INFLUENCE OF FOREARM ORIENTATION ON MODULATION OF ELECTROMYOGRAPHIC ACTIVITY OF SHOULDER MUSCLES DURING ELBOW FLEXION TASKS IN HEALTHY ADULTS

Kazushi Tsuchiya and Shuji Suzuki
Graduate School of Human Sciences, Waseda University, Tokorozawa, Japan
email: kazushi@suou.waseda.jp, web: www.f.waseda.jp/shujiwhs/index-j.htm

SUMMARY
We studied influence of forearm orientation on modulation of electromyographic (EMG) activity of shoulder muscles during elbow tasks in healthy adults. In the result, we found EMG at shoulder joint was changed with forearm conditions with accompanying changes in EMG for elbow flexors.

INTRODUCTION
Single-joint elbow flexions are associated with muscle activity at the shoulder that opposes interaction torques arising from rotation of the elbow. By mechanically fixing the shoulder joint and preventing shoulder rotation, one can eliminate the need to oppose interaction torques with active muscle contraction, but the muscle activity remains [3]. Similarly, the activity of muscles that cross the elbow joint are influenced by forearm orientation as the muscles perform various actions [4,5]. It is possible that forearm orientation and displacement of the forearm influences muscle activity at the shoulder that opposes interaction torques arising from rotation about the elbow.

The purpose of this study was to determine the influence of forearm orientation and elbow-flexion actions on muscle activity at the shoulder joint.

METHODS
Four healthy men (21.8 ± 0.5 yrs, 1.73 ± 0.02 m, 65.8 ± 9.0 kg; mean ± SD) were seated with the upper arm abducted from the trunk by 90º and the forearm supported in a horizontal plane (Fig. 1). They performed elbow-flexion tasks (from 60 to 110º) in a horizontal plane with four different forearm conditions (Fig. 2): the forearm pronated (F@P), the forearm supinated (F@S), the forearm rotating from supination to pronation (F+P), or the forearm rotating from pronation to supination (F+S). Based on a metronome, movement duration was 300 ms. Ten trials were recorded for each condition.

Surface EMG activity of seven muscles on the right side of the subject’s body was recorded: anterior deltoid (ADL), clavicular head of pectoralis major (PM), posterior deltoid (PDL), long head of biceps brachii (BB), brachioradialis (BRD), pronator teres (PT), and long head of triceps brachii (TB). The bipolar recordings were transmitted (ZB-581G) to a receiver (ZR-550H) and then amplified and band-pass filtered (20–500 Hz) (NIHON-KOHDEN, WEB-5500) before being digitized at 2 kHz. The digitized EMG signals were full-wave-rectified after subtracting the DC component. The amplitudes of the EMG signals were normalized to the values recorded during maximal voluntary contractions (MVC).

Figure 1: Experimental condition. A: Wrist secured with a bracelet made by foam polystyrene covered with Teflon sheet to minimize the friction with the acrylic table. The bracelet could rotate about to enable forearm pronation and supination. B: Two sticks denote the range of flexion about the elbow joint. C: Fixed base of the elbow.

Figure 2: Four different forearm conditions during elbow flexion. The movements involved elbow flexion with the forearm pronated (F@P), supinated (F@S), rotating from pronation to supination (F+P), or rotating from pronation to supination (F+S).
Ensemble-averaged EMG profiles were determined from the normalized EMG data for each muscle and each subject. The EMG signals were averaged over every 20 ms from 100 ms before movement onset to 400 ms after movement onset.

Two digital video cameras (SANYO DMX-HD1010) that operated at 300 Hz were used to record the kinematics of each trial. Movement duration, movement amplitude, mean movement velocity, and peak movement velocity for elbow flexion were computed.

The mean value for each condition was compared with two-way repeated measure ANOVA. The within-subject factors were the forearm position (prone and supine) and forearm movement (constant and varying).

RESULTS AND DISCUSSION
There were no significant differences in the kinematics (movement duration, movement amplitude, mean movement velocity, and peak movement velocity for elbow flexion) across the four conditions (Fig. 3).

There was a significant interaction (p < 0.05) for BB averaged EMG from 60 ms to 140 ms corresponding to the start of movement. Post-hoc analysis indicated that F+S was significantly greater than F@S (p < 0.05) and that F+S was significantly greater than F+P (p < 0.05). Similarly, there was a significant interaction (p < 0.05) for BRD averaged EMG from 0 ms to 100 ms. Post-hoc analysis indicated that F+S was significantly smaller than F@S (p < 0.05) and that F+S was significantly smaller than F+P (p < 0.05). The averaged EMG for TB elbow extensor was not influenced by forearm condition.

The averaged EMG for shoulder muscles was smaller than that for the elbow muscles. Nonetheless, there was a significant interaction (p < 0.05) for PM averaged EMG, which post-hoc analysis indicated as F+S being significantly smaller than F@S (p < 0.05) and F+S being smaller than F+P (p=0.072). PM had a burst of EMG activity at the beginning of the movement for 3 conditions (F@P, F@S, F+P), but not the last condition (F+S).

CONCLUSIONS
The EMG activities of pectoralis major and brachioradialis were modulated in opposite directions to that of biceps brachii when the forearm rotated into supination compared with the other three conditions. These adjustments in EMG activity are likely accompanied by changes in the responsiveness of reflex pathways between the involved muscles [1,2].

REFERENCES

Figure 3: Typical examples of elbow and forearm angle, and the rectified EMG for the shoulder, upper arm and forearm muscles of a subject during the elbow flexion with four forearm conditions: F@P – forearm pronated; F@S – forearm supinated; F+P – forearm rotating into pronation; and F+S – forearm rotating into supination. Each trace is the average of 10 trials. The vertical dotted line indicates the initiation of the movement (time 0).