Utilizing Vibromyography to assess muscle contributions to functional motion (elbow flexion)

Understanding the contribution of the primary muscle groups involved in functional activities is important in the fields of ergonomics, occupational therapy, physical therapy, and sports medicine. Poor training can result in inefficient repetitive motions which lead to rapid fatigue, pain and injury, and as well, can significantly limit the ability of an individual to achieve optimal performance.

Elbow injuries rank among the most common repetitive motion joint injuries, arising in a wide variety of athletic activities (baseball, golf, tennis, etc) as well as in the workplace. This should not be surprising given the diverse range of loading environments the elbow joint must sustain, as evidenced by the fact that elbow flexion alone relies on three different muscle groups. While the brachioradialis and brachialis are the primary synergists in elbow flexion, the biceps brachii (which is generally considered a supinator muscle) can make significant contributions to flexion under certain arm loading conditions (Figure 1).

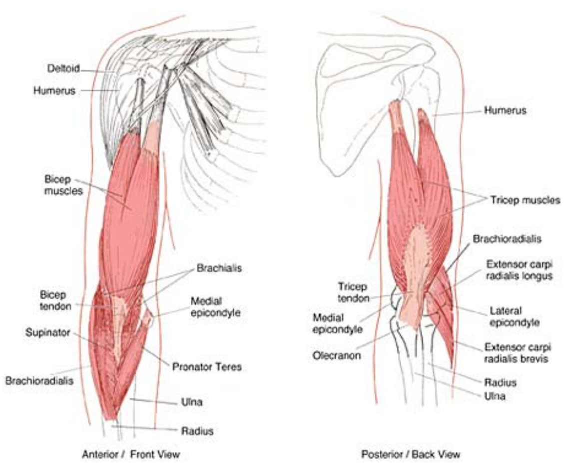

Figure 1. *Anatomy of the forearm. The brachioradialis and brachialis are the primary flexors of the forearm, though the biceps contributes to arm flexion under certain circumstances.*

Because vibromyography (VMG) provides a measurement of absolute muscle effort, this technology provides a convenient means for evaluating the contributions of individual muscle groups to the completion of functional activities. Here we show how VMG can be utilized to delineate the contribution of the three primary elbow flexors during pronated and supinated "curl" exercises using free weights.

Methods

Elbow flexor muscle effort was obtained using three BIOPAC BPS-II VMG transducers. One VMG transducer was placed over the brachioradialis just distal to the elbow, and secured in place using a two-inch strap (Chattanooga Group) wrapped around the forearm. Similarly, one transducer was placed over the brachialis and one over the biceps brachii in the middle of the upper arm, with both held in place with a two inch strap.

While in the standing position, the subject completed slow 90^o "curl" exercises holding free weights of 2, 4, 8, 15, and 25 pounds. Elbow flexion was completed over approximately a two second interval, followed by a two second extension to the resting position. Following a three second pause, the exercise was repeated for a total of six repetitions. VMG values were converted to muscle effort values using the BIOPAC VMG filter.

Analysis of the data involved identifying each "curl" event based on the peak effort observed in the brachioradialis time series recording. Muscle effort data for all three muscles for each curl event were then extracted from the time series by selecting the two seconds prior to, and two seconds following, this peak. The six, four second events were then averaged for each weight trial.

To obtain muscle effort as a function of load weight, the muscle effort data were averaged over the 500 milliseconds centered on the peak value muscle effort value during concentric contraction.

Results

During the concentric contraction phase of a pronated curl, the brachioradialis was observed to dominate elbow flexion, with the biceps and brachialis contributing significantly only when the elbow approached 90^{o} of flexion (Figure 2). Similarly, the brachioradialis is seen to serve as the dominant antagonist during the eccentric contractile activities associated with arm extension.

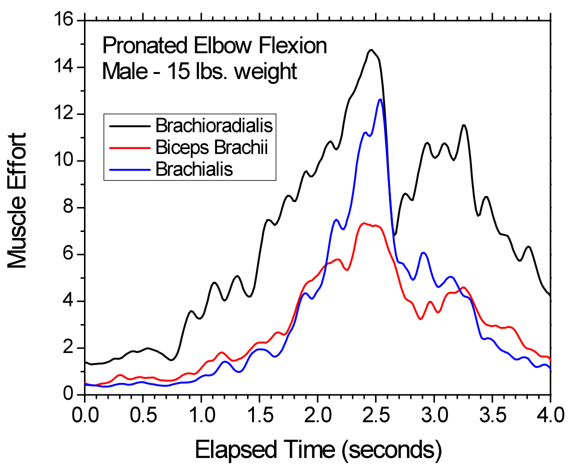

Figure 2. *Brachioradialis, biceps brachii, and brachialis activity during pronated elbow flexion and extension (curl exercise) while holding a 15-pound weight.*

Conversely, during supinated elbow flexion, the three flexors contribute almost identically in terms of peak muscle effort, though the brachioradialis and biceps lead the brachialis throughout the range of motion (Figure 3).

These relationships largely hold throughout the loading range tested (Figure 4). At the peak of concentric contraction, the brachialis and biceps contribute minimally up to a load of 10 pounds, after which their contribution increases, and that of the brachialis rapidly approaches the effort of the brachioradialis.

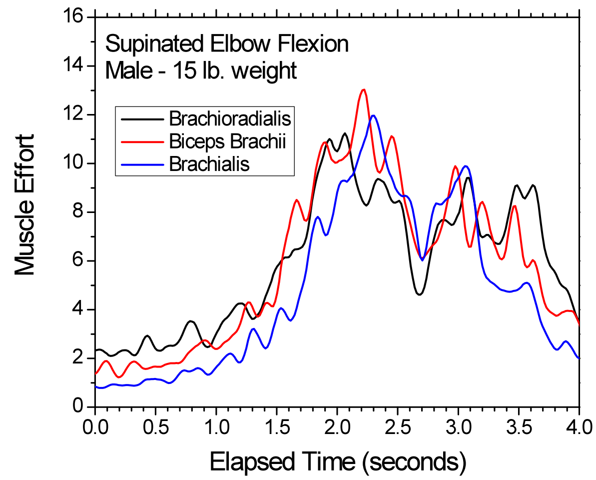

Figure 3. *Contribution of elbow flexors during a supinated "curl" exercise with a 15 lb. weight.*

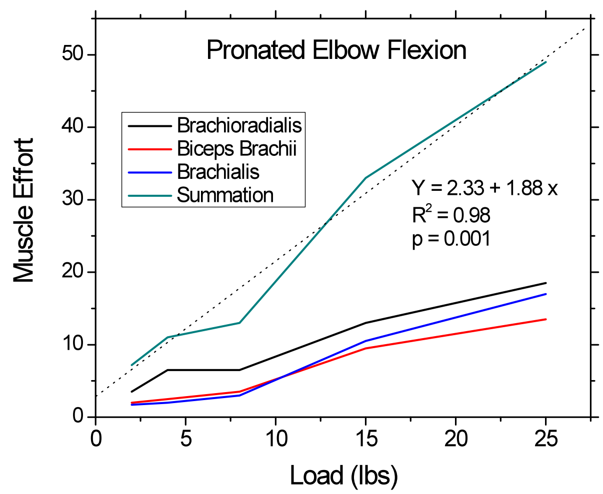

Figure 4. *Elbow flexor contribution as a function of load. Data reflects peak muscle effort during concentric contraction.*

Importantly, in addition to demonstrating how VMG can be used to assist in optimizing functional motions so as to reduce fatigue or prevent injury, the muscle effort versus load curves demonstrate the linearity of the VMG response over the full range of voluntary muscle contraction effort.