Al-Mustaqbal University
College of Engineering
Biomedical Engineering Department

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Lecture No.: - 1 -

Lecture Title: [Introduction to Electromyography]

Introduction to Electromyography

Voluntary muscle contraction is the result of communication between the brain and individual muscle fibers of the musculoskeletal system. A thought is transformed into electrical impulses that travel down interneurons and motor neurons (in the spinal cord and peripheral nerves) to the neuromuscular junctions that form a motor unit (see Figure 1).

The individual muscle fibers within each motor unit contract with an all-or-none response when stimulated, meaning that the muscle fiber contracts to its maximum potential or not at all. The strength of contraction of a whole muscle depends on how many motor units are activated and can be correlated with electrical activity measured over the muscle with a technique called electromyography, or EMG.

In this experiment, you will use the Hand Dynamometer to measure maximum grip strength and correlate this with electrical activity of the muscles involved as measured using the EKG Sensor. You will see if electrical activity changes as a muscle fatigues during continuous maximal effort. Finally, you will observe the results of a conscious effort to overcome fatigue in the muscles being tested.

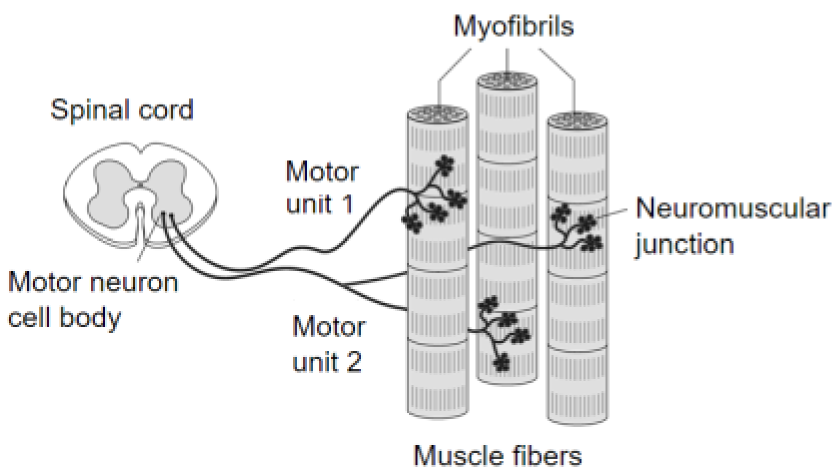

Figure 1

OBJECTIVES

- Obtain graphical representation of the electrical activity of a muscle.
- Correlate grip strength measurements with electrical activity data.
- Correlate measurements of grip strength and electrical activity with muscle fatigue.
- Observe the effect on grip strength of a conscious effort to overcome fatigue.

MATERIALS

Chromebook, computer, **or** mobile device
Graphical Analysis 4 app
Go Direct Hand Dynamometer
Go Direct EKG
electrode tabs

PROCEDURE

Part I Grip strength without visual feedback

Select one person from your group to be the subject. **Important**: Do not attempt this experiment if you suffer from arthritis or other conditions of the hand, wrist, forearm, or elbow.

1. Connect and set up the sensors.
   a. Launch Graphical Analysis.
   b. Connect Go Direct EKG to your Chromebook, computer, or mobile device.
   c. Click or tap Sensor Channels. Deselect the EKG channel and select the EMG Rectified channel.
   d. Connect Go Direct Hand Dynamometer to your Chromebook, computer, or mobile device. The default channel is correct for this experiment.
   e. Click or tap Done.
2. Click or tap Mode to open Data Collection Settings. Change Rate to 100 samples/s and End Collection to 60 s. Click or tap Done.
3. Zero the readings for the Hand Dynamometer.
   a. Set the Hand Dynamometer on a flat surface. Do not put any force on the pads of the Hand Dynamometer.
   b. When the readings stabilize, click or tap the Force meter and choose Zero. The readings for the sensor should be close to zero.
4. Set up the EKG sensor.
   a. Attach three electrode tabs to one of your arms as shown in Figure 2. Two tabs should be placed on the ventral forearm, 5 cm and 10 cm from the medial epicondyle along an imaginary line connecting the epicondyle and the middle finger. The third tab should be on the upper arm.
   b. Attach the green and red leads to the tabs on ventral forearm. For this activity, the green and red leads are interchangeable.
   c. Attach the black lead to the upper arm.

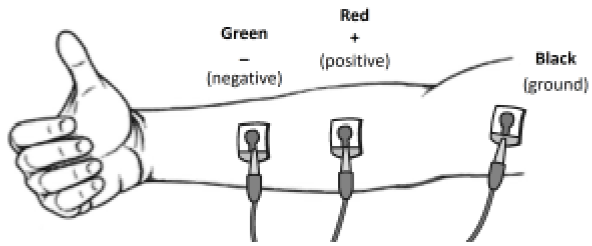

Figure 2

5. Have the subject sit with his or her back straight and feet flat on the floor. The elbow should be at a 90° angle, with the arm unsupported.

6. Have the subject close his or her eyes or avert them from the screen.

7. Instruct the subject to grip the sensor with full strength and click or tap Collect to start data collection. The subject should exert maximum effort throughout the data-collection period.

8. At 40 s, the lab partner(s) should encourage the subject to grip even harder. Data will be collected for 60 s.

9. Determine the mean force exerted during three time intervals.

   a. Select the data from 0 s to 20 s on the force *vs*. time graph.
   b. Click or tap Graph Tools, , and choose View Statistics.
   c. Record the mean force in Table 1, rounding to the nearest 0.1 N.
   d. Dismiss the Statistics box.
   e. Repeat this process to determine the mean force for two other intervals: 20−40 s and 40−60 s.

10. Using the EMG graph, repeat Step 9 to record the maximum, minimum, and ΔmV during three time intervals: 0–20 s, 20−40 s, and 40−60 s. Record the values in Table 1, rounding to the nearest 0.01 mV.

Part II Grip strength with visual feedback

11. Have the subject sit with his or her back straight and feet flat on the floor. The Hand Dynamometer should be held in the same hand used in Part I of this experiment. Instruct the subject to position his or her elbow at a 90° angle, with the arm unsupported, and to close his or her eyes, or avert them from the screen.

12. Instruct the subject to grip the sensor with full strength and click or tap Collect to start data collection. The subject should exert near maximum effort throughout the duration of the experiment.

13. At 40 s, instruct the subject to watch the screen and attempt to match his or her beginning grip strength (the level achieved in the first few seconds of the experiment). The subject should maintain this grip for the duration of the data-collection period. Data will be collected for 60 s.

14. Determine the mean force exerted during three time intervals.

    a. Select the data from 0 s to 20 s on the force *vs*. time graph.
    b. Click or tap Graph Tools, , and choose View Statistics.
    c. Record the mean force in Table 1, rounding to the nearest 0.1 N.
    d. Dismiss the Statistics box.
    e. Repeat these steps to find the mean force for two other intervals: 20−40 s and 40−60 s.

15. Using the EMG graph, repeat Step 14 to record the maximum, minimum, and ΔmV during three time intervals: 0–20 s, 20−40 s, and 40−60 s. Record the values in Table 1, rounding to the nearest 0.01 mV.

Part III Repetitive grip strength

16. Have the subject sit with his or her back straight and feet flat on the floor. The Hand Dynamometer should be held in the same hand used in Parts I and II of this experiment. Instruct the subject to position his or her elbow at a 90° angle, with the arm unsupported, and to close his or her eyes or avert them from the screen.

17. Instruct the subject to rapidly grip and relax his or her grip on the sensor (approximately twice per second). Click or tap Collect to start data collection. The subject should exert maximum effort throughout the duration of data collection.

18. At 40 s, the lab partner(s) should encourage the subject to grip even harder. Data will be collected for 100 s.

19. Determine the mean force exerted during three time intervals.

    a. Select the data from 0 s to 20 s on the force *vs*. time graph.
    b. Click or tap Graph Tools, , and choose Statistics.
    c. Record the mean force in Table 1, rounding to the nearest 0.1 N.
    d. Dismiss the Statistics box.
    e. Repeat these steps to determine the mean force for two other intervals: 20−40 s and 40−60 s.

20. Using the EMG graph, repeat Step 19 to record the maximum, minimum, and ΔmV during three time intervals: 0–20 s, 20−40 s, and 40−60 s. Record the values in Table 1, rounding to the nearest 0.01 mV.

DATA

Table 1: Continuous Grip Strength without Visual Feedback				
Time interval	Mean grip strength (N)	EMG data		
		Max (mV)	Min (mV)	ΔmV
0–20 s				
20–40 s				
40–60 s				

Table 2: Continuous Grip Strength with Visual Feedback				
Time interval	Mean grip strength (N)	EMG data		
		Max (mV)	Min (mV)	ΔmV
0–20 s				
20–40 s				
40–60 s				

Table 3: Repetitive Grip Strength				
Time interval	Mean grip strength (N)	EMG data		
		Max (mV)	Min (mV)	ΔmV
0–20 s				
20–40 s				
40–60 s				

DATA ANALYSIS

1. Use the data in Table 1 to calculate the percent loss of grip strength that occurred between the 0–20 s and 20–40 s intervals. Describe a situation in which such a loss of grip strength is noticeable in your day-to-day life.

2. Use the data in Table 1 to calculate the percent change in amplitude (ΔmV) in electrical activity that occurred between the 0–20 s and 20–40 s intervals. Do the same for grip strength. What accounts for the difference in the percent change observed in grip strength and ΔmV for the two time intervals?

3. Compare mean grip strengths and ΔmV for the 0–20 s and 40–60 s in Table 1. Do your findings support or refute the practice of "coaching from the sidelines" at sporting events?

4. Use the graphs and the data in Table 1 to explain how our neuromuscular systems attempt to overcome fatigue during heavy work or exercise. How might fatigue increase the risk of musculoskeletal injury?

5. Compare the data in Tables 1 and 2. Explain any differences seen in the 40–60 s time intervals between the two tables. What does this tell you about the brain's role in fatigue?

6. The mean grip strength is much lower for repetitive gripping (Table 3) than for continuous gripping because repetitive relaxation of the hand is averaged into the calculation.

    a. Compare your mean grip strength during the 0–20 s and 40–60 s time intervals in Tables 1 and 3. Comparing continues gripping to repetitive gripping, was there a difference in your ability to recover strength with coaching?

    b. Calculate the percent change in mean grip strength between the 1–20 s and 20–40 s time intervals in Tables 1 and 3. Do your answers support brief relaxation of muscles to delay fatigue?