Combined peripheral and cortical neural stimulation in motor neurorehabilitation

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Persistent changes in synaptic efficacy (long-term potentiation – LTP) is one of the candidate mechanisms underlying motor cortex plasticity. Paired associative stimulation (PAS) is one methodology that has been demonstrated to induce long lasting increases in cortical excitability through an LTP-like mechanism.

The aim of this study was to investigate if such changes can be induced in lower limb muscles and if these changes depend on the activation state of the target muscle. This is the first study in the human lower extremity investigating PAS at both rest and in active muscles.

In 14 sitting able-bodied subjects, PAS was applied as a peripheral electrical stimulus at the common peroneal nerve (1 × motor threshold), combined with a magnetic stimulus over the area of the motor cortex associated with the tibialis anterior (TA) (120% rest threshold). The timing of the magnetic stimulus coincided with the arrival of the peripheral afferent volley at the motor cortex. Three conditions were examined; PAS at 0.2 Hz for 30 minutes while the subjects were either relaxed or commencing a dorsi-flexion movement and dorsi-flexion alone at 0.2 Hz for 30 minutes.

The TA MEP size increased significantly only for the PAS intervention in the dorsiflexion condition ($p = 0.001$). The MEP size increased on average by 87%. PAS delivered during the relaxed condition or dorsiflexion performed on its own resulted in a slight and non-significant ($p = 0.238$) increase in TA MEP size.

Results demonstrated that cortical excitability can be increased following a bout of PAS delivered to lower limb muscles. As compared to hand muscles studied previously, the effects of PAS seemed to require an increased number of paired stimuli as well as a pre-activated motor cortex to show a significant effect.

PAS as a possible therapeutic tool is able to increase (or decrease) cortical excitability that is specific to the target muscle. Furthermore, if combined with a simple dorsi-flexion movement these increases are evident following only 15 min of the intervention. With the small number of stimuli and its proven effectiveness, PAS combined with a simple task appears an attractive rehabilitative tool. However, to date it is not known if these carry over to functional benefits and this should be further investigated.