Electromyography (EMG)

Introduction

In this laboratory, you will explore the electrical activity of skeletal muscle by recording an electromyogram (EMG) from a volunteer. You will examine the EMG of both voluntary and evoked muscle action, and use this technique to measure nerve conduction velocity.

Background

Skeletal muscles do the majority of the work for locomotion and support of the animal skeleton. Each muscle is made up of individual muscle fibers organized in fascicles (Figure 1).

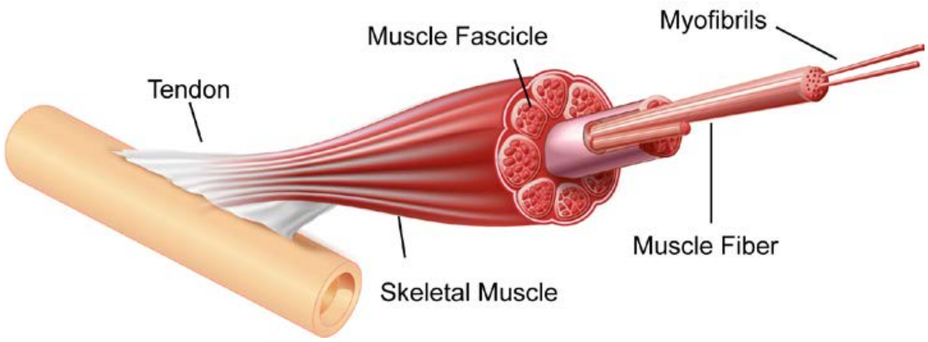

Figure 1. Skeletal muscle structure.

Each individual fiber is innervated by a branch of a motor axon. Under normal circumstances, a neuronal action potential activates all of the muscle fibers innervated by the motor neuron and its axonal branches. The motor neuron, together with all of the individual muscle fibers that it innervates, is termed a motor unit (Figure 2).

This activation process involves the initiation of an action potential (either voluntarily, or as a result of electrical stimulation of a peripheral nerve), conduction of the action potential along the nerve fiber, release of neurotransmitter at the neuromuscular junction and depolarization of the muscle membrane with resultant contraction of the muscle fibers.

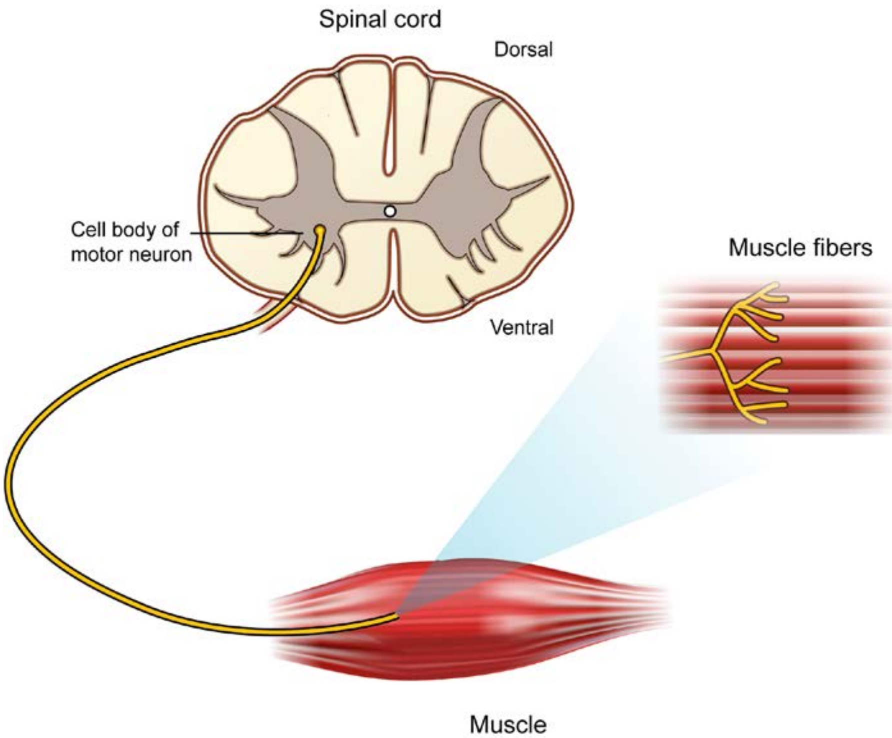

Figure 2. The components of a motor unit.

Electromyography is a technique that measures the electrical activity of the muscles and the nerves controlling the muscles. The data recorded is an Electromyogram (also known as an ‘EMG’ or ‘Myogram’). There are two methods of recording: needle electrodes inserted through the skin into the muscle, or electrodes placed on the skin surface. The size and shape of the waveform measured provide information about the ability of the muscle to respond when the nerves are stimulated. In the clinical setting, EMG is most often used when people have symptoms of weakness, and examination shows impaired muscle strength. It can help to differentiate muscle weakness caused by neurological disorders from other conditions.

The EMG provides a depiction of the timing and pattern of muscle activity during complex movements. The raw surface EMG signal reflects the electrical activity of the muscle fibers active at that time. Motor units fire asynchronously and it is sometimes possible, with exceedingly weak contractions, to detect the contributions of individual motor units to the EMG signal. As the strength of the muscular contraction increases, however, the density of action potentials increases and the raw signal at any time may represent the electrical activity of perhaps thousands of individual fibers.

In the first exercise, you will record EMG activity during voluntary contractions of the biceps and triceps muscles of the arm (Figure 3).

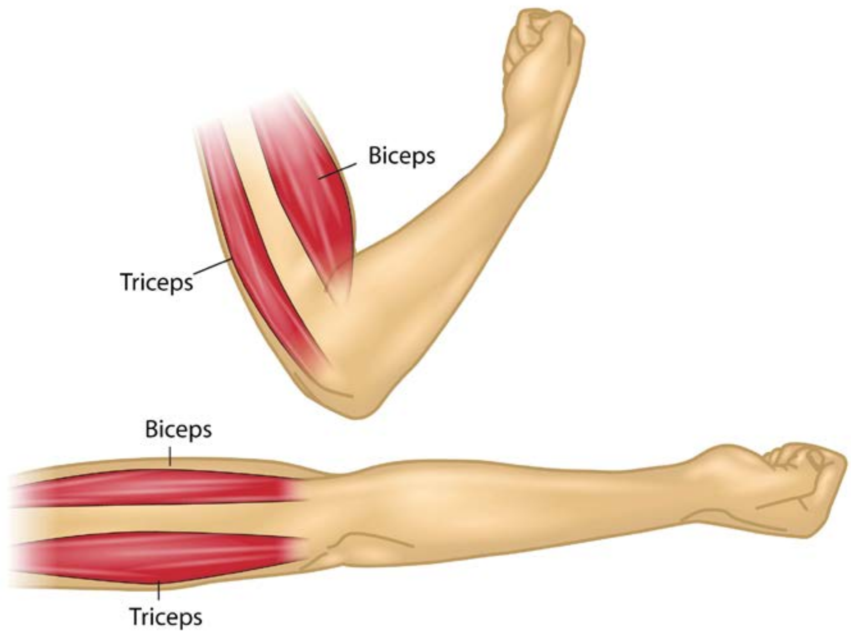

Figure 3. Skeletal muscle structure.

The raw EMG signal during voluntary contractions may be processed in various ways to indicate the intensity of EMG activity. In the method used here, the negative-going portions of the EMG are inverted, and then the whole signal is integrated in such a way as to smooth out individual spikes, and make the time course of changing activity much clearer.

In this part of the exercise you will examine coactivation: a phenomenon in which contraction of a muscle leads to more minor activity in the antagonist muscle. The physiological significance of this is not entirely clear, but it has been suggested that it helps to stabilize the joint.

You will also record evoked EMG signals produced by electrical stimulation of a motor nerve supplying a muscle. The abductor pollicis brevis muscle is a member of the thenar muscle group on the palmar surface of the hand (Figure 4).

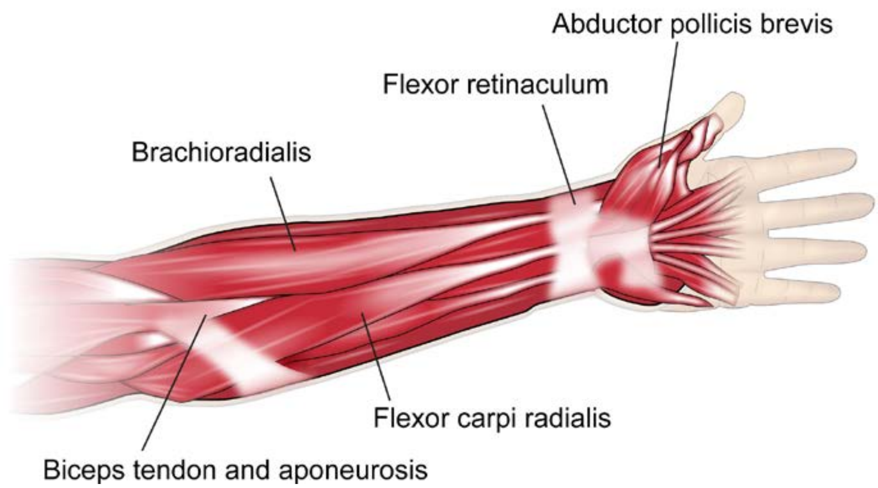

Figure 4. Some muscles of the forearm and hand.

The motor nerve to the abductor pollicis brevis muscle (the median nerve) is easy to stimulate at the wrist and elbow. In this exercise, flat metal disc electrodes are attached to your skin. Brief electrical pulses are administered through the skin to the nerve, and the time it takes for the muscle to contract in response to the electrical pulse is recorded.

The speed of the response is dependent on the conduction velocity. In general, the range of normal conduction velocities will be approximately 50 to 60 meters per second. However, the normal conduction velocity may vary from one individual to another and from one nerve to another.

Nerve and muscle disorders cause the muscles to react in abnormal ways. Measuring the electrical activity in muscles and nerves can help detect the presence, location and extent of diseases that damage muscle tissue (such as muscular dystrophy) or nerves (such as amyotrophic lateral sclerosis: Lou Gehrig's disease). In the case of nerve injury, the actual site of nerve damage can often be located. In a clinical setting, EMG and nerve conduction studies are usually done together.

When external nerve stimulation is applied, the volunteer will feel a brief 'pinch', a tingling sensation and a twitching of the muscle. It may feel similar to the static discharge felt when rubbing one's feet on the carpet and then touching a metal object. In our exercises, each electrical pulse is very brief (less than a millisecond). The energy of electrical pulses is not high enough to cause an injury or damage. There are no risks associated with these small currents. Nothing is inserted into the skin, so there is no risk of infection.

What you will do in the Laboratory

You will perform four exercises:

1. **Voluntary change in contractile force**. You will record EMG during voluntary muscle contractions, and investigate how contractile force changes with increasing demand.

2. **Alternating activity and coactivation**. Here you will examine the activity of antagonist muscles and the phenomenon of coactivation.

3. **Evoked EMG**. In this exercise, you will record EMG responses evoked by stimulating the median nerve at the wrist.

4. **Nerve conduction velocity**. In this exercise, you will measure nerve conduction velocity from the difference in latencies between responses evoked by nerve stimulation at the wrist and the elbow.