Am J Transl Res 2021;13(4):3759-3765
www.ajtr.org /ISSN:1943-8141/AJTR0126532

Original Article

Nursing effects of finger exercise on cognitive function and others for cerebral ischemic stroke patients

Ping Li, Yongning Deng, Xiaojuan Guo, Jin Wang

Department of Neurology, The First Affiliated Hospital of Xi'an Jiaotong University, Xi'an, Shaanxi Province, China

Received November 18, 2020; Accepted December 23, 2020; Epub April 15, 2021; Published April 30, 2021

Abstract: Objective: To investigate the nursing effects of finger exercise training on cognitive function and others for patients with cerebral ischemic stroke (CIS). Methods: A total of 200 patients with CIS were selected in this prospective study. According to the random number table method, they were divided into control group (n=100, routine nursing) and research group (n=100, routine nursing combined with finger exercise training). Various scales were used to evaluate the cognitive function, hand function, upper limb motor function, wrist flexor muscle tone, degree of neurological impairment and ability of daily living (ADL) in the two groups before and after intervention. And the incidence of mild vascular cognitive impairment (VCI) after intervention was compared. Results: After intervention, Montreal Cognitive Assessment (MoCA), Mini Mental State Examination (MMSE), hand function, Fugl-meyer Assessment (FMA) and ADL scores in both groups were significantly increased, and those in the research group were significantly higher than those in the control group (all P<0.05). There were opposite trends in the Neurologic Functional Defect (NIHSS) and Modified Ashworth Scale (MAS) for wrist flexor scores (all P<0.05). The incidence of mild VCI in the research group was significantly lower than that in the control group (P<0.05). Conclusion: On the basis of early rehabilitation nursing, combined finger exercise training can improve cognitive function, hand function, upper limb function and ADL for patients with CIS.

Keywords: Finger exercise, cerebral ischemic stroke, cognitive function, hand function

Introduction

Cerebral stroke (CS) is one of the major diseases that lead to disability in China, among which cerebral ischemic stroke (CIS) is the most common one. And the number of CIS patients accounts for about 80% of all CS patients [1]. After CS, patients usually have a variety of physiological dysfunction, such as cognitive dysfunction, hand dysfunction, motor dysfunction, etc. [2]. Delavaran et al. reported that the incidence of cognitive dysfunction after CS was 20-80% worldwide, and Yeh et al. found that about 1/3 of the survivors would have significant cognitive dysfunction one month after stroke [3, 4]. Finger exercise is a simple way of training, which is easy to learn and master. Previous studies have shown that finger exercise has a relatively obvious effect on the rehabilitation of CS patients and significantly improves their upper limb function, hand function and cognitive function [5]. However, some scholars believe that the effects of improvement, especially the improvement on cognitive function, is limited and difficult to observe [6]. Therefore, this study evaluated the intervention effect of finger exercise on cognitive function, hand function, upper limb motor, sensory function, and ability of daily living (ADL) for patients with CIS.

Materials and methods

General information

A total of 200 patients with CIS admitted to The First Affiliated Hospital of Xi'an Jiaotong University from November 2018 to November 2019 were selected in this prospective study. They were divided into control group (n=100, routine nursing) and research group (n=100, routine nursing combined with finger exercise training) by the random number table method. This study was approved by the Ethics Committee of The First Affiliated Hospital of Xi'an Jiaotong University and all patients or their families signed the informed consent.

Inclusion criteria: Patients aged 50-75 years old; patients who met the diagnostic criteria of CIS in Chinese Guidelines for Diagnosis and Treatment of Acute Cerebral Ischemic Stroke 2014 and were confirmed by relevant imaging examination [7]; patients with first CS and course of disease <6 months; patients who were conscious with stable vital signs and volunteered to this training; patients with muscle strength of both upper limbs ≥ level 4.

Exclusion criteria: Patients with cerebral trauma, cerebral tumor and other cerebral diseases; patients with a pacemaker or metal implant placed in the skull; patients with Alzheimer's disease, depression, etc.; patients who couldn't complete the cognitive examination due to physical dysfunction; patients who participated in other researches within the same period.

Methods

Both groups received routine treatment for CIS, such as improving cerebral circulation and nourishing brain nerve, etc. Details are as follows. Intravenous drips of edaravone injection (30 mg; China Resources Double-Crane Pharmaceutical Co., Ltd., China) and Xueshuantong Injection (350 mg; Harbin Shengtai Bio-Pharmaceutical Co., Ltd., China) were given twice a day, respectively. Deproteinized extract of calf blood (800-1,200 g; Harbin Shengtai Bio-Pharmaceutical Co., Ltd., China) was injected once a day. All the drugs were administered continuously for 2 weeks.

The control group received routine education and early rehabilitation nursing of CIS, including limb active movement, joint activity exercise, etc. On the basis of the above measures, the research group received finger exercise training. In addition to hands and fingers, this training also involves wrist, elbow and shoulder joints. Details are as follows. 1) Palm massage: One hand were made to draw circles in the palm of the other hand alternately. 2) Dorsum massage: One hand were made to draw circles in the dorsum of the other hand alternately. 3) Finger grasp: One hand were made to grasp the fingers of the other hand interactively. 4) Fingers opening and closing: Both hands were opened or closed to make fists at the same time. 5) Finger extension: Five fingers of both hands were outstretched successively. 6) Finger clicking: The five fingers were clicked in turn by the other hand interactively. 7) Palm and dorsum hitting: The palm and dorsum were hit by the other hand. 8) Wrist flipping: The palms were put together, and turned over in turn to the inside and outside. Each of the above movements was repeated for 20 times, with 3-5 cycles each time, twice a day. After discharge, the training was performed continually at home, and the medical staff supervised and instructed patients through WeChat, telephone or monthly face-to-face communication. The effects were observed after 3 months.

Outcome measures

The following scales were filled in by the patient himself or the nursing staff according to the patients' wishes before and 3 months after intervention, and were retrieved on the spot.

Primary outcome measures: 1) Cognitive function: The Montreal Cognitive Assessment (MoCA) and Mini Mental State Examination (MMSE) scales were used to evaluate the cognitive function, with a total score of 30 points [8, 9]. Cognitive function is improved as the score increases. 2) Hand function: The hand fine motor assessment scale was used to evaluate the hand function, including 6 items as finger adduction/abduction, finger flexion and extension, digital opposition, palmar opposition, wrist-joint rotation and wrist-joint flexion and extension [10]. Higher score suggest better functions in the above items.

Secondary outcome measures: 1) Upper limb motor function: Fugl-meyer Assessment (FMA) Scale includes 33 items such as coordination ability and stability of various joints of upper limb movement (shoulder, elbow, wrist and hand), with a total score of 66 points [11]. Higher score refers to better upper limb motor function. 2) Wrist flexor muscle tone: In the Modified Ashworth Scale (MAS), 6 points and 0 point represent rigid and normal state when passive flexion and extension occurs, respectively [12]. 3) Degree of neurological impairment: The total score of Neurologic Functional Defect (NIHSS) is 42 points and the increased score indicates more serious neurological impairment [13]. 4) ADL: The total score of ADL scale is 100 points [14]. Higher score suggests stronger ADL. 5) The incidence of mild vascular cognitive impairment (VCI) after intervention was compared between the two groups. And 22-26 points of MoCA or MMSE presages mild VCI [8, 9]. The incidence of mild VCI = Number

Table 1. Comparison of general information ($\bar{x}$ ± sd, n)

Index	Research group (n=100)	Control group (n=100)	χ^2/t	P
Gender			0.720	0.396
Male	54	48		
Female	46	52		
Age (years)	63.3±5.7	64.2±5.0	1.187	0.237
BMI (kg/m^2)	23.45±2.22	23.10±2.84	0.971	0.333
Brunnstrom stage [15]			2.321	0.313
I	36	29		
II	30	40		
III	34	31		
Level of education			1.807	0.405
Junior high school education or below	50	58		
Senior high school education or associate degree	26	25		
Bachelor or above degree	24	17		
Nursing knowledge			0.272	0.602
Yes	9	7		
No	91	93		

Note: BMI: body mass index.

Table 2. Comparisons of cognitive function ($\bar{x}$ ± sd, score)

Group	MoCA score	MMSE score
Research group (n=100)		
Before intervention	20.04±2.20	21.40±3.22
After intervention	25.96±3.22$^{*,\#}$	25.40±3.50$^{*,\#}$
Study group (n=100)		
Before intervention	20.48±2.40	21.03±4.39
After intervention	22.94±3.08*	23.98±4.05*

Note: Compared with before intervention, *P<0.05; compared with control group after intervention, $^{\#}$P<0.05. MoCA: Montreal Cognitive Assessment; MMSE: Mini Mental State Examination.

of case of mild VCI/total number of cases * 100%.

Statistical analysis

SPSS 20.0 was used for statistical analysis. The count data were expressed as case/percent (n, %) and comparison of count data was conducted by χ^2 test. The measurement data conforming to the normal distribution was expressed by the mean ± standard deviation ($\bar{x}$ ± sd). Paired t test was used for intra-group comparison before and after intervention, and independent t test was used for inter-group comparison. P<0.05 is considered statistically significant.

Results

Comparison of general information

There was no difference in the general information between the two groups (all P>0.05, **Table 1**).

Comparisons of cognitive function and hand function

After intervention, scores of cognitive function and hand function in both groups were significantly increased, and those in the research group were significantly higher than those in the control group (all P<0.05, **Tables 2**, **3**).

Comparison of the incidence of mild VCI

The incidence of mild VCI in the research group was significantly lower than that in the control group (3.00% vs. 12.00%; χ^2=5.838, P=0.016). See **Figure 1**.

Comparisons of upper limb motor function, wrist flexor muscle tone, degree of neurological impairment and ADL

After intervention, FMA and ADL scores in both groups were significantly increased, and the

Table 3. Comparison of hand function ($\bar{x} \pm$ sd, score)

Group	Finger adduction/abduction	Finger flexion and extension	Digital opposition	Palmar opposition	Wrist-joint rotation	Wrist-joint flexion and extension
Research group (n=100)						
Before intervention	5.50±1.04	13.30±2.04	4.09±1.01	5.10±1.10	2.01±0.92	2.33±0.95
After intervention	7.03±1.25*,#	16.80±2.10*,#	6.40±1.38*,#	6.98±1.02*,#	3.98±1.01*,#	4.03±0.80*,#
Study group (n=100)						
Before intervention	5.20±1.19	12.95±3.29	4.25±1.24	5.03±1.05	1.97±0.95	2.18±0.96
After intervention	6.22±1.14*	14.50±2.88*	5.86±1.30*	6.06±1.29*	3.02±0.88*	3.04±0.89*

Note: Note: Compared with before intervention, *P<0.05; compared with control group after intervention, #P<0.05.

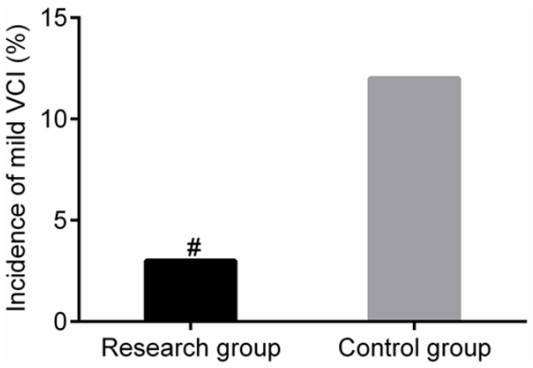

Figure 1. Comparison of the incidence of mild VCI. Compared with control group after intervention, #P<0.05. VCI: vascular cognitive impairment.

changes in the research group were more obvious than those in the control group (all P< 0.05). There were opposite trends in NIHSS and MAS for wrist flexor scores (all P<0.05). See **Tables 4**, **5**.

Discussion

Cerebral tissue ischemia in patients with CIS leads to neuronal necrosis and further neurological damage. In the development of the disease, most patients have multiple physiological dysfunctions, such as limb motor dysfunction, cognitive dysfunction, sensory dysfunction, etc. [16]. Among them, cognitive dysfunction after CS has been widely studied. However, since most of CS patients are middle-aged and elderly, and they are often combined with other basic diseases, drug therapy is inevitable. It brings a great impact on liver and kidney function and takes high cost and heavy economic burden to family. In contrast, finger exercise training is more practical for elderly CS patients.

Finger exercise training is an exercise form of hand motor. Plentiful researches have shown that finger exercise can activate the function of cerebral cortex in multiple brain regions, and delay the decline of cognitive function [17-19]. This study found that the MoCA and MMSE scores in the research group were higher than those in the control group after intervention, and the incidence of mild VCI in the research group was significantly lower than that in the control group (3.00% vs. 12.00%). Our study results confirmed that the combination of finger exercise training on the basis of early rehabilitation nursing had a more obvious improvement effect on the cognitive function of CIS patients. Sindi et al. also believed that finger exercise training was helpful to increase the brain excitability, thereby contributing to the recovery of cognitive dysfunction [20]. The increase of cerebral blood flow during finger activity is conducive to improving intelligence and sharpening mind. And regular finger exercise can improve brain circulation and form new exciting points in the brain, which is beneficial to the improvement of understanding, memory and thinking [21].

Hand function accounts for about 90% of upper limb function. It is innervated by complex nerves, and the distribution of hand nerves in the cerebral cortex is quite exquisite. If patients have hand dysfunction, almost all upper limb function will be lost [22]. However, the limitation of conventional rehabilitation therapy extremely blocks the improvement of hand function after stroke [23]. This study discovered that after intervention, the improvement of various hand functions, FMA score and MAS for wrist flexor score in the study group was better than those in the control group. It is suggested that for patients with CIS, on the basis of early rehabilitation nursing, combined finger exercise training can help to significantly improve various hand functions and also con-

Table 4. Comparisons of upper limb motor function and wrist flexor muscle tone ($\bar{x}$ ± sd, score)

Group	FMA score	MAS for wrist flexor score
Research group (n=100)		
Before intervention	44.40±4.30	2.88±0.70
After intervention	55.30±4.93*,#	1.43±0.49*,#
Study group (n=100)		
Before intervention	45.09±5.04	2.96±0.85
After intervention	51.40±5.69*	1.99±0.79*

Note: Compared with before intervention, *P<0.05; compared with control group after intervention, #P<0.05. FMA: Fugl-meyer Assessment; MAS: Modified Ashworth Scale.

Table 5. Comparisons of degree of neurological impairment and ADL ($\bar{x}$ ± sd, score)

Group	NIHSS score	ADL score
Research group (n=100)		
Before intervention	34.40±4.06	68.70±6.50
After intervention	26.49±5.30*,#	78.89±7.10*,#
Study group (n=100)		
Before intervention	33.96±4.94	67.98±5.69
After intervention	28.80±5.44*	72.20±6.60*

Note: Compared with before intervention, *P<0.05; compared with control group after intervention, #P<0.05. NIHSS: Neurologic Functional Defect; ADL: ability of daily living.

tribute to the recovery of upper limb function and wrist flexor muscle tone. Guidelines for CIS rehabilitation nursing intervention recommends repetitive task training as a routine training to improve the function of the upper limbs. Therefore, finger exercise through repeated movement of fingers and joints is designed, in order to improve the various motor functions of the patients' upper limbs [24]. Lezkan et al. reported that the repeated practice of palm massage, dorsum massage, finger grasp, fingers opening and closing, finger extension, finger clicking, palm and dorsum hitting improved the flexibility of the fingers and joints, thus helping the gradual recovery of the hand function [25].

In this study, compared with the control group, the NIHSS and ADL scores of the research group were significantly decreased and increased after intervention, respectively. It suggests that combined finger exercise training based on early rehabilitation nursing is helpful to improve the degree of neurological impairment in patients with CIS and improve their self-care ADL. Eschmann et al. also believes that finger exercise involves the massage and repeated movement of fingers, hand acupoints and joints; repeated massage and hand-eye coordination movement are helpful to stimulate the activation of one side of cerebral hemisphere to the other side of cerebral tissue in CS patients, thus helping to improve the defect of nerve function [26]. The recovery of various physiological functions also depends on the recovery of neurological functions. It can be a long process with many effect factors for CS patients; therefore, persistence is critical in the finger exercise training [27].

This study also has some limitations. No follow-up was conducted in this study, and the effect of finger exercise training on long-term physiological function of CS patients still needs further investigation.

Based on early rehabilitation nursing, combined finger exercise training can improve cognitive function, hand function, upper limb function and ADL for CIS patients, which is worth promoting in clinic.

Acknowledgements

This work was supported by The First Affiliated Hospital of Xi'an Jiaotong University Fund Project for *The effect of finger exercises on cognitive function intervention in patients with ischemic stroke* (2018HL-18) and the Key R&D Program Projects in Shaanxi Province for *The effect of cerebral blood flow autoregulation disorder on lymphatic system function and β-amyloid clearance and its mechanism* (2019SF-227).

Disclosure of conflict of interest

None.

Address correspondence to: Jin Wang, Department of Neurology, The First Affiliated Hospital of Xi'an Jiaotong University, No. 277 Yanta West Road, Xi'an 710061, Shaanxi Province, China. Tel: +86-029-85324033; E-mail: wangjin30wj@163.com

References

[1] Yamashita T and Abe K. Recent progress in therapeutic strategies for ischemic stroke. Cell Transplant 2016; 25: 893-898.

[2] Oberlin LE, Waiwood AM, Cumming TB, Marsland AL, Bernhardt J and Erickson KI. Effects of physical activity on poststroke cognitive function: a meta-analysis of randomized controlled trials. Stroke 2017; 48: 3093-3100.
[3] Delavaran H, Jönsson AC, Lövkvist H, Iwarsson S, Elmståhl S, Norrving B and Lindgren A. Cognitive function in stroke survivors: a 10-year follow-up study. Acta Neurol Scand 2017; 136: 187-194.
[4] Yeh TT, Wu CY, Hsieh YW, Chang KC, Lee LC, Hung JW, Lin KC, Teng CH and Liao YH. Synergistic effects of aerobic exercise and cognitive training on cognition, physiological markers, daily function, and quality of life in stroke survivors with cognitive decline: study protocol for a randomized controlled trial. Trials 2017; 18: 405.
[5] Lee SI, Liu X, Rajan S, Ramasarma N, Choe EK and Bonato P. A novel upper-limb function measure derived from finger-worn sensor data collected in a free-living setting. PLoS One 2019; 14: e0212484.
[6] Liu X, Rajan S, Ramasarma N, Bonato P and Lee SI. Finger-worn sensors for accurate functional assessment of the upper limbs in real-world settings. Annu Int Conf IEEE Eng Med Biol Soc 2018; 2018: 4440-4443.
[7] Chinese Medical Association Neurology Branch, Chinese Medical Association Neurology Branch Cerebrovascular Disease Group, Liu Ming and Pu Chuanqiang. Chinese Acute Ischemic Stroke Diagnosis and Treatment Guidelines 2014. Chin J Neurol 2015; 246.
[8] Carson N, Leach L and Murphy KJ. A re-examination of montreal cognitive assessment (moca) cutoff scores. Int J Geriatr Psychiatry 2018; 33: 379-388.
[9] Trivedi D. Cochrane review summary: mini-mental state examination (MMSE) for the detection of dementia in clinically unevaluated people aged 65 and over in community and primary care populations. Prim Health Care Res Dev 2017; 18: 527-528.
[10] Pessina MA, Bowley BGE, Rosene DL and Moore TL. A method for assessing recovery of fine motor function of the hand in a rhesus monkey model of cortical injury: an adaptation of the fugl-meyer scale and eshkol-wachman movement notation. Somatosens Mot Res 2019; 36: 69-77.
[11] Hiragami S, Inoue Y and Harada K. Minimal clinically important difference for the fugl-meyer assessment of the upper extremity in convalescent stroke patients with moderate to severe hemiparesis. J Phys Ther Sci 2019; 31: 917-921.
[12] Bohannon RW and Smith MB. Interrater reliability of a modified ashworth scale of muscle spasticity. Phys Ther 1987; 67: 206-207.
[13] Kwah LK and Diong J. National institutes of health stroke scale (NIHSS). J Physiother 2014; 60: 61.
[14] Harper KJ, Riley V, Jacques A, MacDonald K and Spendier N. Australian modified lawton's instrumental activities of daily living scale contributes to diagnosing older adults with cognitive impairment. Australas J Ageing 2019; 38: 199-205.
[15] Huang CY, Lin GH, Huang YJ, Song CY, Lee YC, How MJ, Chen YM, Hsueh IP, Chen MH and Hsieh CL. Improving the utility of the brunnstrom recovery stages in patients with stroke: validation and quantification. Medicine (Baltimore) 2016; 95: e4508.
[16] Eraifej J, Clark W, France B, Desando S and Moore D. Effectiveness of upper limb functional electrical stimulation after stroke for the improvement of activities of daily living and motor function: a systematic review and meta-analysis. Syst Rev 2017; 6: 40.
[17] Ngandu T, Lehtisalo J, Solomon A, Levälahti E, Ahtiluoto S, Antikainen R, Bäckman L, Hänninen T, Jula A, Laatikainen T, Lindström J, Mangialasche F, Paajanen T, Pajala S, Peltonen M, Rauramaa R, Stigsdotter-Neely A, Strandberg T, Tuomilehto J, Soininen H and Kivipelto M. A 2 year multidomain intervention of diet, exercise, cognitive training, and vascular risk monitoring versus control to prevent cognitive decline in at-risk elderly people (FINGER): a randomised controlled trial. Lancet 2015; 385: 2255-2263.
[18] Rosenberg A, Ngandu T, Rusanen M, Antikainen R, Bäckman L, Havulinna S, Hänninen T, Laatikainen T, Lehtisalo J, Levälahti E, Lindström J, Paajanen T, Peltonen M, Soininen H, Stigsdotter-Neely A, Strandberg T, Tuomilehto J, Solomon A and Kivipelto M. Multidomain lifestyle intervention benefits a large elderly population at risk for cognitive decline and dementia regardless of baseline characteristics: the FINGER trial. Alzheimers Dement 2018; 14: 263-270.
[19] Stephen R, Liu Y, Ngandu T, Antikainen R, Hulkkonen J, Koikkalainen J, Kemppainen N, Lötjönen J, Levälahti E, Parkkola R, Pippola P, Rinne J, Strandberg T, Tuomilehto J, Vanninen R, Kivipelto M, Soininen H and Solomon A. Brain volumes and cortical thickness on MRI in the finnish geriatric intervention study to prevent cognitive impairment and disability (FINGER). Alzheimers Res Ther 2019; 11: 53.
[20] Sindi S, Ngandu T, Hovatta I, Kåreholt I, Antikainen R, Hänninen T, Levälahti E, Laatikainen T, Lindström J, Paajanen T, Peltonen M, Khalsa DS, Wolozin B, Strandberg T, Tuomilehto J, Soininen H, Kivipelto M and Solomon A. Baseline telomere length and effects of a multidomain lifestyle intervention on cognition: the

FINGER randomized controlled trial. J Alzheimers Dis 2017; 59: 1459-1470.
[21] Bisio A, Avanzino L, Biggio M, Ruggeri P and Bove M. Motor training and the combination of action observation and peripheral nerve stimulation reciprocally interfere with the plastic changes induced in primary motor cortex excitability. Neuroscience 2017; 348: 33-40.
[22] Franck JA, Smeets R and Seelen HAM. Changes in arm-hand function and arm-hand skill performance in patients after stroke during and after rehabilitation. PLoS One 2017; 12: e0179453.
[23] Pessina MA, Bowley BGE, Rosene DL and Moore TL. A method for assessing recovery of fine motor function of the hand in a rhesus monkey model of cortical injury: an adaptation of the fugl-meyer scale and eshkol-wachman movement notation. Somatosens Mot Res 2019; 36: 69-77.
[24] Norman SL, McFarland DJ, Miner A, Cramer SC, Wolbrecht ET, Wolpaw JR and Reinkensmeyer DJ. Controlling pre-movement sensorimotor rhythm can improve finger extension after stroke. J Neural Eng 2018; 15: 056026.
[25] Lezkan A and Drewing K. Interdependences between finger movement direction and haptic perception of oriented textures. PLoS One 2018; 13: e0208988.
[26] Eschmann H, Héroux ME, Cheetham JH, Potts S and Diong J. Thumb and finger movement is reduced after stroke: an observational study. PLoS One 2019; 14: e0217969.
[27] Irwin ZT, Schroeder KE, Vu PP, Bullard AJ, Tat DM, Nu CS, Vaskov A, Nason SR, Thompson DE, Bentley JN, Patil PG and Chestek CA. Neural control of finger movement via intracortical brain-machine interface. J Neural Eng 2017; 14: 066004.