TO WHAT EXTENT CAN POSTURE-RELATED CHANGES IN CORTICOMOTOR EXCITABILITY BE EXPLAINED BY MUSCLE BIOMECHANICS?

1,2 Jeremy P.M. Mogk, 1,3 Lynn M. Rogers, 1,2,3,4 Wendy M. Murray, 1,2,3 Eric J. Perreault, and 1,2,5 James W. Stinear

1SMPP, Rehabilitation Institute of Chicago, 2Dept of Physical Medicine & Rehabilitation, and 3Dept of Biomedical Engineering, Northwestern University, 4Edward Hines, Jr. VA Hospital, 5Dept Sport & Exercise Science, University of Auckland,

email: j-mogk@northwestern.edu, http://www.smpp.northwestern.edu/research/arms/index.html

INTRODUCTION

The excitability of motor pathways is task-dependent and is, in part, modulated by posture. For example, corticomotor excitability of a muscle tends to increase at joint angles that place that muscle at shorter lengths [1, 2]. To date, posture-dependent excitability has only been examined for changes in position of a single joint. How motor pathways respond to postural changes that involve multiple joints remains unclear.

We used transcranial magnetic stimulation (TMS) to examine the effects of upper limb posture on excitability of the posterior deltoid (PD) and biceps brachii (BIC). We hypothesized that the excitability of the multiarticular BIC would increase in all postural combinations that shorten the BIC (i.e. flexed elbow or shoulder, or supinated forearm), while the excitability of the uniaxial PD would be primarily impacted by shoulder position.

METHODS

Excitability of the corticospinal pathways projecting to the PD and BIC muscles was assessed in twelve healthy subjects (3 females and 9 males; mean age 26.5 ± 3.3 years) using TMS delivered when the muscles were at rest. Single-pulse TMS was delivered to the contralateral motor cortex using a figure-of-eight coil. All stimuli were applied at the location where the largest peak-to-peak amplitude MEP was evoked in the BIC using the lowest stimulation intensity. During experimental trials, the stimulus intensity was set at 120% of resting threshold of the BIC, as determined when the arm was hanging relaxed by the side of the body. Surface electromyography was used to monitor muscle activity prior to each stimulus and record the responses evoked in the PD and BIC muscles.

Changes in corticomotor excitability of the BIC and PD muscles were quantified by the changes in MEP amplitude across a total of fifteen arm postures. Subjects were seated with their dominant arm fully supported in each of seven primary upper limb postures (Fig. 1). These included three “reference” postures (side, lap, and chair) and four “functional” postures (forward, horizontal, and overhead reach, and pressure relief). Additionally, three forearm postures (full pronation, neutral, and full supination) were examined in each functional posture. Significant differences in MEP amplitudes associated with changes in posture were evaluated using a separate ANOVA for each muscle.

Figure 1. Reference and functional postures examined. All TMS-evoked responses were normalized to those elicited in the side posture.

We used a biomechanical model of the upper limb [3] to determine the posture-related changes in muscle fiber lengths in each posture. Note that BIC length changes as a function of shoulder, elbow and forearm posture, while PD fiber length changes only with shoulder posture.
RESULTS AND DISCUSSION

In general, corticomotor excitability of the BIC and PD was greater in postures where each target muscle was shorter (Fig. 2). For example, relative to the side posture, BIC excitability increased in all postures (p<0.01 for all postures except forward reach); the musculoskeletal model indicated that side posture was associated with the longest BIC length. Shortening of the BIC from pronation to supination also increased excitability within each functional posture (p<0.0025). Similarly, PD excitability was greater in pressure relief compared to the side posture (p=0.00003). Pressure relief was the only functional posture where PD length was shorter than the reference posture.

Supporting the arm with a flexed elbow (lap and chair) increased the BIC excitability relative to the arm hanging at the side (p<0.005), as would be predicted from decreases in muscle length (Fig. 3). However, PD excitability decreased from the side to both lap and chair postures (36% and 26%, respectively; p<0.0001) despite similar muscle length in all 3 reference postures. A previous study described a similar result, where distal muscle excitability changed when proximal joint posture was altered, but target muscle length remained constant [4]. Biomechanically, elbow posture could impact shoulder muscle excitability via length-related changes to the multiarticular BIC and long head of the triceps. For example, changes in length of the BIC will alter the passive properties about the forearm, elbow and shoulder joints. Relative to the side posture, excitability of the uniarticular PD changed to a greater extent when it shortened (pressure relief) than when its length remained constant (lap and chair).

CONCLUSIONS

Identifying postures that either facilitate or suppress the excitability of specific muscles carries utility for training of muscle recruitment and coordination patterns during rehabilitation. Posture-related modulation of muscle excitability of these two muscles, in particular, may be important for understanding each muscle’s potential for motor learning following tendon transfer to restore elbow extension following cervical spinal cord injury.

REFERENCES


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