Example of experiment hm-1: grip strength and electromyogram (emg) activity repor...

Literature

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Abstract—In this experiment, a hand dynamometer was used to measure the grip strength of a subject. The forearm muscles were engaged in an activity, and the grip recorded. The electromyogram (EMG) activity was related to the grip strength by making a graph of the maximum grip strength against area under the EMG activity's absolute integral during the contraction of muscle. Data was recorded from the dominant and non-dominant forearms of the subject and the electrical activity of each forearm compared to its diameter. Prolonged grip strength was also recordings and forearm EMG activity made to determine fatigue rate in both the dominant and non-dominant forearms. The dominant forearm has a greater grip strength and wider diameter as compared to the non-dominant forearm. The increase in tension is more rapid in the non-dominant forearm than it is in the dominant forearm and dominant forearm does not fatigue as quickly as the non-dominant forearm. The steady increase in tension, great grip strength and low fatigue are contributed to the member and the size of muscle fibers in the dominant forearm.

INTRODUCTION

A

motor unit refers to a motor neuron together with the muscle fibers that it innervates (Seeley, Stephens, & Tate, 2004). In a persistent muscle contraction, there is a repetitive firing by multiple motor units throughout muscle contraction process. The strength developed by the contracting muscles is related to the number of motor units that are active at the moment. Most of the mature extrafusal fibers of the skeletal muscle in

mammals have only a single α motor neuron that innervates them. Within the muscles, individual motor axons make branches in order to synapse on a lot of different fibers distributed over a huge area in the muscle. This is due to the fact that the number of muscle fibers exceeds the number of motor neurons by far. The branching is presumed to make sure that the force of contraction by the motor unit is evenly distributed (Purves, Augustine, & Fitzpatrick, 2001). The technique that is used in the evaluation and recording of the electrical activities from a skeletal muscle is known as electromyography. The technique is done using electromyograph, to produce a record known as an electromyogram (EMG) (Robertson, Caldwell, Hamill, Kamen, & Whittlesey, 2001).

The EMG that is recorded during the muscle contraction is viewed as a burst of spike-like signals, and the burst duration is almost equal to the duration taken by muscle contraction. The raw data given by EMG have to be transformed mathematically in order to quantify the amount of electrical activity in a muscle. The most common method of transformation is the integration of the absolute values of the EMG spikes amplitudes. This integration results to a linear proportion between the area under the curve and the strength of the muscle contraction.

In this experiment, a hand dynamometer was used to measure the grip strength of a subject. The forearm muscles were engaged in an activity, and the grip recorded. The EMG activity was related to the grip strength by making a graph of the maximum grip strength against area under the EMG activity's absolute integral during the contraction of muscle. Data was recorded from the dominant and non-dominant forearms of the subject and

the electrical activity of each forearm compared to its diameter. Prolonged grip strength was also recordings and forearm EMG activity made to determine fatigue rate in both the dominant and non-dominant forearms.

Methods

The experiment was conducted using PC Computer, IWX/214 data acquisition unit, C-AAMI-504 ECG cable and electrode lead wires and the FT-325 Hand Dynamometer as the major equipments. All the equipments were set up according to the manual (Iworx, 2013).

EMG Intensity And Force In Dominant Arm

This was done with an aim of determining the relationship existing between the force of contraction and the intensity of EMG activity in the dominant arm. The subject was allowed to sit quietly with the dominant forearm resting on the table top and the experimental procedure explained. The subject was allowed to squeeze the fist around the hand dynamometer four times. Each of the contractions was two seconds long and was followed by two seconds of relaxation. Each successive contraction was made to be approximately stronger than the first contraction by two, three, and four times. Using a piece of string and a metric ruler, the circumference of the dominant forearm was measured at approximately 3 centimeters below the elbow and the data recorded.

EMG Intensity and Fatigue in Dominant Arm

This was done with an aim of observing the relationship existing between the length of muscle contraction, strength of a muscle contraction and the EMG activity in the dominant forearm. The subject was allowed to sit quietly with

the dominant forearm on the table top, and the experimental procedure explained. The subject squeezed the bulb of the hand dynamometer as tightly for as long as possible in order to fatigue the muscles of the forearm. When the muscle strength of the subject dropped to a level that was below half the maximum muscle force at the beginning, the recording was stopped.

EMG Intensity and Force in the Non-Dominant Arm

This was done with an aim of determining the relationship existing between the intensity of EMG activity and the muscle contraction force in the subject's non-dominant arm. The subject was allowed to sit quietly with the non-dominant forearm resting on the table top and the experimental procedure explained. The subject was allowed to squeeze the fist around the hand dynamometer four times. Each of the contractions was two seconds long and was followed by two seconds of relaxation. Each successive contraction was made to be approximately stronger than the first contraction by two, three, and four times. Using a piece of string and a metric ruler, the circumference of the forearm at approximately 3 centimeters below the elbow was measured and the data recorded.

EMG Intensity and Fatigue in Non-Dominant Arm

This was done with an aim of observing the relationship existing between the length of muscle contraction, muscle contraction strength and EMG activity in the non-dominant forearm. The subject was allowed to sit quietly with the non-dominant forearm on the table top, and the experimental procedure explained. The subject squeezed tightly the bulb of the hand dynamometer for as long as possible in order to fatigue the muscles. When the muscle of

the subject dropped to a level that was below half the maximum force of the muscle at the beginning, the recording was stopped.

Results

The results for the EMG intensity and force in the dominant arm are shown in below (Table 1). Both the values for the absolute area of EMG and that of absolute area under force curve increased as the contraction intensity increased. This trend is clearly shown by a graph of absolute area of the contraction of the muscle as a function of the absolute area of the EMG signal (Figure 2).

Figure 1: A graph of absolute area of muscle contraction against the absolute area of the EMG signals

There is a linear relationship between the absolute area under the EMG signal and the area under the muscle contraction in both the dominant and non-dominant arms. The muscles fibers also have a refractory period just like the nerve fibers. When a progressive increased tension is required, the smallest motor units are the ones that are usually recruited. When the load on the muscle is increased, the larger motor units are recruited, and the maximum contraction is attained when all the motor units have been recruited. The increase is also dependent on the number of muscle fibers that are firing.

The results for the EMG intensity and fatigue in dominant and non-dominant forearms are shown below (Table 2).

The muscles attained a maximum contraction force of about 140 units and the time taken to get to half-max fatigue time was around 10. 7 seconds for

the dominant forearm. For the non-dominant forearm, the maximum force was 114 units and the time taken to get to half-max fatigue time was around 9. 5 seconds for the dominant forearm. This shows that the dominant forearm is stronger than the non-dominant one with the percent difference in maximum grip strength between the two arms being 18%. The weaker forearm has a higher ratio of average maximum grip strength to the EMG absolute integral area than the dominant or the stronger forearm. The gradient of the dominant forearm was 44. 6 while the non-dominant forearm had a gradient of 67. 44. This gives a percentage difference of 33. 84%. This big difference may be contributed to the fact that the dominant forearm has a diameter of 260 mm and hence more motor units as compared to a diameter of 240 mm for the non-dominant one with a percentage difference of 7. 6%. The big motor units in the non-dominant arm are, therefore, recruited sooner than those in the dominant arm and thence the sharp rise in force.

Difference in the diameter of the arms also contributes to the difference in the maximum force attained by each arm. This is because of the number of motor units in each arm with the dominant arm having more units than the non-dominant one. The circumference difference is due to the difference in the diameter of each muscle fiber with the dominant arm having larger muscle fibers than the non-dominant arm. This result from the frequent use of the dominant arm since exercise enhances the size of muscle fibers. The dominant arm took more time to fatigue as compared to the non-dominant one. This results from the big muscle fibers in the dominant forearm in which the myofibrils, as well as, the contractile proteins are many.

This enables the muscle fibers to contact for a longer time than when these proteins are less.

conclusion

In conclusion, the experiment provided a number of finding. First, the dominant forearm has a greater grip strength and wider diameter as compared to the non-dominant forearm. Secondly, the increase in tension is more rapid in the non-dominant forearm than it is in the dominant forearm. Finally, dominant forearm does not fatigue as quickly as the non-dominant forearm. The steady increase in tension, great grip strength and low fatigue are contributed to the member and the size of muscle fibers in the dominant forearm.

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