FEASIBILITY OF USING MUSCLE VIBRATION ON REHABILITATION

Bing-Shiang Yang
Department of Mechanical Engineering and Brain Research Center, National Chiao Tung University, Taiwan
Eco-City Integrated Smart Living Technology Regional Center, Taiwan; email: bsyang@mail.nctu.edu.tw

SUMMARY
The most common impairment following stroke is hand dysfunction. We examined the feasibility of using muscle vibration to increase the excitability of motor pathway and ability of independent control of finger movements in chronic stroke individuals. This technique may also be feasible for neurorehabilitation of other neurologically-injured populations.

INTRODUCTION
The most common impairment post stroke is hand dysfunction [1], which may result from muscle weakness, lack of finger independency, decreased corticomotor excitability, and/or changes in intracortical inhibitory pathways [2]. While studies have addressed the stroke-related motor cortical changes [2] and changes in cortical- or spinal-level neuromuscular control of hand muscles [3], few have examined the corresponding changes on the interaction between sensory and motor functions. However, these interactions between afferent input and voluntarily generated motor commands are the basis of unimpaired motor behavior and may be critical to restoring motor function following stroke. This potential has been demonstrated in studies using peripheral electrical stimulation to assist motor retraining following stroke. In these studies, enhanced functional outcomes were observed by combining sensory stimulation with traditional movement-based physiotherapy [e.g. 4].

Studies have shown that small-amplitude muscle vibration (MV) may provide a way to selectively induce cortical plasticity and to facilitate motor recovery following stroke. In unimpaired subjects, transcranial magnetic stimulation (TMS) has been used to show that MV can increase corticomotor excitability in the pathways innervating the vibrated muscle [5]. More recently, Rosenkranz and Rothwell [6] have demonstrated that small amplitude MV not only enhances cortical excitability in the vibrated muscle but also decreases excitability in neighboring muscles. The ability to differentially control motor excitability could be of great benefit in stroke rehabilitation, where the lack of an ability to selectively control individual muscles contributes to motor dysfunction [7, 8]. It needs to be first established whether or not MV induce a differential effect on motor excitability and voluntary control of movements following stroke. Therefore, the purpose of this study was to quantify the effects of MV on corticomotor and spinal-level excitability, and independent control of finger movements in individuals with chronic stroke; hence, to examine the feasibility of using muscle vibration on stroke hand neurorehabilitation. Three hypotheses were tested: (a) muscle vibration could significantly modulate motor-evoked potentials (MEPs), elicited by transcranial magnetic stimulation, in the vibrated or non-vibrated muscles in stroke-affected hand; (b) the vibration-induced MEP modulation did not occur in spinal-level neural pathways; (c) there would be corresponding vibration-induced modulations in voluntary control of finger movements.

METHODS
Six stroke subjects (aged 60-75 yrs; 2-5 yrs post stroke) have been tested so far (more subjects will be recruited). To examine the possibility of using muscle vibration on stroke hand rehabilitation, biomechanical and neurophysiological measurements were employed. Each subject was/will be tested in the following three sets of experiments (each set was performed in a different week to eliminate crossed effects) in a randomized order:

A. Corticomotor Excitability Evaluation. The experimental protocol in this set was similar to a previous study [9]. Muscle vibration (MV), 80 Hz and amplitude just below the threshold of inducing tonic vibration reflex or illusory movement, was delivered to the rested muscle belly of individual hand muscles, first dorsal interosseus (FDI), abductor pollicis brevis (APB), or abductor digitii minimi (ADM) in the stroke-affected hand, by an electromechanical vibrator. The excitability of contra-laterally descending motor pathways was assessed by TMS. Supra-threshold (120%-resting motor threshold of FDI) TMS stimuli were used to elicit motor-evoked potentials (MEPs) in stroke-affected FDI, APB and ADM muscles simultaneously, recorded using surface electromyography (EMG), without and during vibration to one of the three hand muscle locations.

B. Spinal Excitability Evaluation. In intact individuals, the MV-induced MEP modulation appears to have a cortical origin [6, 10]; however, the spinal-level contribution to the MEP change is not yet clear, especially following brain injuries. To determine the origin of vibration-induced MEP changes (if any) in individuals following stroke, more specifically the spinal-level contribution on these changes, we measured stretch reflex responses of the same subjects with and without muscle vibration to the same above-described locations with the same EMG measurement setup. A custom-made finger stretching device driven by a servo motor was
employed to induce a rapid finger adduction at 850°/s through a range less than 70% of subject’s range of motion, hence to stretch the target muscle. A custom-designed software written in LabVIEW 8.2 was used to control the device and conduct EMG data acquisition. Subjects were instructed to perform an isometric contraction in the target muscle at 20% of maximum voluntary contraction before finger stretching and maintain the activation level until the end of each trial. The primary variable investigated here was the peak amplitude of rectified EMG signals induced by muscle stretch, i.e. the so-called M1 response described in previous studies [11], and the latency of M1 (Figure 1). The mean peak amplitudes and latencies of M1 of 30 trials were determined for each target muscle. Paired t tests were used to compare the means with to without MV.

**RESULTS AND DISCUSSION**

For each stroke subject tested so far, MV to at least one vibration location in the stroke-affected significantly modified corticomotor excitability (MEP increased up to 35% as compared with no MV) of the pathway controlling the stroke-affected hand and provide differential effect on the vibrated and non-vibrated same hand muscles (p<0.05), although large inter-subject variations in the vibration-induced modification patterns were found.

Similar to the results we found in healthy individuals [13], muscle vibration did not significantly facilitate short-latency stretch-reflex responses in the stroke subjects, which implies that MV-induced modulations in stroke-affected motor pathway may occur primarily in cortical or supra-spinal level.

In addition to inducing neurophysiological modulations, MV to hand muscles could also improve voluntary control of finger movements, specifically the independent (lind) finger control: lind significantly increased 5-16% with selected vibration locations.

Our current results demonstrate that small-amplitude muscle vibration can be used to facilitate corticomotor excitability and voluntary control of finger movements in individuals following stroke; hence, could be feasible for stroke neurorehabilitation. We are testing more subjects to provide more quantitative supports on this.

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**REFERENCES**