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Focal Muscle Vibration and Progressive Modular Rebalancing with neurokinetic facilitations in post- stroke recovery of upper limb

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Abstract

*Background.*Stroke is one of the leading causes for disability worldwide. Exercise therapy is a key element of stroke rehabilitation but no evidence are present in literature. Moreover recently focal muscle vibrationis described as a useful therapeutic approach in the post stroke recovery. In this study the efficacy of the vibration therapy in association to progressive modular re balancing rehabilitative approach has been evaluated and compared to the conventional therapy alone and associated to the muscle vibration.

*Methods.*A pilot randomized controlled trial, using a pragmatic triple-blind, parallel-group study design in chronic stroke patients upper limb function.

Results: Functional outcomes resulted increased in the group treated with vibration therapy and in particular in the group associated to progressive modular rebalancing approach.

Conclusion: the combining neurophysiologically-based rehabilitative technique and vibration therapy may improve functional recovery in chronic stroke patients. ***Clin Ter 2017; 168(1):e33-36. doi: 10.7417/CT.2017.1979***

Key words: *Progressive Modular Rebalancing, Rehabilitation, Spasticity, Stroke, Vibration Therapy*

Introduction

Stroke is one of the leading causes for disability worldwide. A third of first-time stroke survivors remain physically disabled 5 years after their stroke (1). The most common deficit after stroke is hemiparesis of the contralateral upper limb, with more than 80% of stroke patients experiencing this condition acutely and more than 40% chronically (2). Common manifestations of upper extremity motor impairment include muscle weakness or contracture, changes in muscle tone and impaired motor control. Functionally, the motor problems resulting from sensory deficits after stroke can be summarized as impaired detection of sensory information, disturbed motor tasks performance requiring somatosensory information, and diminished upper extremity rehabilitation outcomes (3).

A recent Cochrane review focusing on the recovery of function and mobility in stroke patients reported the potential benefit of rehabilitation therapy on motor impairments and disabilities,comparedwithnotreatment,infunctionofth etimesincestroke(4). Exercise therapy is a key element of stroke rehabilitation. Among all the techniques Progressive Modular Re-balancing (RMP) with neurokinetic facilitations is a relatively new rehabilitation technique, empirically validated across last thirty years by Monari et al. in treatment of acute and chronic post-stroke motor deficits (5). Based on Kabat's concept that goal-oriented motor skill can physiologically activate functionally-related muscular groups (5,6) Monari et al elaborated a different approach in which neuromuscular facilitations of original method were placed in a progressive process of motor re-balancing (5). The motor tasks consisted in complex afferential stimulations exploiting both proprioceptive and sensorial components of task to determine motor response in specific functionally related muscular groups that form a kinetic chain, according to a kinetic chain approach (5-9) associated to lengthening of neuromuscular chain elements.

Moreover in neurorehabilitation a new therapeutic approach is recently used in the post stroke recovery: the muscle vibration. This is a technique that applies a low-amplitude/high-frequency vibratory stimulus to a specific muscle using a mechanical device. Several studies showed clinical benefits of focal vibration in patients with different diseases, as stroke (10-12), Charcot Marie Tooth disease (13), multiple sclerosis (14,15), Parkinson disease (16,17) and also in other non-neurological conditions (18-21).

The aim of this study was to evaluate the efficacy of combined RMP-FMV therapy and to compare the results in comparison to conventional therapy with resistance strength training of upper limb in patients with chronic stroke.

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Material and Methods

Study design and Participants

We performed a pilot randomized controlled trial, using a pragmatic triple-blind, parallel-group study design. Chronic stroke patients following the neuro rehabilitation service of Neurology department of the Umberto I Hospital has been recruited to 6 month trial. Patient has been considered eligible for the study if they met the following criteria: first-time stroke from infarction and hemorrhage confirmed by computed tomography or magnetic resonance imaging scan, onset of stroke from almost 1 year before study entry, a mean modified Rankin score ≥ 2 at the admission. Exclusion criteria were: significant cardiologic complications (unstable angina or congestive heart failure), peripheral arterial disease, cognitive deficits that precluded following simple commands consistently or painful orthopedic conditions not related to stroke, previous treatment with FMV or RMP. The patients were randomly placed into Group 1 (FMV+RMP), Group 2 (FMV+ conventional physiotherapy [CP]) or Group 3(CP) using a computer-generated randomization list. The patients were allocated by sealed envelope, sequentially numbered, which were opened just before the treatment. The clinical evaluations were performed by a neurologist blinded to the intervention. Data analysts were kept blinded to the allocation.

The experimental protocol was designed according to the Declaration of Helsinki and was approved by the local ethics committee. All study participants provided informed consent.

Focal Muscle Vibration

Vibratory stimulation was applied to the muscles using a specific device that consisted of an electromechanical transducer, a mechanical support, and an electronic control. The support was rigidly anchored to the floor to guarantee good mechanical contact with tissue. A mechanical arm permitted the transducer to be placed on the treatment site. The soft tissues were compressed to ensure better transmission of vibrations to the muscles. The transducer applied perpendicular to the muscle, near its distal tendon insertion, generated a sinusoidal displacement of 0.2 to 0.5mm (peak to peak). The transducer was driven to produce forces ranging between 7 and 9N. The vibration frequency was set at 100Hz, as previously described(10). During FMV, the participants were supine, and they wererequested to contract the treated muscles. The assessors monitored the muscular contraction throughout theseries of applications. FMV was simultaneously applied to the pectoralis minor and the biceps brachii of the affected limb.During another session on the same day, 1 transducer wasapplied to the flexor carpi muscle. The mechanical applicationswere applied over 3 consecutive days. For each muscle, theapplications consisted of 3 vibration sessions, each with aduration of 10 minutes. A 1-minute interval separated thesessions. During the intervals, FMV was interrupted and thesubject was requested to relax the muscle.

Progressive Modular Rebalancing

RMP protocol was based on exercises of lengthening and potentiation by means of complex motor skills involving muscular kinetic chains in upper limb. According to Monari's model, the tasks were progressively applied from distal-to-proximal muscular elements evolving through postural pyramidal progression and lengthening of neuromuscular chains. The exercises were administered in one hour session twice per weeks for six weeks.

Convectional Physiotherapy

Conventional therapy consisted in one hour session twice per weeks for six weeks of passive movement and active strength increase by muscle potentiation.

Outcome Measures

All patients has been evaluated before and after the six weeks of treatment using the following scale: Wolf Motor Function Test (WMFT), the Modified Ashworth Scale (MAS), and the visual analog scale (VAS) and the Motricity Index (MI) for strength deficits.

The WMFT quantifies the movement ability of the upper extremity through functional timed tasks (22). It requires few tools and minimal training. The WMFT is one of the most used outcome measures in studies on stroke rehabilitation to assess upper extremity function. We evaluated the 15 items (of the 17 items comprising the WFMT, 2 of the tasks are a simple measure of strength) that investigate functional ability. Total score (85) indicates normal functionality.

The MAS was used to measure spasticity; the scale evaluates the resistance of a relaxed limb to a rapid passive stretch in 6 stages (23). Zero indicates a normal or slightly increased muscle tone, and 5 indicates a state in which the passive movement ofthe affected limb is impossible. We tested the flexion and extension of the elbow.

The VAS was applied to evaluate pain severity during passivemobilization of the shoulder, elbow, and wrist of theaffected upper limb (VAS, 0–10cm: 0, no pain; 10, severepain) (24).

The upper Motricity Index (MI) score is the average of the MI scores for upper limb (prehension, elbow flexor, and shoulder flexor) (25,26).

Statistical analysis

The statistical analysis was conducted with the SPSS software package for Windows. The statistical analysis of the continuous variables was conducted calculating median and range (min-max), because these variables were not normally distributed.

To evaluate the changes of the WMFT,MAS, MI and VAS scorebetween the T0 to T1 we used the

Wilcoxon test for paired samples.The probability level for statistical significance in all tests was set at $P<0.05$.

Results

Eighteen patients has been considered eligible for the study. Demographic and clinical characteristics of the sample are reported in Table 1. No statistically significant different among groups were present at the baseline.

The pre e post treatment results for the three groups are expressed in Table 2.

The WFMF scores were statistically increased at T1 in both the group 1 and 2 but not in group 3; the same results has been showed for the MI while the VAS score shows a significant reduction in the same groups; MAS score instead, resulted reduced in T1 in all three groups of treatment.

Discussion

In this study, we evaluated the possible application of rMV therapy in association with RMP therapy or traditional physiotherapy in comparison to the conventional rehabilitation treatment alone in the functional recovery of the upper limb afterstroke.

We have observed that also if the spasticity may be reduced into the three type of treatment group, the functional outcome are different. In particular the upper limb function evaluated with the WMFT and the MI seems to be improved in the patients treated with vibration therapy associated with the rehabilitative approach; specifically when vibration therapy has been associated with the RMP we can observe the better outcome results. This date seems to be associated also with the pain perception.

These results, also if observed in small groups, may indicate that vibration therapy is useful in spasticity treatment independently of associated rehabilitation technique, confirming its action on inhibitory circuits at both spinal and cortical level (27). Vibratory stimulation could activate the proprioceptive sensory system, which is based on the excitation of Ia afferent signals from the neuromuscular spindle. Vibration stimulates spinal and supraspinal functions, leading to better nervous control of muscular fibers recruitment.

Since the association of FMV and RMP induced a high motor performance in upper limb, we can speculate that neuromuscular facilitations may induce a functionally-related cortico-cortical connections between primary and supplementary motor (M1) cortices that smooth the progress of motor relearning in subcortical stroke.

Conclusion

Despite the limitations of this study, our data suggest that a multidisciplinary approach to chronic spastic hemiplegia by combining neurophysiologically-based rehabilitative technique and vibration therapy may improve functional recovery via a suspected rebalancing of cortical inhibitory and excitatory system but further studies are warranted to verify this hypothesis.

Table 1. Demographic baseline characteristics of patients.

	Age	Time from acute event	Sex (M/F)	Laterality (right/left)	Type of stroke (hemorrhagic/ischemic)
Group 1	43 (31-68)	6 (2-33)	4/2	3/3	3/3
Group 2	43 (30-57)	2,5 (2-4)	4/2	2/4	4/2
Group 3	62,5 (46-69)	5,5 (2-7)	4/2	4/2	2/4
p	0,060	0,13	1,00	0,51	0,51

Table 2. Outcome results before (T0) and after (T1) treatment in the three groups. Significant results (p< 0,05) are in bold.

	WMFT Group1	WMFT Group2	WMFT Group3	MAS Group1	MAS Group2	MAS Group3	M.I. Group1	M.I. Group2	M.I. Group3	VAS Group1	VAS Group2	VAS Group3
T0 Median (Min-Max)	20 (8-48)	24 (4-51)	19 (11-32)	2 (1,6-3)	2,35 (1,8-2,9)	2,6 (0,2-3,2)	39,5 (18-52)	37 (9-69)	34,5 (18-47)	5 (5-10)	5,75 (3-10)	8 (7-10)
T1 Median (Min-Max)	48 (24-58)	36 (10-61)	19 (11-34)	1,1 (0,3-1,7)	1,6 (1,2-1;3)	2,2 (0,2-2,8)	68,5 (44-84)	43 (18-74)	41,5 (18-52)	1,75 (1-5)	4 (2-8)	7,25 (7-10)
p	**0,027**	**0,026**	0,109	**0,027**	**0,026**	**0,042**	**0,028**	**0,027**	0,059	**0,027**	**0,027**	0,059

WMFT: Wolf Motor Function Test; MAS: Modified Ashworth Scale; MI: Motricity Index; VAS : visual analog scale.
Group 1: Focal Muscle Vibration + Progressive Modular Re-balancing; Group 2 : Focal Muscle Vibration + Conventional Physiotherapy; Group 3: Conventional Physiotherapy

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Abbreviations:

CP: conventional physiotherapy
FMV: focal muscle vibration
MAS: Modified Ashworth Scale
MI: Motricity Index
RMP: progressive modular rebalancing
VAS : visual analog scale
WMFT: Wolf Motor Function Test