Muscle Function Analysis

Muscle tissues maintain electrical imbalances, or potentials, across cell membranes by concentrating positive or negative charges on opposite sides of those membranes. These potentials are a form of stored energy. With activation (such as from a nerve impulse), the ions are allowed to cross the muscle cell membranes, generating electrical activity and resulting in muscle contraction.

An electromyogram, or EMG, is a graphical recording of electrical activity within muscles. It is useful in the diagnosis of disorders affecting muscles and the nerves that supply them. Inherited and acquired disorders of muscles (such as the muscular dystrophies), and disorders of the central and peripheral nervous systems (such as Huntington’s disease and diabetic neuropathy) result in abnormal EMG readings.

EMG studies are also useful for investigating normal muscle function. In this experiment, you will analyze electrical activity in the extensor muscles of the forearm. These muscles originate in tendons of the proximal dorsal forearm in the region of the lateral epicondyle and attach distally to tendons which control extension of the hand and fingers (see Figure 1). Inflammation of the tendons at the elbow is common and can result from repetitive motions used in sports, hobbies, and in the workplace. This experiment will demonstrate the rationale behind treating tennis elbow with a wrist splint.

**Figure 1**

**Important**: Do not attempt this experiment if you suffer from tennis elbow or other disorders of the arm or hand. Inform your instructor of any possible health problems that might be exacerbated if you participate in this exercise.
OBJECTIVES

In this experiment, you will

- Obtain graphical representation of the electrical activity of a muscle.
- Associate muscle activity with movement of joints.
- Correlate muscle activity with injury.

MATERIALS

- computer
- electrode tabs
- Vernier computer interface
- ruler
- Logger Pro
- 1–2 kg (3 lb) weight (barbell or similar)
- Vernier EKG Sensor

PROCEDURE

Select one person from your lab group to be the subject.

1. Connect the EKG Sensor to the Vernier computer interface. Open the file “15 Muscle Funct Analysis” from the *Human Physiology with Vernier* folder.

2. Attach three electrode tabs to your dominant arm, as shown in Figure 2. Two tabs should be placed on the dorsal forearm, 5 cm and 10 cm from the lateral epicondyle along an imaginary line connecting the epicondyle and the middle finger. A third electrode tab should be placed on the upper arm.

3. Connect the EKG clips to the electrode tabs as shown in Figure 2. The red and green leads are interchangeable for this experiment. Stand facing your table or lab bench so that your arm is angled down toward the surface (Figure 2).

4. Rest your fingertips on the table, with your palm above the surface and in line with your forearm, as shown in Figure 2. Click [Collect] to begin data collection. If your graph has a stable baseline (see Figure 3), click [Stop] and continue to Step 5. If your graph has an unstable baseline, click [Stop] and try again until you have a stable baseline for 5 s.

*Figure 2*

*Figure 3*
5. Collect data while flexing and relaxing the extensor muscle.
   a. Click [Collect].
   b. After recording a stable baseline for 5 s, gently cock your hand back as far as you can (Figure 4). Hold this position for 5 s.
   c. Return your hand to its relaxed position, with fingertips resting on the table surface, for a period of 5 s.
   d. Repeat the extension and relaxation action for one more full cycle—5 s with the hand cocked, followed by 5 s with the hand in a resting position. Data will be collected for 25 s.

6. Store this run by choosing Store Latest Run from the Experiment menu.

7. Click and drag to highlight the first 5 s of data collected. Click the Statistics button, [ ], click the box in front of Run 1 to obtain statistics for this run, and click [OK]. Record the minimum and maximum values displayed in Table 1, rounding to the nearest 0.01 mV.

8. Drag the Statistics brackets to highlight each of the next 5 s intervals until you reach 20 s (5–10 s, 10–15 s, 15–20 s). Record the minimum and maximum values displayed in the Statistics boxes in Table 1. When you are finished, close the Statistics box by clicking the × in the corner of the box. Note: You may have to slightly adjust the time parameters for the data selected, as flexion and relaxation times may not conform strictly to the 5-second time periods.

**Ergonomics and Muscle Protection**

9. Obtain a 1–2 kg (3 lb) weight (barbell or similar) from your instructor.

10. Place your relaxed hand on the weight, with your palm facing downward. Click [Collect] to begin data collection. If your graph has a stable baseline, click [Stop] and continue to Step 11. If your graph has an unstable baseline, click [Stop] and repeat data collection until you have obtained a stable baseline for approximately 5 s.

11. Collect data to examine the effect of lifting a weight using your extensor muscles:
   a. Click [Collect].
   b. After recording a stable baseline for 5 s, grip the weight with your hand. Using only the action of your wrist, lift the weight to a height of 5–10 cm off the surface of the table (Figure 5). Hold this position for 5 s.
   c. Gently lower the weight onto the table and rest for 5 s.
   d. Repeat the extension and relaxation action for one more full cycle—5 s with the hand cocked, followed by 5 s with the hand in a resting position. Data will be collected for 25 s.

12. Store this run by choosing Store Latest Run from the Experiment menu.

13. Click and drag to highlight the first 5 s of data collected. Click the Statistics button, [ ], click the box in front of Run 2 to obtain statistics for this run, and click [OK]. Record the minimum and maximum values displayed in Table 1, rounding to the nearest 0.01 mV.

14. Drag the Statistics brackets to highlight each of the next 5 s intervals until you reach 20 s (5–10 s, 10–15 s, 15–20 s). Record the minimum and maximum values displayed in the Statistics boxes in Table 1. When you are done, close the Statistics box by clicking the × in
the corner of the box. Note: You may have to slightly adjust the time parameters for the data selected, as flexion and relaxation times may not conform strictly to the 5-second time periods.

15. Place your hand, palm facing upwards, under the weight. Lightly grip the weight. Click \textbf{Collect} to begin data collection. If your graph has a stable baseline, click \textbf{Stop} and continue to Step 16. If your graph has an unstable baseline, click \textbf{Stop} and repeat data collection until you have obtained a stable baseline for approximately 5 s.

16. Collect data while lifting a weight using your flexor muscles:
   a. Click \textbf{Collect}.
   b. After recording a stable baseline for 5 s, using only the action of your wrist, lift the weight to a height of 5–10 cm off the surface of the table (see Figure 6). Hold this position for 5 s.
   c. Gently lower the weight onto the table and rest for 5 s.
   d. Repeat the flexation and relaxation action for one more full cycle–5 s of flexing upward with weight, followed by 5 s with the hand in a resting position.

17. Click and drag to highlight the first 5 s of data. Click the Statistics button, click the box in front of Run 3 to obtain statistics for this run, and click \textbf{OK}. Record the minimum and maximum values in Table 1, rounding to the nearest 0.01 mV.

18. Drag the Statistics brackets to highlight each of the 5-second intervals until you reach 20 s (5–10 s, 10–15 s, 15–20 s). Record the minimum and maximum values in Table 1. Note: You may have to slightly adjust the time parameters for the data selected.

19. Calculate the difference between each minimum and maximum value and record this value in the data table.
DATA

<table>
<thead>
<tr>
<th>Condition</th>
<th>Interval (approximate)</th>
<th>Minimum (mV)</th>
<th>Maximum (mV)</th>
<th>ΔmV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fingers resting on table</td>
<td>0–5 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand cocked back</td>
<td>5–10 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fingers resting on table</td>
<td>10–15 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand cocked back</td>
<td>15–20 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fingers resting on weight–overhand</td>
<td>0–5 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand cocked back with weight</td>
<td>5–10 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fingers resting on weight–overhand</td>
<td>10–15 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand cocked back with weight</td>
<td>15–20 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fingers loosely gripping weight–underhand</td>
<td>0–5 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand flexed upward with weight</td>
<td>5–10 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fingers loosely gripping weight–underhand</td>
<td>10–15 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand flexed upward with weight</td>
<td>15–20 s</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DATA ANALYSIS

1. Reviewing your data, what conclusion can you reach regarding the relationship between the strength of muscle contraction and the amplitude of electrical activity generated?

2. What do the results in Table 1 show about the relationship between hand position and muscle activity when lifting an object?

3. What advice would you give to a friend with tennis elbow about how she should lift a frying pan onto the stove or a can of paint onto a work bench?
4. Using what you have learned in this experiment, explain why a wrist brace is effective treatment for tennis elbow.

5. Some people keyboard with their wrists resting on the table or on a wrist support. In light of what you have learned from this experiment, would you recommend this practice as a way of preventing injury to the extensor muscles of the forearm? Why or why not?

6. Based on this experiment, what advice would you give to a beginning piano player about proper hand position?

7. Pitcher’s elbow is a repetitive use injury of the medial epicondyle. What do the muscles that attach to the medial epicondyle control? How would you adapt this experiment to test these muscles?

**EXTENSION**

In Step 2, the leads may be placed on the ventral forearm instead of the dorsal forearm (Figure 6). The remaining steps can then be carried out without change. Explain the resulting EMG tracing.
Vernier Lab Safety Instructions Disclaimer

THIS IS AN EVALUATION COPY OF THE VERNIER STUDENT LAB.

This copy does not include:

- Safety information
- Essential instructor background information
- Directions for preparing solutions
- Important tips for successfully doing these labs