Effects of Repetitive Facilitative Exercise on Spasticity in the Upper Paretic Limb After Subacute Stroke

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Background: Repetitive facilitative exercise is an effective method for recovery of the affected limb in stroke patients. However, its effects on spasticity are unknown. We aimed to determine the effects of repetitive facilitative exercise on spasticity using the Modified Ashworth Scale (MAS) and the F-wave, and to determine the relationship between the changes in spasticity and functional recovery of the hemiplegic upper limb. *Methods:* Subacute stroke patients underwent repetitive facilitative exercise (n = 11) or conventional rehabilitation (n = 8) for 4 weeks. We investigated spasticity and functional recovery in a hemiplegic upper limb retrospectively. The MAS, F-wave, Fugl-Meyer Assessment (FMA), and the Action Research Arm Test (ARAT) were assessed immediately before and after the 4-week session. *Results:* Repetitive facilitative exercise did not change the MAS and decreased F persistence and the F amplitude ratio, and improved both the FMA and the ARAT for the affected upper limb. The reduction of F-wave parameters was not correlated with the improvements in the FMA and ARAT in the repetitive facilitative exercise group. Conventional rehabilitation had no effect on the MAS, F-wave parameters, FMA, or the ARAT. *Conclusions:* Repetitive facilitative exercise decreases spinal motoneuron excitability and promotes functional recovery. However, there was no correlation between the change in spinal motoneuron excitability and the improvement of upper-limb function. The present results suggest that repetitive facilitative exercise is useful for treating spasticity in the subacute phase of stroke.

Key Words: Repetitive facilitative exercise—spasticity—F-wave—stroke

Introduction

Stroke is a major cause of disability and leaves about two thirds of its survivors with long-term impairments. Most patients with stroke who survive the initial injury experience limited activity and reduced participation.[1] Various physiotherapies have been developed to improve the function of a hemiplegic upper limb in patients due to stroke.

Repetitive facilitation exercise (RFE) is a form of physiotherapy that has been shown to reduce the impairment after stroke.[2,3] In RFE, the therapist provides physical stimulation, such as by eliciting the stretch reflex or skin-muscle reflex, immediately before the patient tries to move their hemiplegic hand or finger, to increase the level of excitation of the corresponding injured descending motor tracts; this increased excitation allows the patient to initiate movements of the hemiplegic hand or finger in response to their intention.[2] The results of a randomized controlled trial (RCT) study showed that RFE significantly improved motor function of the affected upper limb.[3]

In addition to motor deficits, muscle spasticity in the affected upper limb is another feature of stroke. Spasticity influences body functions and limits activity in stroke patients. For example, patients who were nonspastic had statistically and significantly better motor and activity scores than spastic patients.[4] In addition, spasticity in the affected limbs often inhibits the efficacy of physiotherapy

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for the treatment of stroke.[5,6] Therefore, it is important to control spasticity to improve movements of the upper limb. Although RFE has been shown to be effective for improving recovery of the affected limb in stroke patients, its effects on spasticity are unclear.

Constraint-induced movement therapy (CIMT) is also effective for promoting motor recovery of a hemiplegic upper limb.[7] Several reports have described the effects of CIMT on spasticity and motoneuron excitability in the affected upper extremity.[8-10] These studies used the Modified Ashworth Scale (MAS) or F-wave parameters. The F-wave is a motor response produced by the backfiring of alpha motoneurons after the antidromic stimulation of motor nerve fibers. The amplitude and persistence of the F-wave have been used as indicators of spasticity in previous studies.[11,12] It has been reported that the F-wave can be used to reliably detect the inhibition of alpha motoneuron excitability.[13] F-wave activity is modified by cortical activity and influenced by the excitability of the motor neuron pool.[14,15] CIMT produced a significant decrease in both the MAS score and F-wave parameters in the affected upper limb in chronic stroke patients.[10]

It is unclear whether RFE decreases spasticity as well as promoting functional recovery of an affected upper limb in subacute stroke patients. We aimed to determine the effects of RFE on spasticity using MAS and the F-wave and to determine the relationship between the changes in spasticity and the improvement of motor function in hemiplegic upper limbs.

Methods

Patients

Participants were extracted from among the subjects of a previous RCT study on RFE.[3] Eleven of the 27 patients in the RFE group and 8 of the 25 patients in the conventional rehabilitation group were subjected to measurements of MAS and F-waves (evaluation of spasticity) in addition to the Fugl-Meyer Assessment (FMA) and Action Research Arm Test (ARAT) (evaluation of motor deficits). Therefore, in the present study, a total of 19 patients were extracted from the previous RCT study. The mean age was 60.9 years (standard deviation = 14.4) and the mean duration after stroke onset was 50.8 days (standard deviation = 21.0).

Inclusion criteria for the previous RCT study were as follows[3]: (1) a new, single, computed tomography-confirmed stroke within the previous 3-13 weeks; (2) Brunnstrom proximal upper-limb stage ≥III[16]; and (3) the ability to follow simple directions. Subjects were excluded due to (1) arm contractures/pain; (2) preexisting upper-extremity impairment; (3) cerebellar lesion; (4) unstable medical status; (5) perceptual, apraxic, or cognitive deficits that would prevent adequate participation in the study; or (6) inability to provide informed consent. The study was approved by the ethics committee at Kagoshima University Hospital (27-183). Written informed consent was obtained from each patient before inclusion.

Measurement

Patients underwent RFE (n = 11) or conventional rehabilitation (n = 8) for 4 weeks. We measured MAS scores and F-waves in addition to FMA and ARAT in a hemiplegic upper limb immediately before and after the 4-week session. The MAS score was used to evaluate spasticity in the elbow and wrist of the affected upper limb.[17] To facilitate data analysis, MAS scores (0, 1, 1+, 2, 3, and 4) were assigned numerical values (0, 1, 2, 3, 4, and 5, respectively). F-waves were recorded in a supine or sitting position. A Nihon-Kohden Neuropack was used with a band-pass filter of 20 Hz-5 kHz, with the sensitivity set to 5 mV and 500 μV/division, respectively. Compound muscle action potentials (CMAPs) and F-waves were recorded from the abductor pollicis brevis on both sides. The median nerve was stimulated at the wrist at 1 Hz. Stimuli were .2 ms in duration and 20% higher than the intensity that elicited the largest CMAPs. Ninety-six F-waves were recorded. The F-wave persistence on both sides, the F/M ratio (trial average of the F-wave amplitude [which averages trials with no response]/CMAP amplitude) of the affected side and the F-wave amplitude ratio (trial average of the F-wave amplitude on the affected side/that on the unaffected side) were used for evaluation. FMA was used to evaluate motor function.[18] The motor score for the upper extremity includes 33 items and ranges from 0 to 66. The ARAT was used to assess the ability of the subject to manipulate objects. The ARAT is a validated and reliable measure of upper-extremity function with 4 subsections (grip, grasp, pinch, and gross movement) and ranges from 0 to 57.[19]

Intervention

The 11 patients underwent RFE in 40-minute sessions on a 4-week, 5 sessions/week schedule. RFE involves the use of rapid passive stretching of the muscles in conjunction with tapping and rubbing of the skin to assist in inducing contraction of the targeted muscles. Participants were directed to concentrate on generating movement of the joint being treated while avoiding the contraction of nontargeted muscles. Therapists helped the subjects to achieve a full range of motion. The target movements (shoulder flexion, elbow extension, wrist extension, and finger extension) can be repeated many times during a relatively short time period.

The remaining 8 patients in the subacute group received conventional rehabilitation for the hemiplegic upper limb in 40-minute sessions on a 4-week, 5 sessions/-week schedule. Sessions consisted of (1) ROM exercises; (2) passive, assistive, active, and progressive resistive exercise; (3) the use of skateboards or weighted sanders; and (4) pinching or grasping blocks of various sizes.