

Applications of Surface Electromyography In Strength and Conditioning

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Electromyography (EMG) involves recording the action potentials (or electrical currents) that activate skeletal muscle fibers (4). The action potentials are initiated at the muscle fiber membranes and resemble electrical waves that pass along the fibers to stimulate muscle contraction. In most cases, the action potentials are detected with two electrodes (called a bipolar arrangement) placed on the surface of the skin over the muscle. Thus, during muscle contraction, the action potentials travel through the tissue overlying the muscle and are picked up by the electrodes on the skin surface. Because these electrodes are not very selective, the surface EMG signal is generated by a summation of the action potentials from many muscle fibers (1). From the electrodes the EMG signal is passed through an amplifier to remove noise and increase its magnitude, and finally to a computer where it can be stored and analyzed.

Although surface EMG provides valuable information regarding muscle activity, it has some limitations that must be understood for proper interpretation (7). Unfortunately, these limitations are not always obvious. For example, a common misconception is that greater EMG amplitude values during a specific exercise (e.g. a dumbbell bench press) indicate that the muscle is more fully activated when compared to a different exercise for the same muscle group (e.g. a barbell bench press). This is not true in all cases because the electrodes on the skin surface only detect the electrical current from a portion of the muscle (i.e. the muscle fibers within the pick-up area of the electrodes) (1). Thus, the surface EMG signal usually does not reflect the electrical activity of the entire muscle, and it is inappropriate to conclude that a certain exercise is in some way better than another exercise based on EMG amplitude values. Furthermore, the EMG signal can be influenced by factors that are different for each exercise, such as biomechanical factors and movement speed (3, 4). Thus, increases or decreases in EMG amplitude do not always reflect changes in muscle activation. Another misconception is that EMG amplitude reflects neural output from the central nervous system (CNS). The results from recent studies, however, indicate that EMG amplitude underestimates the activation signal sent from the CNS (8). Thus, it is not appropriate to assume that greater EMG amplitude values at the surface of the skin are due to increased activation from the CNS.

Although surface EMG has several limitations that must be understood for proper interpretation, it also has many applications that may be useful in strength and conditioning. For example, when used properly, surface EMG can be used to examine changes in muscle activation/coactivation during strength training programs (2). Specifically, increases in strength during the initial stages (i.e. approximately the first 2 weeks) of a resistance training program may be due to increased activation of the agonist muscle and/or decreased coactivation of the antagonist muscle, both of which could be examined with EMG (11). Another potentially useful application of surface EMG is for examining delayed-onset muscle soreness (DOMS). For example, previous studies (5, 6) have suggested that some of the pain that is felt after intense, unaccustomed exercise may be due to spasms of the affected muscle(s). This hypothesis is supported by the results of de Vries (6), who reported increased resting EMG amplitude values for the biceps brachii and brachialis muscles 48 hours after intense weightlifting exercises with one arm. There was no change, however, in EMG amplitude for the biceps brachii and brachialis muscles in the arm that was not exercised (6). Thus, these findings suggested that surface EMG may be useful for examining the mechanisms underlying DOMS.

Since surface EMG is a very sensitive indicator of muscle activity (6), it can also be used to identify when certain muscles are activated during exercise. For example, EMG could be used to investigate activation timing of the quadriceps femoris and hamstring muscles during a squat exercise. Another example would be to examine timing of activation for the pectoralis major, triceps brachii, and deltoid muscles during the bench press exercise. This information could potentially be useful for investigating muscle coordination during multi-joint exercises.

Surface EMG has also been used to examine muscle fatigue (10). For example, several studies have found that the frequency of the EMG signal (i.e. the rate at which the signal fluctuates) decreases during fatiguing exercise (9, 10, 12). This information may be useful because changes in EMG frequency reflect physiological changes that occur within the muscle during fatigue, even when the force and/or power that the muscle is producing is not decreasing (1).

It is important to note that there are many potential uses of surface EMG in strength and conditioning. Regardless of the application, it is important that the user understands the limitations of EMG and the types of questions that it can be used to answer. As acknowledged by De Luca (4, p. 135), "...electromyography is too easy to use and consequently too easy to abuse." The purpose of this article, however, was to discuss some of the common misconceptions regarding EMG, and to describe a few applications where it can be used to provide simple, reliable information regarding muscle activity. Hopefully, future studies will continue to examine the potential uses of surface EMG in strength and conditioning.

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