

# EFFECTS OF MUSCLE VIBRATION ON CONTROL OF FINGER MOVEMENTS FOLLOWING STROKE

Bing-Shiang Yang

Assistant Professor, Department of Mechanical Engineering and Brain Research Center,  
National Chiao Tung University, Hsinchu, Taiwan, [bsyang@mail.nctu.edu.tw](mailto:bsyang@mail.nctu.edu.tw)

## INTRODUCTION

Stroke is the leading cause of long-term disability. Hand dysfunction, primarily contributed by lack of finger independency or muscle selectivity, is the most common impairment in stroke survivors (Lang and Schieber, 2004; Nakayama et al., 1994). Muscle vibration to hand or wrist muscles can selectively modulate corticomotor excitability in unimpaired individuals (e.g. Kossev et al., 2001; Rosenkranz and Rothwell, 2003) and individuals following chronic stroke (Yang et al., 2006). A small-amplitude muscle vibration can enhance the excitability of a selective motor pathway controlling stroke-affected hand muscle while inhibiting (or providing no change to) the pathways controlling neighbouring same-hand muscles, though there are large inter-subject variations of vibration-induced modulations in corticomotor excitability (Yang et al., 2006). If this vibration-induced neurophysiological changes reflect in the control of finger movements, it would be a useful tool for improving independent control of finger movements. The purpose of this study is to examine the corresponding changes in active finger independency to the vibration-induced neurophysiological modulations in the stroke-affected sensorimotor functions.

## METHODS

Ten stroke subjects (aged 55-75 yrs; 2-12 yrs post stroke) have been tested so far. Each subject was/will be tested in two sets of experiments:

**Neurophysiological Evaluation.** The protocol is similar to our previous study (Yang et al., 2006). Muscle vibration (MV) was delivered to the rested muscle belly of individual hand muscles, bilateral abductor pollicis brevis (APB), first dorsal interosseus (FDI), or abductor digiti minimi (ADM), by an electromechanical vibrator (ET-132-203, Labworks Inc., California, USA) with a 7-mm diameter probe. The vibration frequency was set at 80 Hz and the amplitude adjusted to be just below each subject's threshold for perceiving an illusory movement or tonic vibration reflex. The excitability of contralaterally descending motor pathways was assessed by transcranial magnetic stimulation (TMS, Magstim 200, Magstim, Dyfed, UK). 120%-resting motor threshold TMS stimuli were used to elicit motor-evoked potentials (MEPs) in APB, FDI and ADM muscles in the stroke-affected hand, recorded using surface electromyography (EMG, AMT-4, Bertec Biomedical, Alberta, Canada), without and during vibration to one of the six hand muscles.

This set of experiment was used to identify the vibration location(s)/muscle(s) at which vibration provided facilitation to one of the three investigated motor pathways and inhibition or no change to the other two pathways, according to the MEP amplitudes measured from the target muscles. This identified vibration location was then used for the biomechanical study (described below).

**Biomechanical Study.** While the same-type vibration as used in Neurophysiological Evaluation was applied to the above identified location, subjects were instructed to move the individual finger in the direction (abduction) which the agonist muscle pathway was facilitated during vibration. The same EMG measurements were conducted as in Neurophysiological Evaluation. Kinematics of the thumb, index and little finger of the stroke-affected hand were recorded at 100 Hz using accelerometers. An *individuation index* and an *index of selective activation* were calculated to quantify the individuation of finger control and selectivity of muscle activation (Lang and Schieber, 2004).

## RESULTS AND DISCUSSION

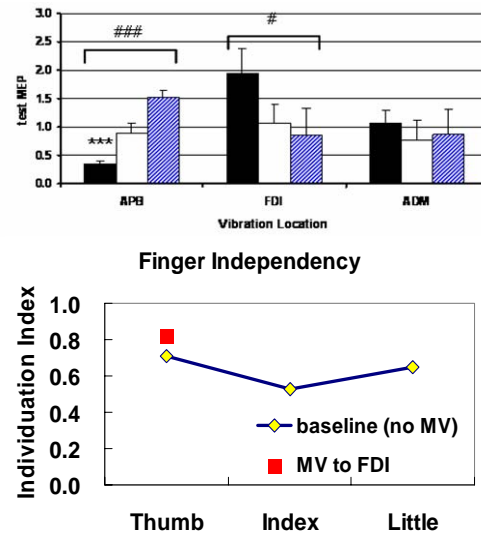
For every tested subject, MV to at least one location significantly modified corticomotor excitability ( $p < 0.05$ ). Subject-specific vibration-induced corticomotor excitability modulations were also identified. Figure 1 shows example data from one subject. For this subject, vibration to either stroke-affected APB ( $p < 0.001$ ) or FDI ( $p < 0.05$ ) provided differential modulations to the three tested motor pathways, e.g. MV to FDI facilitated MEPs in APB but provided no change to MEPs in FDI or ADM.

The observed MV-induced modulations in the Neurophysiological Evaluation also reflected in the control of finger movements. While APB was instructed to ab/adduct repeatedly, the *individuation index* of thumb and *selective activation* of APB (not shown) were higher during MV to FDI than that without MV (Figure 1).

## SUMMARY

Individual muscle vibration could selectively modulate corticomotor excitability and active control of finger movements in individual

following chronic stroke. Vibration might be a useful tool for stroke hand rehabilitation to promote more independent finger movements.



**Figure 1.** Example data of one subject. Means of ten MEPs (normalized by MEPs of each muscle without vibration) in the stroke-affected hand muscles during vibration to three different locations (top); *individuation index* of instructed ab/adductions of different fingers without vibration (no MV) and with MV to FDI (bottom).

## REFERENCES

- Kossev, A, et al. (2001). *Clin Neurophysio*, 112:453-456.
- Lang, CE and Schieber, MH (2004). *J Neurophysio*, 91:1722-1733.
- Nakayama, H, et al. (1994). *Arch Phys Med and Rehab*, 75:394-398.
- Rosenkranz, K and Rothwell, JC (2003). *J Physio*, 551:649-660.
- Yang, B-S, et al. (2006). *Soc for Neurosci Ann Meeting*, Atlanta, Georgia, USA.

## ACKNOWLEDGEMENTS

Financially supported by Taiwan National Science Council grants NSC 95-2218-E-009-202 and NSC 96-2221-E-009-163-MY3.