

Lab 5: Electromyograms (EMGs)

Overview

A motoneuron and all the muscle fibers that it innervates is known as a motor unit. Under normal circumstances, a neuronal action potential activates all of the muscle fibers in the motor unit. This activation process involves a muscular action potential and a contraction of the muscle fibers. During a contraction, there is synchronous activity in a number of fibers in the same muscle. The electrical signal recorded from a contracting muscle is called an electromyogram or EMG. As in the electrocardiogram (ECG), this activity can be detected by electrodes placed on the skin. A muscle contraction is produced by multiple action potentials in multiple fibers. Therefore, the EMG is not a series of predictable waves like those of the ECG, but a burst of spike-like signals. Integrating this complex signal will give an indication of the intensity of muscle activity during a contraction.

Clinically, recording of EMGs is very important to detect the cause of motor unit diseases. The motor unit has four functional components: the motoneuron, the axon of the motoneuron, the neuromuscular junction and the muscle cells innervated by the motoneuron. Recording of the EMG may help determine whether a motor unit disease is due to injury of the nerve or the muscle. Thus, motoneuron injuries are characterized by spontaneous activity at rest (also known as fibrillations or spontaneous activity in single muscle fibers), and reduced spike amplitude during maximal contraction. These features are absent following muscle injuries (like muscular dystrophies and myotonia). Nerve injuries resulting from demyelination generate a significant slow down in the conduction velocity of electrical signals in a nerve and can be detected by EMG.

In this lab you will record EMGs from arm muscles and examine recruitment, tetanus and temporal motor activity of antagonistic muscle groups.

Equipment Required

PC computer
iWorx/214 and USB cable
AAMI cable and five EMG leads
Alcohol swabs

Notice: During the following experiments the person being tested **can not look** at the computer screen!

Equipment Setup

- 1 Connect the iWorx/214 unit to the computer.
- 2 The volunteer should remove all jewelry from their wrists and ankles.
- 3 Use an alcohol swab to clean and scrub three regions on the left forearm for electrode attachment (Figure 3-15). One area is near the wrist, the second is in the middle of the forearm, and the third area is about 2 inches from the elbow. Let the areas dry.

4 Remove the plastic disk from a disposable electrode and apply it to one of the scrubbed areas. Repeat for the other two areas.

5 Attach the AAMI connector on one end of the cable to the isolated Channel 1 and 2 inputs on the iWorx/214 unit.

6 Attach three color-coded electrode cables to the ground and Channel 1 inputs on the lead pedestal and snap the other ends onto the disposable electrodes, so that:

- the red “+1” lead is attached to the electrode near the elbow
- the black “-1” lead is attached to the electrode in the middle of the forearm.
- the green “C” lead (the ground) is attached to the electrode on the wrist.

7 The volunteer should hold a small object (like the bulb of the hand dynamometer) in their right hand.

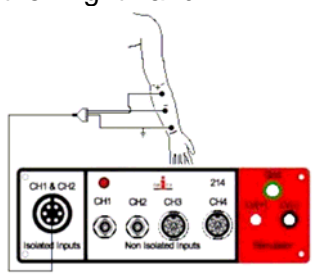


Figure 3-15: The equipment used to monitor EMGs from a volunteer.

Start the Software

1 Click the Windows **Start** menu, move the cursor to **Programs** and then to the **iWorx** folder and select **LabScribe**; or click on the LabScribe icon on the Desktop

2 When the program opens, select **Load Group** from the **Settings** menu.

3 When the dialog box appears, select **ahk214.iws** and then click **Load**.

4 Click on the **Settings** menu again and select the **EMG-214** settings file.

5 After a short time, LabScribe will appear on the computer screen as configured by the **EMG-214** settings.

Exercise 1: Recruitment and the EMG

Aim: To examine the EMG when more fibers are recruited into a single twitch.

Procedure

1 Click **Start**. The subject should hold a **ball** in their hand. Squeeze the ball using a

single, brief twitch of your fingers. Click **Stop**.

2 Click the **AutoScale** buttons for the **EMG** (CH 1) and **EMG Integral** (CH 2) channels. Examine the recording; it should be similar to Figure 3-16.

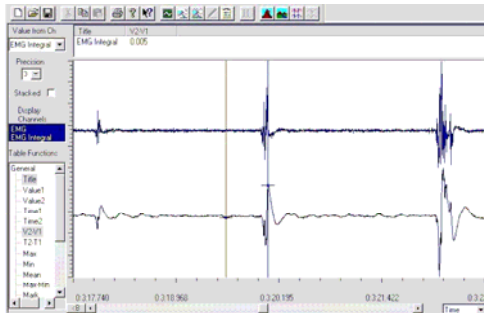


Figure 3-16: The EMG (upper trace) and the integral (lower trace) recorded during three increasing finger movements. The data are displayed in the Analysis window and the two cursors are positioned to measure the amplitude of the second integrated response.

3 Click **Start**, Type “EMG and Increasing Twitches” in the comment line to the right of the **Marks** button. Press the **Enter** key on the keyboard.

4 Record EMGs from a series of single twitches that begin with a gentle contraction and gradually increase in intensity until a maximum response is attained. Press the **Enter** key on the keyboard, when each contraction occurs. Click **Stop** to halt recording.

5 Select **Save As** in the **File** menu, type a name for the file. Choose a destination on the computer in which to save the file (e.g. the **iWorx** or class folder). Click the **Save** button to save the file (as an ***.iwd** file).

Data Analysis

1 Scroll the data on the Main window until the first twitch of the series is positioned in the center of the screen.

2 Click the **2-Cursor** icon (Figure 3-17), so that two blue vertical lines appear over the recording window.

3 Drag the lines to the left and right so that the twitch is between the two blue lines.

4 Click the **Analysis** icon (Figure 3-17) to open the **Analysis** window.

5 Display only the **EMG Integral** (CH 2) by clicking and deselecting Channel 1 (**EMG**) in **Display Channel** list, on the left side of the **Analysis** window.

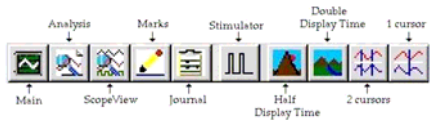


Figure 3-17: The LabScribe toolbar.

6 Use the mouse to click and drag one cursor to the baseline, prior to the first response, and the second cursor to the peak of the integrated response (Figure 3-18).

7 Select **Title** and **V2-V1** from the **Table Functions** list on the left side of the **Analysis** window. This data can be entered into the **Journal** by either typing the titles and values directly or by using the right-click menu. Place the cursors to take measurements; then, select **Add Title to Journal** or **Add Data to Journal** from the right click menu to add the measurements to the **Journal**. Repeat for all responses.

8 Measure the amplitudes of the other twitch integrals in the series and record their values in the **Journal**.

Questions

1 Is there a correlation between the amplitude of the integrated EMG signal and the amount of contraction?

2 Look at your data. Is the duration (length) of each integrated signal about the same for each contraction? If not, this would indicate that some fibers are contracting more than once because they were stimulated by more than a single action potential in the motorneurons.

3 How do you explain the increase in the amplitude of the integrated EMG signal with an increase in contraction?

***Hint:** If a contraction involves a single twitch of the contracting muscle fibers, how can the contraction amplitude be increased without making the muscle fibers twitch more than once?*

Exercise 2: Maximum Finger Contraction

Aim: To measure the EMG when the fingers are squeezed hard.

Procedure

1 Click **Start**. Type “Hard Squeeze.” in the comment line to the right of the **Marks** button.

2 Ask the subject to squeeze **the ball** in their hand as hard as they can. Press the **Enter** key on the keyboard. Have the subject relax their hand.

3 Click **Stop** to halt recording.

4 Select **Save** in the **File** menu.

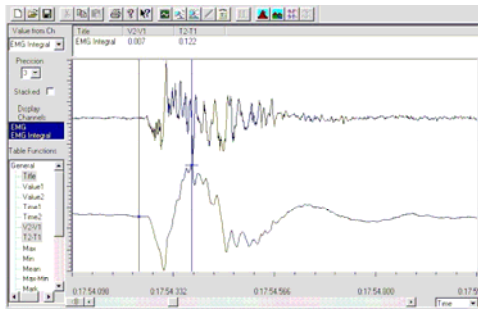


Figure 3-18: An EMG (upper trace) and the integral (lower trace) recorded during a maximum contraction. The data are displayed in the Analysis window and the two cursors are positioned to measure the amplitude of the integrated response.

Data Analysis

Your EMG data should like Figure 3-18.

1 Click the **2-Cursor** icon (Figure 3-17), so that two blue vertical lines appear over the recording window.

2 Drag the lines to the left and right so that the whole contraction is between the two blue lines.

3 Click the **Analysis** icon (Figure 3-17) to open the **Analysis** window.

4 Select **EMG integral** from the **Value from Ch** menu. Select **Title**, **V2-V1**, and **T2-T1** from the **Table Functions** list.

5 Use the mouse to click and drag:

- one cursor to the baseline, prior to the contraction, and the second cursor on the peak of the integral on Channel 2 (**EMG Integral**) to measure the amplitude of the contraction (**V2-V1**).
- one cursor to the beginning and the other to the end of the EMG trace recorded on Channel 1 (**EMG**) to measure the contraction time (**T2-T1**).

6 This data can be entered into the **Journal** by either typing the titles and values directly or by using the right-click menu. Place the cursors to take measurements; then, select **Add Title to Journal** or **Add Data to Journal** from the right click menu to add the measurements to the **Journal**.

7 Also, measure **V2-V1** and **T2-T1** for the largest single twitch recorded in the previous exercise.

Questions

- 1 Using the EMG Integral data, compare the amplitude of the maximum (hard) squeeze with the maximum single twitch. Which is larger?
- 2 If all fibers were contracting in both instances (maximum squeeze and maximum single twitch) explain why the maximum squeeze produced a larger contraction.
- 3 Compare the duration of this maximum squeeze with the maximum single twitch. Which is longer?
- 4 How does the amplitude of the EMG Integral correlate to the duration of the contraction?

Hint: During the second exercise do you think each motor axon fired only once to produce the maximum squeeze? Does the level of intracellular calcium return to normal immediately after a contraction?

Exercise 3: Tetanus and Movement

Aim: To examine the relationship between tetanus and movement.

Procedure

- 1 Place recording electrodes on the left biceps as shown in Figure 3-19.
 - the red “+1” lead is attached to the electrode just below the shoulder.
 - the black “-1” lead is attached to the electrode in the middle of the biceps.
 - the green “C” lead is attached to the electrode just above the elbow.
- 2 Ask the subject to sit on a chair and support their left elbow with their right hand. Place your left hand over the bench top with the palm facing up. Place a **heavy book** on top of the hand.
- 3 Click **Start**. Type “Tetanus” in the comment line to the right of the **Marks** button.
- 4 Ask the subject to flex their left arm against the weight of **the book**.
- 5 Press the **Enter** key on the keyboard.

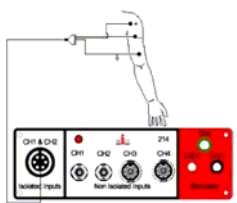


Figure 3-19: The equipment used to monitor EMGs from the biceps muscle of a volunteer.

6 After 15 seconds of hard flexing ask the volunteer to stop, extend their arm and relax (the right hand should still support the left elbow).

7 Click **Stop** to halt recording.

8 Select **Save** in the **File** menu.

Questions

1 When the lower arm was bent toward the shoulder, was the biceps muscle contracting or relaxing?

2 Does myogram activity in the biceps muscle occur during flexion or extension?

3 How does the lower arm move in the absence of significant EMG activity in the biceps?

Exercise 4: Integration of motor activity

Aim: To study activity in antagonistic muscles during normal movement.

Procedure

1 Place another pair of recording electrodes on the left triceps, so that :

- the white "+2" lead is placed on the upper portion of the triceps.
- the brown "-2" lead is placed in the middle of the triceps.

2 Go to the Settings menu and select. **EMG-OpposingMuscles-214**. LabScribe will be configured to record EMGs from the biceps and the triceps on Channels 1 and 2, respectively, and their respective EMG Integrals on Channels 3 and 4.

3 Ask the volunteer to stand up.

4 Click **Start**. Type "No Weight" in the comment line to the right of the **Mark** button, and press the **Enter** key on the keyboard.

5 Ask the volunteer to bend and extend their arm slowly. Type "Bend" and press the **Enter** key every time they bend their arm.

6 Click **Stop** to halt recording

7 Repeat the experiment, while the volunteer try to move the arms against the weight of another person. For this purpose ask the volunteer to try to flex the arm against another person holding his wrist.

8 Click **Start**. Type "Weight" on the comment line to the right of the **Mark** button, and press the **Enter** key to annotate the record.

9 Ask the volunteer to try to contract the arm against the person holding his wrist.

10 Click **Stop** to halt recording.

11 Select **Save** in the **File** menu.

12 Repeat while the volunteer try to push down the arm against the person holding his wrist.

Questions: Look at your data:

1 Where do you see myogram activity when the arm is extended away from the shoulder? When the arm is flexed?

2 Does EMG activity increase or decrease when more weight is moved? What is the relationship between motorneuron activity, EMGs, muscle performance, and work?

3 If the weight is held at arm's length, does EMG activity increase, decrease, or remain constant for the duration of the experiment?

4 Why would muscle activity increase if the load being moved is constant?