INTRODUCTION:

Little is known about forearm biomechanics compared to joints such as the knee or hip. A model of the forearm, particularly one which includes the distal radioulnar joint (DRUJ), is currently being developed. An accurate set of data regarding forearm muscle function is a necessary component of this model. The purpose of the present study was to develop this data set by quantifying the electromyographic activity of fifteen muscles that have the potential to load the DRUJ during forearm pronation – supination rotation.

METHODS:

Data were collected on eleven subjects in an IRB approved study. The fifteen muscles examined were: biceps brachii (BB), brachialis (BRA), brachioradialis (BRAR), supinator (SUP), extensor carpi radialis longus (ECRL), extensor carpi radialis brevis (ECRB), extensor indicis (EI), extensor pollicis longus (EPL), flexor carpi radialis (FCR), palmaris longus (PL), flexor carpi ulnaris (FCU), extensor carpi ulnaris (ECU), abductor pollicis longus (APL), pronator teres (PT), and the pronator quadratus (PQ).

Two indwelling electrodes were placed according to published guidelines in the muscle of interest of each subject by using a 25 gauge needle. (1) A grounding surface electrode was placed on the acromion of the right shoulder. A 5 second baseline test was collected while the subjects relaxed their arm. To scale the muscle activity among subjects, maximum EMG activity of the muscle of interest was determined by using published maximum voluntary isometric contraction exercises (MVIC) (2). Each exercise was performed 3 times for 5 seconds with a 2 minute rest interval between trials. Each subject was then asked to hold the handle of an isokinetic dynamometer with the elbow at 90° of flexion. An abduction pillow was placed under each arm to standardize the testing protocol and allow the subject to comfortably rest between trials. The handle of the dynamometer was placed in one of nine positions of forearm rotation: maximum pronation, 75° of pronation, 50° of pronation, 25° of pronation, neutral, 25° of supination, 50° of supination, 75° of supination, and maximum supination. The subject was then asked to grip the handle at the specified position and pronate their forearm with as much force as possible for 5 seconds. This was done three times with a 2 minute rest interval between each trial. The same procedure was then repeated at the same position except that now the subject was required to supinate their forearm. Data were collected at a rate of 2 kHz.

Data analyses began by full-wave rectification and low-pass filtering of the EMG data, and then the maximum baseline EMG values were subtracted from the EMG data of each muscle. Next, the root-mean-square (RMS) value of the resulting linear envelope was calculated. Peak EMG values were then normalized as a percentage of the maximum RMS value. Ideally the highest value for a specific muscle would be obtained from data collected from the MVIC trials, but this did not always occur. Finally, the normalized EMG values were averaged for each of the three trials in both the pronation and supination directions at each of the nine positions of forearm rotation.

RESULTS:

Quantitatively, of the five most active muscles at each position during isometric forearm pronation (Table 1), it is clear that the PQ, ECU, PT, and FCR predominate. Similarly, of the five most active muscles at each position during isometric forearm supination (Table 2), the SUP, ECU, APL and BB predominate. Qualitatively, the percentage of maximum EMG values for the ECU, BB, and PT are shown as a function of forearm angle rotation (Figures 1-3). The ECU (Fig. 1) is exemplary because it is among the most active muscles at each position of forearm rotation while pronating as well as supinating. In pronated positions, the ECU’s supinating activity is greater than the pronating activity; the opposite is true when the ECU is in supinated positions. Although the BB (Fig. 2) was also one of the five most active muscles during pronation, it was not among the most active muscles at any position while pronating. Conversely, the PT (Fig. 3) was among the five most active muscles during pronation, however it was not among the most active muscles at any position during supination.

DISCUSSION:

These data show that the mechanics of forearm rotation are complex. Individual muscle function must be examined as a function of angle and direction to understand its role in movement. When used with published physiological cross sectional area and tension fraction data, the present findings provide important information enabling an accurate quasi-dynamic biomechanical model of the forearm. This model will enable subsequent advances in understanding the biomechanics of the DRUJ and may also have other more broad reaching advances in understanding the role of specific muscles in forearm rotation and joint loading.

REFERENCES:


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