University of Victoria | Graduate Studies

Notice of the Final Oral Examination
for the Degree of Doctor of Philosophy

of

YAO SUN

MSc (Pennsylvania State University, 2011)
BSc (Beijing University of Aeronautics and Astronautics, 2009)

"Application and refinement of cross-education strength training in stroke"

School of Exercise Science, Physical and Health Education

Thursday, September 12, 2019
12:00 P.M.
McKinnon Building
Room 179

Supervisory Committee:
Dr. E. Paul Zehr, School of Exercise Science, Physical and Health Education, University of Victoria (Supervisor)
Dr. Marc Klimstra, School of Exercise Science, Physical and Health Education, UVic (Member)
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Dr. Daniel Marigold, Department of Biomedical Physiology & Kinesiology, Simon Fraser University

Chair of Oral Examination:
Dr. Ulrich Mueller, Department of Psychology, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

Coordinated movements are regulated by the brain, spinal cord and sensory feedback. The interaction between the spinal cord and sensory feedback also play a significant role in facilitating plasticity and functional recovery after neural trauma. Cross-education describes training one side of the limb to enhance the strength of the homologous muscle on the contralateral side. Previous study with chronic stroke participants found significant strength gains in the more affected leg following unilateral dorsiflexion training on the less affected side, which suggested cross-education can be used to boost strength gain when training the more affected side is hard to initiate. However, there is lack of evidence showing cross-education in the arm muscles after stroke and the neural pathways mediating strength cross-education in stroke participants require further study.

The modulatory role of sensory feedback in movement control has been studied by using cutaneous stimulation as a proxy of the sensory input from skin. Mechanistic studies on neurological intact participants show that cutaneous reflex pathways are widespread in the cervical and lumbar spinal cord and have a global effect on the muscles in the non-stimulated limbs. In rehabilitation training, sensory enhancement from prolonged electrical stimulation has been used to facilitate training outcomes for those had stroke and other neurological disorders. Therefore, cutaneous pathways may be important in regulating cross-education training-induced strength gain.

The purpose of this dissertation was to explore the effects of upper limb cross-education strength training in chronic stroke participants and the role of sensory inputs in regulating intra- and interlimb neural excitability in neurologically intact participants.

In the first project (Chapter 2), we explored the efficacy of cross-education strength training in wrist extensor muscles of chronic stroke participants. Strength improvements were found bilaterally with altered excitabilities in the cutaneous pathways on the untrained side. These results show the potential role of cutaneous pathways in mediating strength transfer after unilateral strength training which led us to further explore the factors may affect the cutaneous modulation. In neurologically intact participants, we investigated the effects forearm position (Chapter 4), stimulation trigger mode and parameters (Chapter 5) on the cutaneous reflexes in

the stimulated limb. Following the findings from Chapter 3, 4, and 5, the interlimb effects of self-induced sensory enhancement on the cutaneous reflexes were examined in Chapter 6.

Taken together, data from this thesis confirms the clinical application of cross-education in strength training after stroke. It addresses that exaggerated bilateral strength gains and neural plasticity can be induced following unilateral strength training on the less affected side. In addition, sensory enhancement may be applied to amplify cross-education effects in strength training.