Basic Medicine

Effect of repetitive training on ameliorating spasm of upper limbs in hemiplegic patients

Lin Zhu, Lin Liu, Weiqun Song

Abstract

BACKGROUND: The main aim of rehabilitation is to ameliorate motor function and use the damaged limbs in the activities of daily living. Several factors are needed in the self-recovery of the patients, and the most important one is to reduce spasm. Some mechanical repetitive movements can affect and change the excitability of motor neurons.

OBJECTIVE: To observe the effect of repetitive training on ameliorating spasm of upper limbs of hemiplegic patients.

DESIGN: A self-controlled observation before and after training.

SETTING: Department of Rehabilitation, Xuanwu Hospital of Capital Medical University.

PARTICIPANTS: Seven hemiplegic patients induced by brain injury were selected from the Department of Rehabilitation, Xuanwu Hospital, Capital Medical University from March to June in 2005. Inclusive criteria: ① Agreed and able to participate in the 30-minute training of hand function; ② Without disturbance of understanding. The patients with aphasia or apraxia, manifestation of shoulder pain, and severe neurological or mental defects. For the 7 patients, the Rivermead motor assessment (RMA) scores ranged 0–10 points, the Rivermead mobility index (RMI) ranged 1–3, and modified Ashworth scale (MAS) was grade 2-4. Their horizontal extension of shoulder joint was 0°–30°, anteflextion was 0°–50°, internal rotation was 50°–90°, external rotation was 0°–10°; and the elbow joint could extend for 15°–135°.

METHODS: The viva 2 serial MOTOmed exerciser (Reck Company, Germany) was used. There were three phases of A-B-A. ① The phase A lasted for 1 week. The patient sat on a chair facting to the MOTOmed screen, and did the circumduction of upper limbs forwardly, 30 minutes a day and 5 days a week. ② The phase B lasted for 3 weeks. The training consisted of forward circumduction of upper limbs for 15 minutes, followed by backward ones for 15 minutes and 5-minute rest. ③ The training in the phase A was performed again for 2 weeks. The extensions of upper limbs were recorded at phase A, the extension and flexion of elbow joints were recorded at phase B, and the extensions were recorded at the second A phase. All the patients were evaluated by the same therapeutist. ① RMA was used to evaluate the motor function completely, including the motor control of both upper and lower limbs, but only the data of upper limbs were recommended to be used. The flexibility and concordance of upper limbs were described by detecting the ability of hand to move objects with 15 items, 2 grades for each item: 0 for could not complete and 1 for could complete. ② RMI was used to measure the flexion and extension of elbow joint and shoulder joint, the scores ranged from 0 (no movement and no obvious muscle contraction) to 5 (close to normal movement). ③ MAS was used to evaluate the muscle tension in clinic. Grade 1 for without abnormal increase of muscle tension, and grade 5 for muscle rigidity, and it was unable for passive movement. ④ Ranges of motion of elbow joint and should joint were measured using protractor.

MAIN OUTCOME MEASURES: ① The strength of each limb to persist for 40 s recorded by two hand pedals; ② Changes of muscle tensions detected by the two hand pedals; ③ Changes of muscle contraction at the flexion and extension of ipsilateral limb recorded by EMG; ④ Minimal moment of iplateral end foot; ⑤ RMA; ⑥ RMI; ⑦ MAS; ⑧ Ranges of motion of elbow joints and shoulder joints.

RESULTS: The functions were evaluated at 6 weeks after training. ① The strength of each limb to persist for 40 s was recorded, and the strength of the ipsilateral limb changed obviously from 20%–40% to 50%–70%. ② The muscle tensions detected by the two hand pedals changed from 2.2–4.0 N·m to 0.2–1.0 N·m. ③ EMG displayed that along with the enhancement of fast movements, the strength curve increased (the EMG for the extension of elbow joints were obvious), which were shown in Figure 1. ④ The minimal moment of iplateral end foot was 5.0 N·m. ⑤ The RMA scores ranged 15-30 points. ⑥ The RMI ranged 4–5. ⑦ MAS were grades 0–2. ⑧ For shoulder joints, the ranges of motion were 90°-180° for external extension, 90° for anteflexion, 90° for internal rotation and 50°–75° for external rotation; For elbow joints, the extension of active movements was close to 0°.

CONCLUSION: After repetitive movements, the strength of upper limb increased, the range of motion enlarged, and spasm reduced.

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INTRODUTION

Objective physiotherapy is usually needed to ameliorate the function for the recovery of post-stroke patients. The aim of physiotherapy is to provide the patients a chance to obtain technical functional activity and improve strength finally. The aim will be realized only when the patients recognize the contralateral and ipsilateral limbs in practice.

At early stroke, the damaged system learns how to do the simply actions in the repetitive training every day. The patients will grasp the key points from the learned actions in repetitive training, which is very important for coordination and improving effect. The basis of traditional physiotherapy is neurophysiology, but its basic theory is still in lack. The differences of functional results induced by some training procedures are not sensible [1-3]. Some recent reports about the repetitive training based on learning movement manifest the accelerated recovery of hand function after stroke[4]. However, the repetitive training of complex movements does not further enhance the functional recovery of the affected arm and hand in stroke patients compared with functionally based occupational and physiotherapy[5]. So far, only Butefisch *et al* [4] have reported the effectiveness of repetitive training on upper limbs.

The main aim of rehabilitation is to ameliorate motor function and use the damaged limbs in the activities of daily living. Several factors are needed in the self-recovery of the patients, and the most important one is to reduce spasm. Some mechanical repetitive movements can affect and change the excitability of motor neurons[6]. This study mainly observed the effect of repetitive training on reducing spasm and ameliorating motor function.

SUBJECTS AND METHODS

Subjects

Seven hemiplegic patients due to brain injury were selected from the Department of Rehabilitation, Xuanwu Hospital, Capital Medical University from March to June in 2005. Inclusive criteria: ① Agreed and able to participate in the 30-minute training of hand function; ②Without disturbance of understanding. The patients with aphasia or apraxia, manifestation of shoulder pain, and severe neurological or mental defects. There were 6 males and 1 female, aged 26-60 years, including 5 cases of cerebral infarction and 2 cases of cerebral hemorrhage, and the time of damage was within 6 months in 3 cases and above 12 months in 4 cases. The tensions of flexion and extension of upper limbs were all increased in the 7 cases, mainly manifested by the increase of tension of flexor muscle. Their Rivermead motor assessment (RMA) scores ranged 0–10 points, the Rivermead mobility index (RMI) ranged 1–3, and modified Ashworth scale (MAS) was grade 2–4. For the 7 patients, the horizontal extension of shoulder joint was 0°–30°, anteflextion was 0°–50°, internal rotation was 50°–90°, external rotation was 0°–10°; and the elbow joint could extend for 15°–135°.

Apparatus: The viva 2 serial MOTOmed exerciser (Reck Company, Germany) was used. The best training effect could be obtained by setting the MOTOmed training conditions. Besides, the screen could display some quantified indexes during the training, and t he two pedals could detect the torques of bilateral limbers. When the muscle tension increased, the current movement would be interrupted and move against the direction of spasm, and then restrained the occurrence of spasm.

Methods

Experimental establishment

There were three phases of A-B-A. ① The phase A lasted for 1 week. The patient sat on a chair facting to the MOTOmed screen, and did the circumduction of upper limbs forwardly, 30 minutes a day and 5 days a week. ② The phase B lasted for 3 weeks. The training consisted of forward circumduction of upper limbs for 15 minutes, followed by backward ones for 15 minutes and 5-minute rest. ③ The training in the phase A was performed again for 2 weeks. Each patient was detected during the training at four sections: ① At the beginning of phase A; ② At the beginning of phase B; ③ At the end of phase B; ④ At the end of the second phase A.

Records of indexes

All the patients exercised towards the same direction. The extensions of upper limbs were recorded at phase A, the extension and flexion of elbow joints were recorded at phase B, and the extensions were recorded at the second A phase. ① The two hand pedals could record the exertions of each limb to persist for 40 s, and the ipsilateral limb maintained generally at 20%–40%; ② The two hand pedals were used to detect the changes of muscle tension, and the displayed signals ranged 2.2–4.0 N·m; ③ Electromyogram (EMG) was used to record the changes of muscle contraction of ipsilateral flexion and extension. Because the muscle tensions increased both at flexion and extension, the muscle maintained the state of contraction continuously, and the EMG generally displayed as paralleled line; ④ The minimal moment of iplateral end foot: The ipsilateral moment signal was obviously lower than the contralateral one. The patient could not relax during the training of extension, and the upper limbs flexed and spasm. When the strength of flexion was greater than that of extension, the moment of the spastic side was easy to be neglected.

Clinical evaluation

All the patients were evaluated by the same therapeutist. ① RMA[7,8] was used to evaluate the motor function completely, including the motor control of both upper and lower limbs, but only the data of upper limbs were recommended to be used. The flexibility and concordance of upper limbs were described by detecting the ability of hand to move objects with 15 items, 2 grades for each item: 0 for could not complete and 1 for could complete. ② RMI[7,9] was used to measure the flexion and extension of elbow joint and shoulder joint, the scores ranged from 0 (no movement and no obvious muscle contraction) to 5 (close to normal movement). ③ MAS was used to evaluate the muscle tension in clinic. Grade 1 for without abnormal increase of muscle tension; grade 2 for mild increase of muscle tension, and there was certain resistance when joint flexion and extension; grade 3 for obvious increase of muscle tension, and there was obvious resistance when muscle stretched, but joint was easy to be extended or flexed passively; grade 4 for significant increase of muscle tension, and it was difficult for passive movement; grade 5 for muscle rigidity, and it was unable for passive movement. ④ Ranges of motion of elbow joint and should joint were measured using protractor.

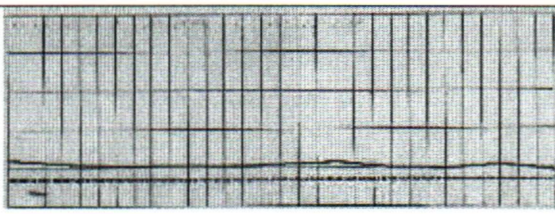
Statistical analysis

The data were processed by the first author using SPSS 10.0 software; The Fisher exact test of Chi-square test was used when the samples were fewer than 40.

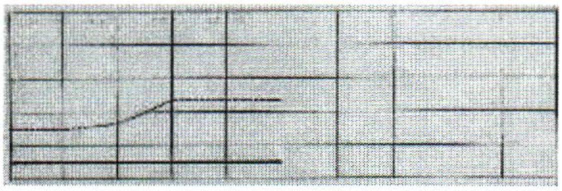
RESULTS

Results of recorded values

① The strength of each limb to persist for 40 s was recorded, and the strength of the ipsilateral limb changed obviously from 20%–40% to 50%–70%. ② The muscle tensions detected by the two hand pedals changed from 2.2–4.0 N·m to 0.2–1.0 N·m. ③ EMG displayed that along with the enhancement of fast movements, the strength curve increased (the EMG for the extension of elbow joints were obvious), which were shown in Figure 1. ④ The minimal moment of iplateral end foot was 5.0 N·m.



a: Before training, the continuous line was the EMG of brachial triceps muscle in single training, and the dashed line was the EMG of biceps brachii muscle in single training. Both were in a straight line when they kept the state of contraction.



b: After training for 6 weeks, the EMG changes were mainly manifested by the extension of elbow joints, the dashed line was the EMG of ipsilateral brachial triceps muscle in single training, and it showed increases at fast contraction; The continuous line was the EMG of biceps brachii muscle in single training, and the EMG had no obvious changes because the patient was asked to extend forwardly with relaxed flexion.

Figure 1 Changes of electromyogram (EMG) before and after training

Results of evaluations

The functions were evaluated at 6 weeks after training. The RMA scores ranged 15–30 points. The RMI ranged 4–5. MAS were grades 0–2. For shoulder joints, the ranges of motion were 90°–180° for external extension, 90° for anteflexion, 90° for internal rotation and 50°–75° for external rotation; For elbow joints, the extension of active movements was close to 0°.

MRI results before and after training (Figure 2)

a: Before training

b: After training for 10 weeks, the spasm was relieved; When the right hand did the active movements of flexion and extension continuously for 1 minute, the fMRI displayed high signals in left primary motor cortex (M1) and supplementary motor area, as well as right M1.

Figure 2 FMRI of a 25-year-old female patients with infarction in basal ganglia

DISCUSSION

Spasm refers to the increase of muscular spasm against gravity within 2 or 3 months of training. Some mechanical repetitive exercises are effective against spasm, and the excitability of motor neurons can be affected and changed by the exercise like circle movements of legs[10], and these results are confirmed by MAS in clinic[11].

Some indexes of spasm can be detected, whereas there are arguments for the assessment of spasm[12]. For example, velocity dependence is the reflect of passive movement, but the results of evaluation are not clear, thus the results of supine position and sitting position are different [13]. The present conditions can mainly evaluate whether rehabilitation reduces spasm, thus this study mainly observed whether training could ameliorate some parameters of spasm.

The authors summarized some indexes, including MAS, range of motion in active movements, surface EMG of upper limbs' movements towards the opposite side due to spasm in repetitive training, and all these indexes were associated with spasm. This study used these indexes to detect the effect on reducing spasm and ameliorating motor function in the repetitive flexion and extension of elbow joints.

Repetitive training is suitable for the ipsilateral limb of the patients, and the main mechanisms are that the repetitive training lies in the axonal plasticity and the axonal plasticity plays an important role in nervous pathway. There were displays of motor control and motor recovery in descending pathway, secondary pathway, contralateral motor area and other brain functional areas[4,14].

The most training devices, which are designed aiming at repetitive training, can clearly display the physiological signals on the screen during training, and the therapeutists can adjust the therapeutic program by judging these signals, and encourage the patients to make efforts towards the correct objects. For example, MOTOmed can make the contralateral limb assist the ipsilateral one to move through the pedals. Because it can quantify the moment at the movements of left and right limbs, which makes the patients directly realize the difference between the left and right sides, and the patients can emphasize which side should be developed by their awareness.

The spasm of different muscles can be quantified with EMG by sticking electrode to the muscle of the ipşilateral limb to be observed. The EMG of a certain muscle of the ipsilateral limb, which was displayed on the screen at the active movement, was compared before and after training. The EMG activity and spastic index should be observed finally to detect whether muscular strength was increased or not. At the continuous contraction, strength and EMG were generally close to a straight line. When the muscles contracted quickly, both the EMG and strength curves increased, but not became a straight line. Whether EMG can really reflect the actual strength of muscle depends on the type of electrode, distance between two electrodes and the position of muscle.

It has been investigated that simple repetitive movements are suitable for the functional recovery [4,8]. The patients can continue the self-training for reinforcement after trained by the therapeutist. Repetitive circle movement is one of the easiest training. The rehabilitation of repetitive movements (supplementary movement by robot) is a new field, and other repetitive trainings (gait training, *etc.*) have begun, and more complex designs are needed to be used in training.

In conclusion, our results confirmed that after repetitive movements, the strength of upper limb increased, the range of motion enlarged, and spasm reduced. It could be observed by several indexes for the improvement of ipsilateral limbs after stroke that repetitive movements have good effects in rehabilitation and motor learning. EMG recorded values are the very significant tool to evaluate the muscular state in circle movement, especially for spasm and strength.

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