



No change in EMG selectivity during individuated finger movements associated with ischemia-induced temporary amputation

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1. Introduction

Amputation of the hand results in the motor cortical representation of stump muscles enlarging, and shifting towards the region of cortex that previously evoked responses in the now-amputated hand muscles. A similar reorganization occurs with a temporary amputation induced by an ischemic block; responses in muscles proximal to the block can be elicited with lower stimulation intensities and from a larger cortical area than before ischemia. We investigated whether this cortical reorganization has functional consequences for the voluntary control of muscles just proximal to the block.

The purpose of this study was to examine whether an ischemic block at the wrist would change the pattern of muscle activity in intrinsic finger muscles during individuated finger movements.

2. Methods

Participants: Studies were conducted on 10 right-handed volunteers.

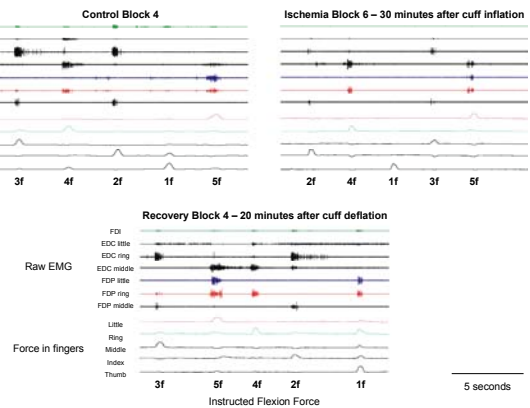
Electrode Placement: Fine-wire electrodes were inserted into the left flexor digitorum profundus and extensor digitorum communis using a hypodermic needle. Once the electrode was in place the needle was removed. We sampled multi-unit electromyographic activity from a range of different regions within the muscles by placing electrodes in parts of the muscles that were related to the isolated flexion of different digits. The approximate position of the electrode in the muscles was determined by identifying which digit, when flexed, produced the most EMG activity. Surface EMG was recorded from the intrinsic hand muscle, first dorsal interosseus (FDI).

Data Acquisition: EMG activity was sampled at 5 kHz, band-pass filtered (300 Hz - 3kHz), and recorded for up to 1.5 hours.

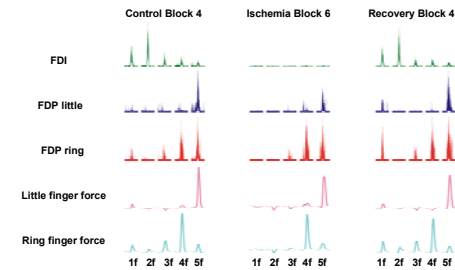
Experimental set-up and behavioral task: Participants placed each digit of their left hand into an apparatus that measured the flexion and extension forces at the distal phalanx of each digit. On a single trial participants received visual instructions, via an LED display, informing them with which digit to produce a 1N flexion force (the force in the other digits was not restricted but was always lower than in the instructed digit).

EMG activity was recorded while subjects produced individuated flexion forces with each finger. All five combinations of direction and digit—flexion of the thumb, index, middle, ring, and little fingers denoted as 1f, 2f, 3f, 4f, and 5f—were presented 10 times within a single block, for a total of 50 trials per block. A block of 50 trials was presented every 5 minutes before, during, and after inflation of the blood pressure cuff. Cutaneous sensory thresholds were tested with von Frey filaments at the end of every block of 50 trials. The cuff remained inflated until the subject lost sensation at the tip and base of the index finger as well as motor innervation of the first dorsal interosseus (FDI) muscle (assessed by the absence of surface EMG activity during attempted abduction of the index finger), after which time one more trial block was presented, the cuff was deflated, and the 4 recovery trial blocks were presented.

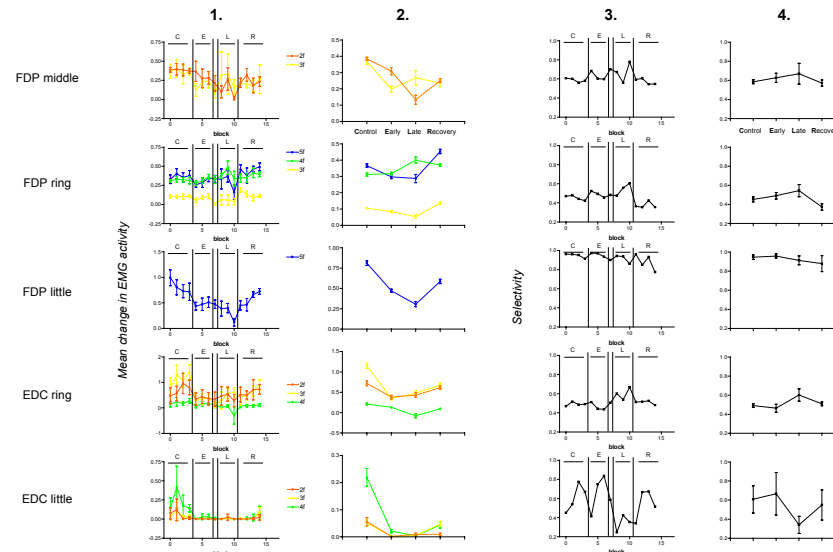
3. Single subject raw data



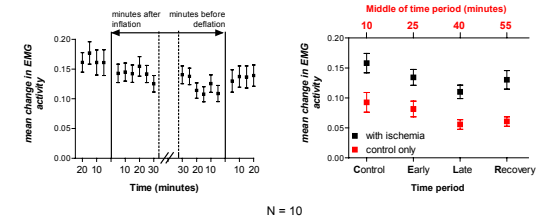
• Single subject multi-trial averaged rectified EMG before, during, and after ischemia



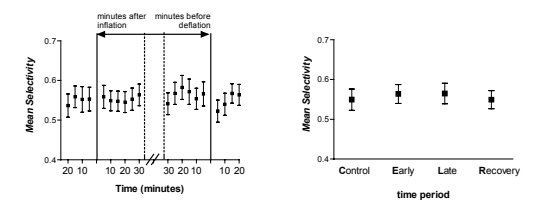
• Single subject: 1) Mean change in EMG block-by-block; 2) Mean change in EMG averaged across Control, Early ischemia, Late ischemia, and Recovery periods; 3) Block-by-block change in Selectivity; 4) Mean change in Selectivity during Control, Early ischemia, Late ischemia, and Recovery periods



6. Group Data. Mean change in EMG activity: Block-by-block and Control, Early ischemia, Late ischemia, and Recovery periods



7. Group Data. Mean change in Selectivity: Block-by-block and Control, Early ischemia, Late ischemia, and Recovery periods



8. Conclusions

•EMG selectivity did not appear to change systematically with ischemia

•At different electrode sites selectivity increased, decreased, and/or became more variable throughout the ischemic period

•Cortical reorganization associated with temporary deafferentation and paralysis of the hand does not have systematic functional consequences for the voluntary control of muscles proximal to the amputation

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