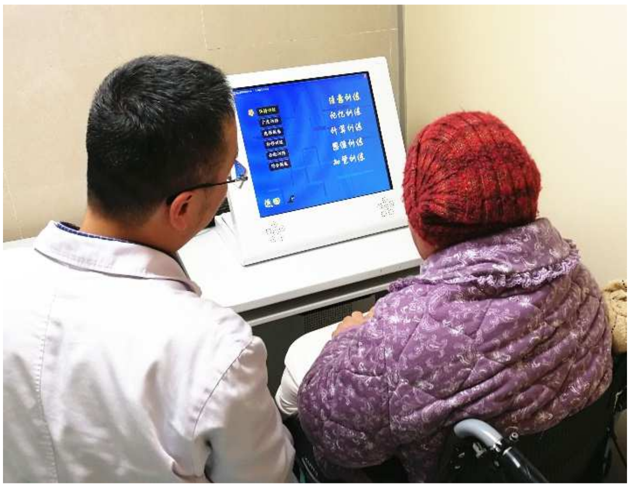

Figure 4. The Example of Computer Assistant Training Process

The MOCA scores of the two groups after four weeks of training therapy are given in the following table (4). The results show that the average score of the computer-aided cognitive training group is higher than that of the traditional rehabilitation training group, and after the independent sample t test, the scores of memory, visual-space executive competence and attention are also higher. The p-values for both naming and orientation and other items are less than 0.05, having a statistical meaning. The p-values for abstraction and language are greater than 0.05, having a statistical difference.

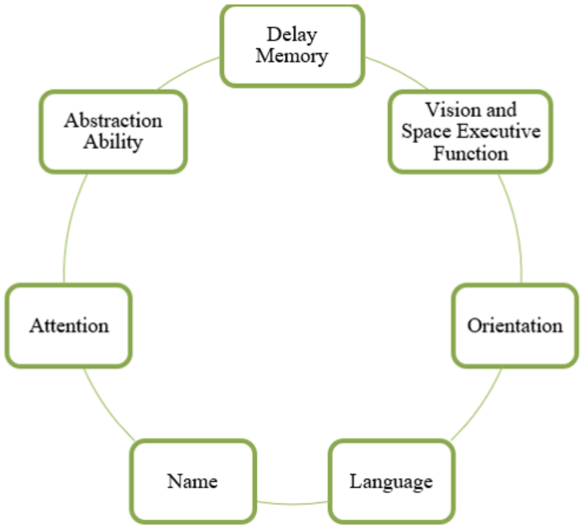

Figure 5. The Items in Computer Assistant Training Process

Comparison of MOCA scores of traditional rehabilitation group before and after training

After four weeks of rudimentary rehabilitation training therapy for traditional group, including placement of limbs, posture alteration, strength training, joint motion and motor homeostasis, they reach a significant improvement in MOCA scores compared with that before training. While pared samples t-test is conducted on MOCA before and after training, and it is found after analysis that in addition to language competence whose score p is greater than 0.05, there is no significantly statistical difference. The p values of remaining items including memory, visual-space executive function, abstraction, attention, naming and orientation and the overall score are all less than 0.05 with statistical significance, as shown in the following table (5).

Table 3. The MOCA Results of the Two Groups before Training

Group	Delay Memory	Vision and Space Executive Function	Abstraction Ability	Attention	Name	Language	Orientation	Total score
Computer Training Group	2.02±1.46	2.43±1.60	0.53±0.75	3.02±1.46	2.02±0.76	0.54±0.85	4.05±1.22	14.55±3.55
Traditional Training Group	2.36±1.22	2.73±1.74	0.82±1.22	3.09±1.16	1.99±0.73	0.83±0.72	3.98±0.90	15.76±3.40
t Value	1.245	0.950	2.020	0.262	-0.135	1.630	-0.082	1.695
P Value	0.214	0.338	0.052	0.794	0.889	0.112	0.932	0.095

Table 4. The MOCA Results of the Two Groups After 4-weeks Training

Group	Delay Memory	Vision and Space Executive Function	Abstraction Ability	Attention	Name	Language	Orientation	Total score
Computer Training Group	3.84±1.20	4.13±1.10	1.65±0.54	4.79±1.20	2.86±0.43	1.43±1.00	5.68±0.64	24.59±3.34
Traditional Training Group	3.30±0.98	3.58±0.80	1.54±0.50	3.37±0.95	2.55±0.50	1.36±0.79	4.59±0.78	20.76±2.69
t Value	-2.565	-2.658	-1.140	-5.060	-3.225	-0.642	-7.164	-6.350
P Value	0.012	0.009	0.524	0.001	0.002	0.524	0.000	0.000

Table 5. The MOCA results of Traditional Group before and after Training

MOCA Score	Score before Training	Score after Training	Difference	t Value	p Value
Delay memory	2.36±1.22	3.30±0.98	0.94±0.89	2.025	0.032
Vision and space executive function	2.73±1.74	3.58±0.80	0.85±0.90	4.102	0.000
Abstraction ability	0.82±1.22	1.54±0.50	0.72±0.68	4.861	0.000
Attention	3.09±1.16	3.37±0.95	0.48±0.85	3.722	0.000
Name	1.99±0.73	2.55±0.50	0.66±0.68	2.114	0.034
Language	0.83±0.72	1.36±0.79	0.53±0.78	1.838	0.075
Orientation	3.98±0.90	4.59±0.78	0.61±0.83	2.456	0.014
Total score	15.76±3.40	20.76±2.69	5.00±1.89	17.589	0.000

Table 6. The MOCA results of Computer Group before and after Training

MOCA Score	Score before Training	Score after Training	Difference	t Value	p Value
Delay memory	2.02±1.46	3.84±1.20	1.82±1.14	7.852	0.000
Vision and space executive function	2.43±1.60	4.13±1.10	1.70±1.20	6.374	0.000
Abstraction ability	0.53±0.75	1.65±0.54	1.12±0.76	6.858	0.000
Attention	3.02±1.46	4.79±1.20	1.77±1.14	7.485	0.000
Name	2.02±0.76	2.86±0.43	0.84±0.80	4.935	0.000
Language	0.54±0.85	1.43±1.00	0.89±0.85	4.118	0.000
Orientation	4.05±1.22	5.68±0.64	1.63±1.14	6.752	0.000
Total score	14.55±3.55	24.59±3.34	10.04±2.53	23.012	0.000

Comparison of MOCA scores of computer-aided group before and after training

For computer-aided training group, after four weeks of training therapy, its MOCA scores are improved more significantly than that before training. A pared samples t-test analysis is also conducted on MOCA before and after training, it turns out that the p-values of memory, visual-space executive function, abstraction, attention, naming, language competence and orientation, as well as the overall score, are all less than 0.05 with significantly statistical differences, as shown in Table (6) ;

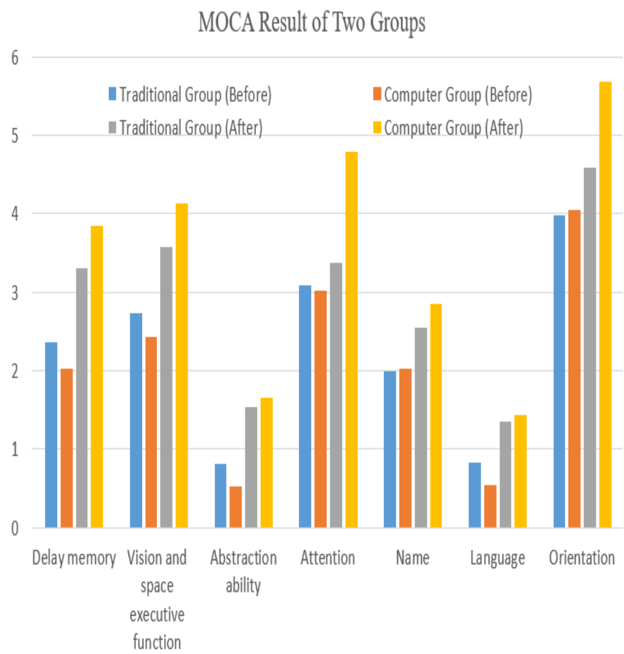

Figure 6. The MOCA Results between Two Groups

Discussion

Theoretical basis for rehabilitation of cognitive dysfunction after stroke

Brain neural network is more complex. Different areas in the brain exercise different functions but are also closely linked. The clinical stroke patients manifest different symptoms of dysfunction, but the retained nerve tissue and partial function make it possible to restructure the neurological functions of patients. Consequently, the plasticity of neural system underlies the rehabilitation of cognitive dysfunction of stroke patients theoretically. The plasticity of the neural system refers to the partial or complete reconstruction of impaired neurological function after the brain functions are restructured by repeated stimulation and learning process. An increasing number of evidences have suggested this possibility. In nerve cell of adult brain, only 20% of the nerve cells are usually activated, the rest are all in a dormant or idle state; at the time of the incidence of cerebrovascular disease, these dormant nerve cells and meridians will be activated by some means to make the brain functions recovery. Currently, the mainstream theories mainly include substitution theory, synaptic adjustment, germination theory and distant inhibition theory, etc.

In recent years, the development of functional imaging has also provided human with technical support for observation about how human brain structure changes. A large number of clinical researches and experiments show that with long-term spontaneous recovery and constant external stimuli, patient's cerebral cortex structure and function can gradually change. It is possible for them to reach functional reorganization. This has proved that cognitive training therapy can activate the corresponding encephalic regions to make the function of the cranial nerves restore to normal level and achieve the neural plasticity.

Rehabilitation measures against cognitive dysfunction after stroke

Currently, the rehabilitation training therapy against cognitive dysfunction in stroke patients is mainly one-to-one manpower type aiming at a certain cognitive area of the patients, for example, some training therapies for memory include picture memory method, story-telling method, recitation method and so on; some for the calculation competence have manual calculations, mental arithmetic and so on. Study shows that these trainings indeed improve the cognitive competence of patients but the artificial cognitive training therapy is due to time-consuming and labor-intensity, relatively low in efficacy. Even more, the training therapy efficacy is poor and greatly impacted by therapists.

In recent years, computer-aided cognitive training therapy has been sprung up in some foreign countries. As it features simple and efficient process, high enjoyment, rich subjects, easy acceptance, and obvious efficacy and so on, this therapy has been finding wider and wider application in the clinical practice.

Efficacy of CAT on cognitive rehabilitation after stroke

The CA cognitive training therapy has been widely applied in the rehabilitation of stroke patients for its numerous advantages. The results in this study reveal that patients who have received a computer-aided cognitive training therapy have a significantly improved performance in memory, visual-space executive function, attention, orientation and the overall score more than those untrained patients, and their values p from statistical analysis are less than 0.05 with statistical differences; their scores also have a significant difference from those of the traditional training group, which means that the computer-aided cognitive training therapy is more effective against defects of patients in some aspects such as memory, attention and other functions, and the overall cognitive competence has also improved greatly. These results coincide with the current clinical practices. Zhou Huichang *et al.* investigated this and believed that computer-aided cognitive training therapy can improve vascular cognitive dysfunction by learning activity and stimuli on cerebral cortex, thus to enhance the quality of life of patients. Du Xiaoxia *et al.* carried out a special computer-aided training therapy for stroke patients and found that it not only had a good efficacy against defects of the attention itself, but also helped the overall cognitive recovery. These results have proved the effectiveness of computer-aided training therapy on the attention recovery.

The MOCA scores of both groups before and after training are shown in Fig. (5). The study discovers that computer aided cognitive training therapy remarkably improves MOCA scores not only in attention, memory and visual-space executive function, but also in language and abstract thinking, and all of them are meaningful statistically. It follows that the computer-aided cognitive training therapy can improve the patient's speech disorder and enhance the abstract thinking competence, for example, studies have shown that computer-based cognitive training therapy can improve patient's thinking competence and directional power by showing them a large number of different images and videos to enhance their interests in training.

However, in relation to the traditional rehabilitation training group, the computer-aided training group does not show any significant difference in the improvement of speech and abstract thinking competence, but this was not completely consistent with the clinical practices. The reason for this may be that the two groups of patients have different pathogenic sites in stroke. Deng Xiaoying's findings suggested that patients with cerebral infarction in the basal ganglia may appear the signs of poor abstraction and attention. However, this study did not divide the stroke sites and the impaired areas in the two groups. Moreover, the application of the MOCA also had certain limitations and misdiagnosis.

As above, it turns out that patients with stroke can improve their cognitive competence in some specific aspects by means of appropriate cognitive rehabilitation training in favor of restoring their overall cognitive function. In addition, in virtue of the computer-aided training therapy, patients' memory, attention, orientation and other functions have been improved more significantly to help the recoveries of patients in limb functions and social activities more rapidly. As computer technology grows in popularity and the rehabilitation technology becomes mature gradually, the computer aided technology will play an increasingly important role in post-stroke rehabilitation training therapy. Although the MOCA has a relatively high sensitivity to mild vascular cognitive impairment of patients, certain misdiagnosis may be caused by the MOCA due to some limitations in application. As this study is subjected to other objective conditions and unexhaustive information, it only aims at comprehensive training for patients, rather than individual exercises specially designed for them. It could be said that the results of this paper are relatively ambiguous, there is still need to further explore and study the treatment of cognitive dysfunction.

Conclusions

This paper probes into assessment on the cognitive functions of stroke patients with the traditional rehabilitation and computer-aided cognitive training therapies, and draws the following conclusions:

(1) After stroke, whether adopting the traditional artificial rehabilitation training or computer-aided cognitive training therapies, the patient's cognitive dysfunction can be improved.

(2) After stroke, the efficacy of computer-aided therapy is better against impairments of patients' memory, visual function, attention and overall rehabilitation than that of the traditional rehabilitation therapy.

Acknowledgements

Public welfare Technology Application Research Program of Science Technology Department of Zhejiang Province (2015C33184).

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