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Original Article

Effect of task-oriented training combined with vibration therapy on upper limb function in patients with hemiplegia after stroke

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Abstract: Objective: To study the effect of task-oriented training combined with vibration therapy on upper limb function in patients with hemiplegia after stroke. Methods: A total of 108 patients with hemiplegia after stroke were randomly assigned to control group (patients who received routine upper limb training, n=36), observation group 1 (patients who received routine upper limb training plus vibration therapy, n=36), and observation group 2 (patients who received routine upper limb training plus vibration therapy plus task-oriented training, n=36). Excluding the patients who withdrew from the study, there were 95 cases in total, including 30 cases in the control group, 32 cases in observation group 1 and 33 cases in observation group 2. The Fugl-Meyer Assessment Scale (FMA), Wolf Motor Function Test (WMFT), modified Ashworth Spasticity Rating Scale (MAS) score and maximal grip strength of all patients were evaluated and compared after treatment. Results: There was no difference in FMA score among the three groups before treatment (P>0.05). There was no difference in FMA, WMFT, MAS scores and maximal grip strength before and after treatment in the control group (all P>0.05), but there were statistical differences in FMA, MAS scores and maximal grip strength before and after treatment in observation groups 1 and 2 (all P<0.05). After treatment, the FMA score and maximal grip strength in observation group 1 were higher than those in control group while MAS score was lower than that in control group, with statistical difference (all P<0.05). FMA, WMFT scores and maximal grip strength in observation group 2 were higher than those in the control group and observation group 1, while MAS score was lower than that in the other groups, with statistical difference (all P<0.05). Conclusion: Task-oriented training combined with vibration therapy has a significant effect on the rehabilitation of upper limb dysfunction in patients with hemiplegia after stroke, which is worthy of clinical application.

Keywords: Task-oriented training, vibration therapy, hemiplegia after stroke, upper limb function

Introduction

Stroke has a high incidence, disability and mortality rate in China. Studies have found that the incidence of stroke is 1,114.8 per 100,000 people in China, of which 114.8 people die per year, and more than 70% of patients are over 60 years old [1]. Hemiplegia often occurs in stroke patients. Walking function of lower limbs can often be recovered through rehabilitation training, while the functional recovery of upper limbs is poor. A study found that about 30-60% of patients still cannot recover after 6 months of rehabilitation training [2]. The reason for this recovery rate may be related to the occurrence of symptoms such as pain and discomfort of upper limbs and contracture of joints due to abnormal upper limb patterns after stroke [3]. Moreover, negative psychology often occurs in the process, which is not conducive to the recovery of hand function [4]. Therefore, better rehabilitation has been actively explored in clinic. Task-oriented training, a rehabilitation method, refers to a guided rehabilitation training of patients' limb function by means of functional work, which can reconstruct brain function [5]. While vibration therapy is a training method to stimulate the body by mechanical vibration and external resistive load, which makes the muscles vibrate after stimulation and enables the nervous system to adapt to the vibration response so as to restore the nerve function of the muscles [6]. For stroke hemiplegic patients with upper limb dysfunction, there is less research on applying the two training methods together. Therefore, this study aimed to investigate the improvement of upper limb function of patients with hemiplegia after stroke by combining task-oriented training with vibration therapy.

Materials and methods

Clinical data

This study was approved by the ethics Committee of The First Affiliated Hospital of Sun Yat-sen University. A total of 108 stroke patients with hemiplegia admitted to the rehabilitation center of The First Affiliated Hospital of Sun Yat-sen University from October 2016 to October 2018 were included in this study. The digital random control method was applied in the study. A total of 36 patients who received routine upper limb training were randomly selected as the control group, 36 patients who received routine upper limb training plus vibration therapy as observation group 1, and 36 patients who received routine upper limb training plus vibration therapy plus task-oriented training as observation group 2. Excluding the patients who withdrew from the study, there were 95 cases in total, including 30 cases in the control group, 32 cases in observation group 1 and 33 cases in observation group 2. All the patients were aged 18-69 years, with an average age of 59.5±8.7 years, and signed consent forms.

Inclusion criteria

Patients diagnosed with stroke [7]; patients who suffered from primary stroke; patients supported by head CT or magnetic resonance imaging (MRI); patients with stable symptoms and clear consciousness after treatment; patients with stroke occurring unilaterally, with a duration of less than 18 months; patients aged under 70; patients with less than 3 points in the modified Ashworth Scale (MAS) score [8]; patients with no limb pain; patients' Brunnstrom stage 3 or above [5].

Exclusion criteria

Patients complicated with heart and lung dysfunction; patients with fracture trauma and bone hypoplasia; patients not cooperating to complete the training; patients who did not sign the informed consent.

Methods

Routine upper limb training: Patients were given upper limb training, one hour at a time, five times a week for four weeks, including upper limb muscle strength training and routine training of daily living ability.

Task-oriented training: To strengthen the common movement components of the patient's affected upper limbs, the patients lifted the affected upper limbs to reach the mouth with their hands. To induce the separation movement of the affected side, the patients pushed away the towel on the table with the stretch of elbow joint. The patients tried to eat steamed bread with the affected hands. The patients tried to eat long-shaped food such as cucumbers and bananas with the affected hands.

Vibration therapy: The trained therapist performed one-to-one treatment. The subjects sit on the Wellengang vibrator manufactured by SVG Company in Germany, with the vibration frequency range of 5-15 Hz and the amplitude range of 1-6 mm. The training intensity increased but not exceeding the load. The subjects were seated in an armless chair in front of the vibrating platform board (0.18 m in height, 0.72 m in width and 0.51 m in depth), with their shoulders flexed by 90 degrees and elbows slightly bent, and with their torso bent so that their palms could contact the circuit board in the middle of the platform board.

The control group received routine upper limb training. Vibration therapy plus routine upper limb training in observation group 1: Patients were given upper limb training for half an hour at a time, then followed by vibration therapy training for half an hour. The training was performed five times a week for four weeks.

Vibration therapy plus task-oriented training plus routine upper limb training in observation group 2: Patients were given upper limb training, half an hour at a time, and followed by 15 minutes of vibration therapy plus 15 minutes of task-oriented training. The training was performed five times a week for four weeks.

Table 1. Comparison of general data and baseline data among the three groups

Item	Control group	Observation group I	Observation group II	χ^2/F	P
Gender				0.010	0.995
Male	19	20	21		
Female	11	12	12		
Age	60.0±9.0	57.8±8.5	60.6±8.0	0.623	0.503
Course of disease	8.1±4.3	6.6±3.6	7.2±4.8	0.789	0.369
Affected limb position				4.101	0.129
Left	18	18	12		
Right	12	14	21		

Table 2. Comparison of FMA score among the three groups

Group	Before treatment	After treatment	t	P
Control group (n=30)	32.90±12.10	33.17±13.29	0.364	0.719
Observation group 1 (n=32)	34.22±14.07	43.38±9.09$^{\#\#\#}$	8.511	<0.001
Observation group 2 (n=33)	32.58±12.77	48.12±8.44$^{\#\#\#,\&}$	15.238	<0.001
F	0.144	16.775		0.144
P	0.866	<0.001		0.866

Note: FMA, Fugl-Meyer Assessment Scale. Compared with the control group after treatment, $^{\#\#\#}$P<0.001; compared with observation group 1 after treatment, $^{\&}$P<0.05.

Efficacy evaluation

The patients were evaluated before treatment and 4 weeks after treatment.

Main outcome measures: Fugl-Meyer Motor Function Assessment Scale (FMA): Assessment of the upper limbs: The main assessment contents include the coordination of flexors and extensors in large joints of the upper limbs, the stability of wrist joints, the coordination of small joints and the corresponding speed [9]. There are 33 projects, each with a maximal score of 2 points, a total score of 66 points. Wolf Motor Function Test (WMFT) is an evaluation of the hand functional status in performing task-based activities, which includes 15 items [10]. The evaluation of the completion quality of each item is divided into 6 grades from 0 to 5, with each grade scoring 0 to 5 points and a total score of 75 points.

Secondary outcome measures: MAS score: This score is a tool for evaluating muscle spasm [8]. It is divided into 6 grades: 0, 1, 1^+, 2, 3 and 4. The higher the grade, the more sever the spasm. This study quantifies it into 6 grades with scores of 0, 1, 1.5, 2, 3 and 4, respectively. Test of maximal grip strength of the affected hand: Selecting a grip dynamometer from the same manufacturer, all patients were allowed to sit in chairs at a rest state for the measurement. Each measurement required the grip strength of the affected hand to last for 3 seconds in order to measure its maximal value [11].

Statistical methods

The SPSS 22.0 statistical software was used to statistically analyze the collected data. The continuous variables were expressed as the mean ± standard deviation ($\bar{x}$ ± sd). Data accorded with normal distribution and homogeneity of variance in group was compared by independent sample t-test or paired t-test, otherwise, by rank sum test. One-way analysis of variance (ANOVA) was used for multiple-group comparison, and differences detected were further analyzed by least significant difference (LSD) method. The difference was statistically significant with P<0.05.

Results

Comparison of general data and baseline data among the three groups

There was no significant difference among the three groups in gender, age, course of disease and affected limb position, which could be compared (all P>0.05). See **Table 1**.

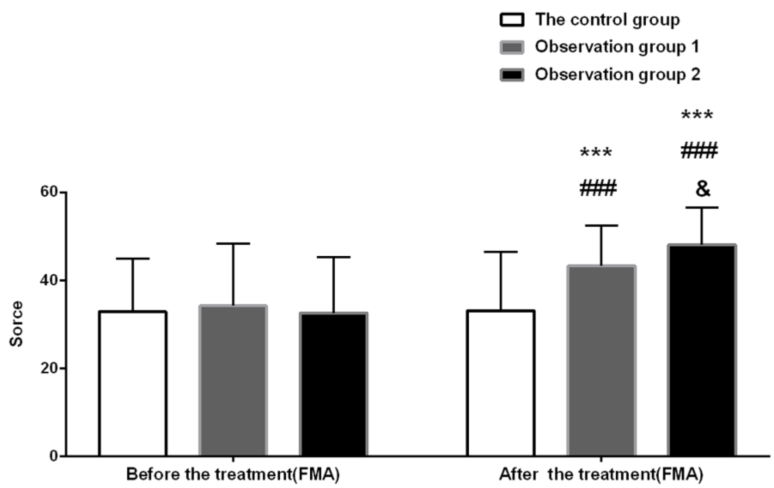

Figure 1. Comparison of FMA score among the three groups. FMA, Fugl-Meyer Assessment Scale. Compared with the same group before treatment, ***P<0.001; compared with the control group after treatment, ###P<0.001; compared with observation group 1 after treatment, &P<0.05.

Comparison of FMA score among the three groups

There was no difference in FMA score among the three groups before treatment (P>0.05). There was no difference in FMA score before and after treatment in the control group (P>0.05), but there were statistical differences before and after treatment in observation groups 1 and 2 (P<0.001). After treatment, the FMA score in observation groups 1 and 2 was higher than that in the control group, with statistical differences, and observation group 2 was higher than observation group 1, with statistical differences (P<0.05). See **Table 2** and **Figure 1**.

Comparison of WMFT score among the three groups

There was no difference in WMFT score among the three groups before treatment (P>0.05). There was no difference in WMFT score before and after treatment in the control group (P>0.05), but there were statistical differences before and after treatment in observation groups 1 and 2 (P<0.05). After treatment, there was no statistical difference in WMFT score between the control group and observation group 1 (P>0.05), while observation group 2 was higher than the control group and observation group 1, with statistical differences (P<0.05). See **Table 3** and **Figure 2**.

Comparison of the maximal grip strength among the three groups

There was no difference among the three groups in the maximal grip strength before treatment (P>0.05). There was no difference in the maximal grip strength before and after treatment in the control group (P>0.05), but there were statistical differences before and after treatment in observation groups 1 and 2 (P<0.001). After treatment, the maximal grip strength in observation groups 1 and 2 was higher than that in the control group, with statistical difference (P<0.05), and observation group 2 was higher than observation group 1, with statistical difference (P<0.05). See **Table 4** and **Figure 3**.

Comparison of MAS score among the three groups

There was no difference in MAS score among the three groups before treatment (P>0.05). There was no difference in MAS score before and after treatment in the control group (P>0.05), but there were statistical differences before and after treatment in observation groups 1 and 2 (P<0.001). After treatment, the MAS score in observation groups 1 and 2 was lower than that in the control group, with statistical differences, and observation group 2 were lower than observation group 1, with statistical differences (P<0.05). See **Table 5** and **Figure 4**.

Discussion

Stroke patients are injured in the cerebral functional area, so the training is performed mainly for the rehabilitation of this area [12, 13]. Task-oriented training is mainly to set goals for patients to take part in corresponding meaningful and practical functional activities. Different from the traditional exercise training, it is designed according to the exercise control and exercise learning theories and the patient's functional loss. With the different func-

Table 3. Comparison of WMFT score among the three groups

Group	Before treatment	After treatment	t	P
Control group (n=30)	40.10±12.13	39.57±13.23	0.734	0.469
Observation group 1 (n=32)	41.16±14.11	43.47±9.49	2.367	0.024
Observation group 2 (n=33)	39.21±12.64	52.06±8.43$^{###,&&&}$	12.884	<0.001
F	0.182	11.779		
P	0.834	<0.001		

Note: WMFT, Wolf Motor Function Test. Compared with the control group after treatment, $^{###}$P<0.001; compared with observation group 1 after treatment, $^{&&&}$P<0.001.

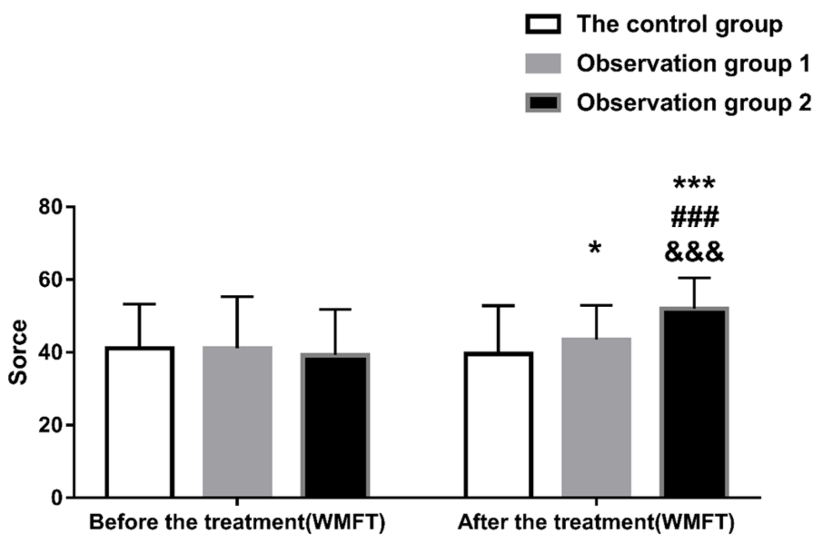

Figure 2. Comparison of WMFT score among the three groups. WMFT, Wolf Motor Function Test. Compared with the same group before treatment, *P<0.05, ***P<0.001; compared with the control group after treatment, $^{###}$P<0.001; compared with observation group 1 after treatment, $^{&&&}$P<0.001.

Table 4. Comparison of the maximal grip strength among the three groups

Group	Before treatment	After treatment	t	P
Control group (n=30)	15.05±9.06	16.03±8.55	1.332	0.193
Observation group 1 (n=32)	16.41±11.86	22.44±10.90$^{#}$	13.535	<0.001
Observation group 2 (n=33)	17.00±11.93	28.24±9.03$^{###,&}$	13.968	<0.001
F	0.145	12.799		
P	0.865	<0.001		

Note: Compared with the control group after treatment, $^{#}$P<0.05, $^{###}$P<0.001; compared with observation group 1 after treatment, $^{&}$P<0.05.

tional loss of the patients, the corresponding target and exercise activities were designed, and the patients were guided accordingly to achieve the goal of improving motor function [14]. This training mode is based on the activities in daily life, allowing patients to participate actively and independently, and combining with the life and training, which is beneficial to the recovery of patients' functions [15]. Some studies have found that the use of assisted task-oriented training can improve the blood circulation in hands of stroke patients, and can also relieve spasm symptoms and relieve hand stiffness [16]. Two other studies have analyzed the feasibility and effectiveness of task-oriented training for stroke patients, and found that it can significantly improve the hand function of the patients [17, 18]. Compared with passive training, research has shown that active training for patients is more conducive to recruiting the cerebral motor cortex, strengthening the interaction between different functional regions, thus improving the recovery and remodeling of hand functions [19].

Vibratory therapy stimulates nerves and muscles after the vibration of muscles, thus obtaining specific response curative effects. It was initially applied in sports with the functions of relieving muscle pain, improving muscle strength and increasing coordination of movement, etc., and then in the rehabilitation field. A study found that the grip strength, spasticity,

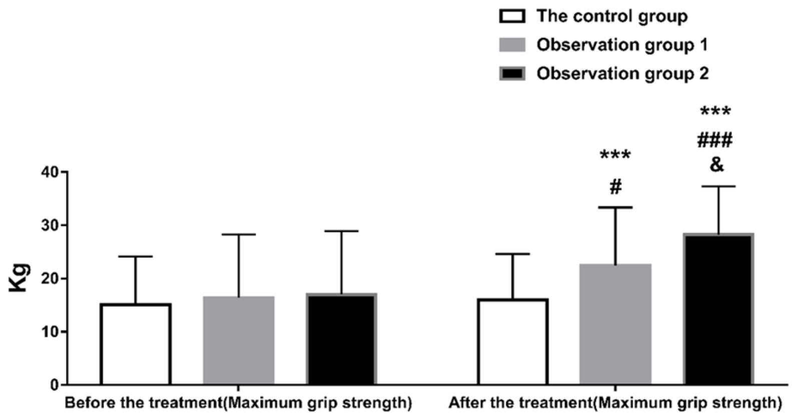

Figure 3. Comparison of the maximal grip strength among the three groups. Compared with the same group before treatment, ***P<0.001; compared with the control group after treatment, #P<0.05, ###P<0.001; compared with observation group 1 after treatment, &P<0.05.

Table 5. Comparison of MAS score among the three groups

Group	Before treatment	After treatment	t	P
Control group (n=30)	2.03±0.73	1.87±0.67	1.863	0.077
Observation group 1 (n=32)	2.09±0.74	1.41±0.87#	6.723	<0.001
Observation group 2 (n=33)	2.06±0.72	0.85±0.71###,&&	12.477	<0.001
χ^2	0.053	14.257		
P	0.948	<0.001		

Note: MAS, modified Ashworth Spasticity Rating Scale. Compared with the control group after treatment, #P<0.05, ###P<0.001; compared with observation group 1 after treatment, &&P<0.01.

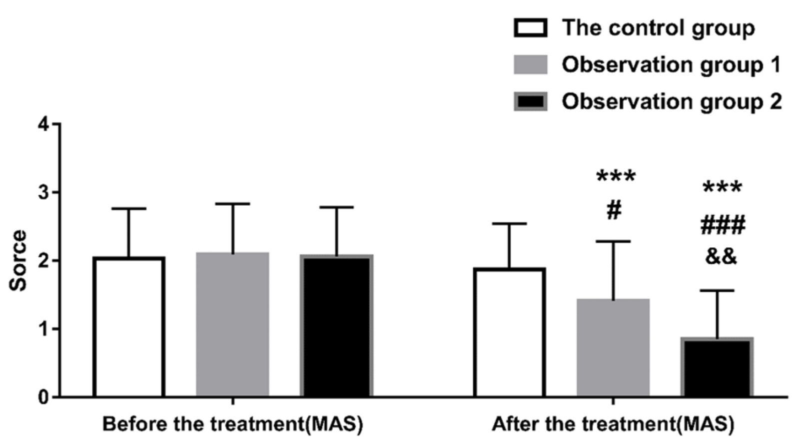

Figure 4. Comparison of MAS score among the three groups. MAS, modified Ashworth Spasticity Rating Scale. Compared with the same group before treatment, ***P<0.001; compared with the control group after treatment, #P<0.05, ###P<0.001; compared with observation group 1 after treatment, &&P<0.01.

pain and quality of life were improved after treatment in upper limb muscles with local vibration therapy [20]. Another study on the effect of vibration therapy on the function of children with cerebral palsy found that the muscle strength of patients was increased and the motor function was improved [21]. This study combined the two methods and found that either vibration therapy alone or task-oriented training combined with vibration therapy could improve the patient's upper limb function, maximal grip strength and spasticity, which may be related to the combined effect of various factors. The improvement of spasticity is due to the use of low amplitude vibration stimulating the generation of Ia inputs at the nerve ends of the muscle spindles, which improves the excitability of the cortex, and the increase in excitability can stimulate the muscles and motor neurons, thus inducing contraction of the muscles [22-24]. Meanwhile, under the stimulation of vibration, the central nervous system can issue instructions to activate the motor units in the muscles, then participate in the contraction of the muscles, which is also the main factor for the increase in the maximal grip strength in this study. The increase in the maximal grip strength has a positive effect on the activity of daily life [25]. This study found that after combining vibration therapy with task-oriented training, the patients' upper limb function, maximal grip strength and spasticity improved significantly, better than those in the control group and observation group I with vibration therapy alone. It may be that task-oriented training is a targeted training, not only a single muscle but multiple muscles of the whole body are involved together in the process of completing the set target. With the cooperation of vibration therapy, more exercise units can participate in and coordinate with each muscle group, and improve the patients' control of movement [26, 27].

Limitations of this research: Due to the small number of observation cases and the short observation time, this research will further expand the sample size and extend the observation time for further study.

To sum up, task-oriented training combined with vibration therapy has a significant effect on the rehabilitation of upper limb dysfunction in patients with hemiplegia after stroke, which is worthy of clinical application.

Disclosure of conflict of interest

None.

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