



# Lesson 1

## ELECTROMYOGRAPHY I

*Standard and Integrated EMG*

Physiology Lessons  
for use with the  
Biopac Student Lab

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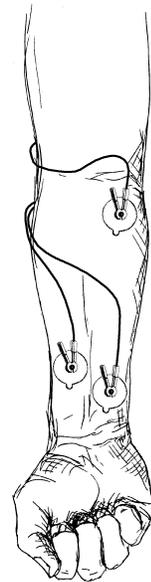
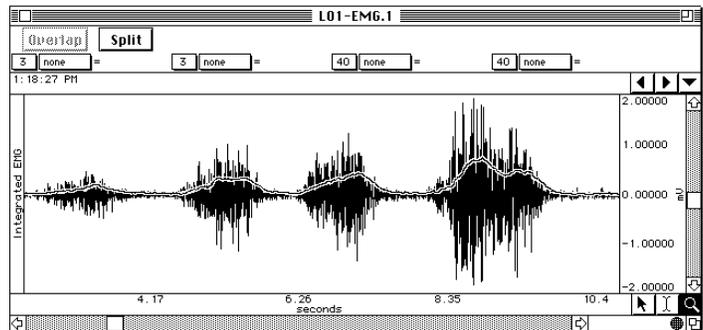
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## II. EXPERIMENTAL OBJECTIVES

- 1) To observe and record skeletal muscle tonus as reflected by a basal level of electrical activity associated with the muscle in a resting state.
- 2) To record maximum clench strength for right and left hands.
- 3) To observe, record, and correlate motor unit recruitment with increased power of skeletal muscle contraction.
- 4) To listen to EMG “sounds” and correlate sound intensity with motor unit recruitment.

## III. MATERIALS

- BIOPAC electrode lead set (SS2L)
- BIOPAC disposable vinyl electrodes (EL503), 6 electrodes per subject
- BIOPAC Headphones (OUT1)
- BIOPAC electrode gel (GEL1) and abrasive pad (ELPAD) *or* Skin cleanser or alcohol prep
- Computer system
- Biopac Student Lab 3.7
- BIOPAC data acquisition unit (MP36, MP35, or MP30 with cable and power)

## IV. EXPERIMENTAL METHODS



For further explanation, use the online support options under the Help Menu.

### A. SET UP

#### FAST TRACK Set Up

1. Turn your computer **ON**.
2. Make sure the BIOPAC MP3X unit is **OFF**.
3. **Plug the equipment in** as follows:  
Electrode lead (SS2L) — CH 3  
Headphones (OUT1) — back of unit

Set Up continues...

#### DETAILED EXPLANATION OF SET UP STEPS

The desktop should appear on the monitor. If it does not appear, ask the laboratory instructor for assistance.

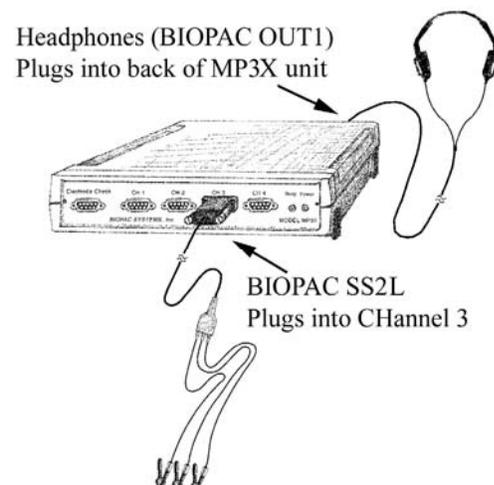


Fig. 1.2

4. Turn **ON** the BIOPAC MP3X unit.



5. **Attach three electrodes** to the forearm (Fig. 1.3).

Attach three electrodes to the forearm as shown in Fig. 1.3.

For the first recording segment, select the **Subject's** dominant forearm (generally the right forearm if the **Subject** is right-handed, or the left forearm if the **Subject** is left-handed) and attach the electrodes onto the forearm as shown; this will be **Forearm 1**.

Use the **Subject's** other arm for the second recording segment; this will be **Forearm 2**.

**Note:** For optimal electrode adhesion, the electrodes should be placed on the skin at least 5 minutes before the start of the Calibration procedure.



6. Attach the electrode lead set (SS2L) to the electrodes, following the color code (Fig. 1.3).

**IMPORTANT**

Make sure the electrode lead colors match Fig. 1.3.

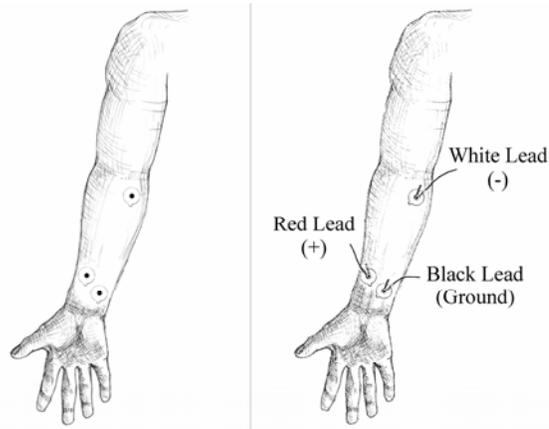


Fig. 1.3 Electrode placement and lead attachment

Each of the pinch connectors on the end of the electrode cable needs to be attached to a specific electrode. The electrode cables are each a different color. Follow Fig. 1.3 to ensure that you connect each cable to the proper electrode.

The pinch connectors work like a small clothespin, but will only latch onto the nipple of the electrode from one side of the connector.

7. **Start** the Biopac Student Lab Program.



8. Choose lesson "**L01-EMG-1**" and click **OK**.



9. Type in a unique **filename**.

No two people can have the same filename, so use a unique identifier, such as the **Subject's** nickname or student ID#.



10. Click **OK**.

This ends the Set Up procedure.

**END OF SET UP**

## B. CALIBRATION

The Calibration procedure establishes the hardware's internal parameters (such as gain, offset, and scaling) and is critical for optimum performance. **Pay close attention to the Calibration procedure.**

### FAST TRACK Calibration

1. Click on **Calibrate**.
2. Read the dialog box and click **OK** when ready.
3. **Wait** about two seconds, **clench** your fist as hard as possible, then **release**.
4. **Wait** for Calibration to stop.
5. **Check** the Calibration data.
  - If similar, proceed to the data Recording Section.

- If different, **Redo Calibration**.

**END OF CALIBRATION**

### DETAILED EXPLANATION OF CALIBRATION STEPS

This will start the Calibration recording.

A dialog box pops-up when you click **Calibrate**, telling you how to prepare for the calibration. The calibration will not begin until you click **OK**.

The program needs a reading of your maximum clench to perform an auto-calibration.



Clench Fist

Fig. 1.4

The Calibration procedure will last eight seconds and stop automatically, so let it run its course.

At the end of the eight-second Calibration recording, the screen should resemble Fig.1.5.

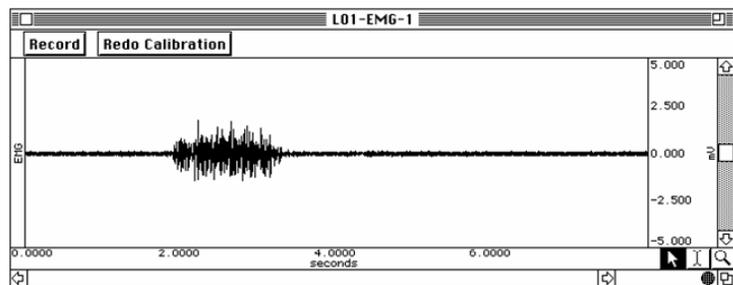


Fig. 1.5

If your calibration recording did not begin with a zero baseline (**Subject** clenched before waiting two seconds), you need to repeat calibration to obtain a reading similar to Fig. 1.5.

## C. DATA RECORDING

### FAST TRACK Recording

1. Prepare for the recording.

#### SEGMENT 1 — Forearm 1 (Dominant)

2. Click **Record**.
3. Clench-Release-Wait and repeat with increasing force to reach your maximum force on the fourth clench.
4. Click **Suspend**.
5. Review the data on the screen.
  - If similar and more recording segments are required, go to **Step 7**.

- If different, go to **Step 6**.

6. Click **Redo** if your data did not match Fig. 1.6, and **repeat Steps 2-5**.
7. Remove the electrodes from your forearm.

#### SEGMENT 2 — Forearm 2

8. For **Forearm 2**, attach electrodes and leads to **Subject's** opposite arm.
9. Click **Resume**.

Recording continues...

### DETAILED EXPLANATION OF RECORDING STEPS

You will record two segments:

- a. Segment one records **Forearm 1 (Dominant)**.
- b. Segment two records **Forearm 2**.

In order to work efficiently, read this entire section so you will know what to do before recording.



Check the last line of the journal and note the amount of time available for the recording. Stop each recording segment as soon as possible to not waste recording time (time is memory).

When you click **Record**, the recording will begin and an append marker labeled “Forearm 1” will automatically be inserted.

Repeat a cycle of Clench-Release-Wait, holding for 2 seconds and waiting for two seconds after releasing before beginning the next cycle. Try to increase the strength in equal increments such that the fourth clench is the maximum force.

The recording should halt, giving you time to review the data and prepare for the next recording segment. If all went well, your data should look similar to Fig. 1.6.

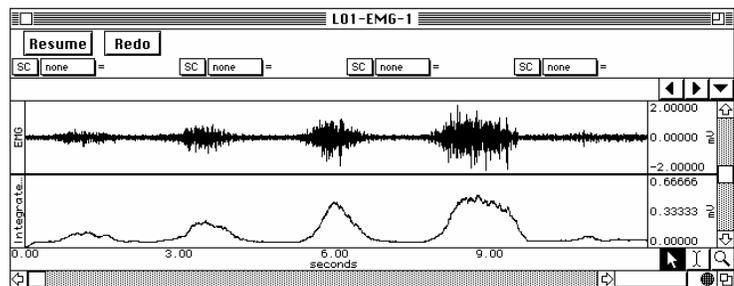


Fig. 1.6 Clench, Release, Wait, Repeat

The data would be different if the:

- a. The **Suspend** button was pressed prematurely.
- b. Instructions were not followed.

Click **Redo** and repeat Steps 2-5 if necessary. Note that once you press **Redo**, the data you have just recorded will be erased.

Remove the electrode cable pinch connectors, and peel off the electrodes. Throw out the electrodes (BIOPAC electrodes are not reusable). Wash the electrode gel residue from your skin using soap and water. The electrodes may leave a slight ring on the skin for a few hours, which is quite normal.

Refer to the Set Up Steps 5 and 6 and Fig 1.3 for proper electrode placement and lead attachment.

When you click **Resume**, the recording will continue and an append marker labeled “Forearm 2” will be automatically inserted.

10. Clench-Release-Wait and repeat with increasing force to reach your maximum force on the fourth clench.
11. Click on **Suspend**.
12. Review the data on the screen.
- If similar, go **Step 14**.
  - If different, go to **Step 13**.
13. If your data did not match Fig. 1.6, click **Redo** and repeat **Steps 9-12**.
14. Click **Stop**.
15. If you want to listen to the EMG signal, go to Step 16.
- or*
- If you want to end the recording, go to Step 21.
16. **Subject** puts on the headphones.
17. Click **Listen**.
18. Experiment by changing the clench force as you watch the screen and listen.
19. Click **Stop**.
20. To listen again, click **Redo**.
21. Click **Done**.
- Repeat a cycle of Clench-Release-Wait, holding for 2 seconds and waiting for two seconds after releasing before beginning the next cycle. Try to increase the strength in equal increments such that the fourth clench is the maximum force.
- The recording should halt, giving you time to review the data for segment two.
- If all went well, your data should look similar to Fig. 1.6.
- The data would be incorrect if the:
- a. The **Suspend** button was pressed prematurely.
  - b. Instructions were not followed.
- Click **Redo** and repeat Steps 9-12 if necessary. Note that once you press **Redo**, the data you have just recorded will be erased.
- When you click **Stop**, a dialog box comes up, asking if you are sure you want to stop the recording. Clicking “yes” will end the data recording segment, and automatically save the data. Clicking “no” will bring you back to the **Resume** or **Stop** options. This is simply one last chance to confirm you don’t need to redo the last recording segment.
- Listening to the EMG can be a valuable tool in detecting muscle abnormalities, and is performed here for general interest.
- Listening to the EMG is optional. The data from this part of the Lesson will not be saved. EMG data is sent to the headphones and simultaneously plotted so you can listen to the signal and see it at the same time. Note the increase in sound intensity as you increase the strength of your clench.*
- Note:** When the **Listen** button is clicked in the next step, it’s possible that the volume through the headphones may be very loud due to system feedback. The volume cannot be adjusted, so you may have to position the headphones slightly off the ear to reduce the sound.
- You will hear the EMG signal through the headphones as it is being displayed on the screen. The screen will display two channels: CH 3 EMG and CH 40 Integrated EMG. The data on the screen will not be saved.
- The signal will run until you press **Stop**.
- If others in your lab group would like to listen to the EMG signal, pass the headphones around before clicking **Stop**.
- This will end listening to the EMG.
- If another person wants to listen to the EMG, switch the headphones from the **Subject** to the new person and click **Redo**.
- A pop-up window with options will appear. Make your choice, and continue as directed.
- If choosing the “Record from another Subject” option:
- a) Attach electrodes per Set Up Step 5 and continue the entire lesson from Set Up Step 8.
  - b) Each person will need to use a unique file name.

<b>END OF RECORDING</b>
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## V. DATA ANALYSIS

### FAST TRACK Data Analysis

1. Enter the **Review Saved Data** mode and choose the correct file.

Note Channel Number (CH) designations:

*Channel*    *Displays*

**CH 3**        **EMG**

**CH 40**      **Integrated EMG**

2. Setup your display window for optimal viewing of the first data segment.

3. Set up the measurement boxes as follows:

*Channel*    *Measurement*

**CH 3**        **min**

**CH 3**        **max**

**CH 3**        **p-p**

**CH 40**      **mean**

### DETAILED EXPLANATION OF DATA ANALYSIS STEPS



Enter the Review Saved Data mode.

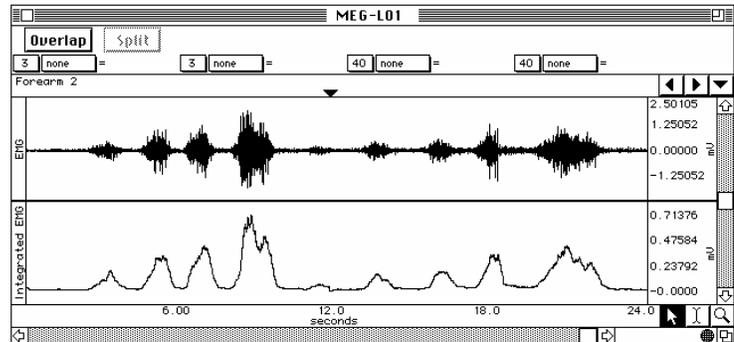


Fig. 1.7

Fig. 1.8 below shows a sample display of the first data segment recorded using the arm of the **Subject's** dominant hand.



The following tools help you adjust the data window:

Autoscale horizontal	Horizontal (Time) Scroll Bar
Autoscale waveforms	Vertical (Amplitude) Scroll Bar
Zoom Tool	Overlap button
Zoom Previous	Split button

The measurement boxes are above the marker region in the data window. Each measurement has three sections: channel number, measurement type, and result. The first two sections are pull-down menus that are activated when you click on them. The following is a brief description of these specific measurements.

**min:** displays the minimum value in the selected area.

**max:** displays the maximum value in the selected area.

**p-p:** finds the maximum value in the selected area and subtracts the minimum value found in the selected area.

**mean:** displays the average value in the selected area.

The “selected area” is the area selected by the I-Beam tool (including the endpoints).

You can record measurement data individually by hand or choose **Edit > Journal > Paste measurements** to paste the data to your journal for future reference.

**Data Analysis continues...**

4. Using the **I-Beam** cursor, select an area enclosing the first EMG cluster (Fig. 1.8).

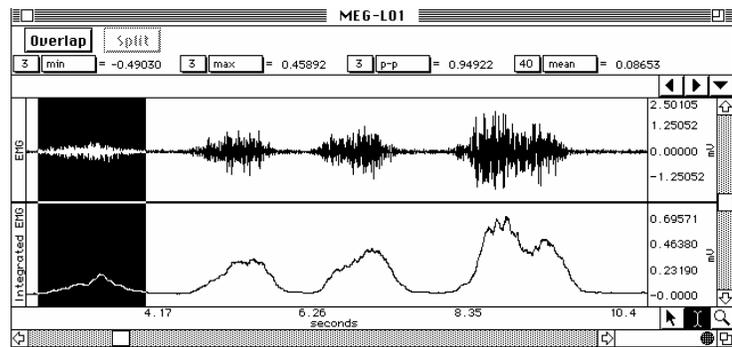


Fig. 1.8

Note: "Clusters" are the EMG bursts associated with each clench. A sample cluster is selected in the figure above.

5. Repeat Step 4 on each successive EMG cluster.



6. Scroll to the second recording segment.

The second recording segment begins at the marker labeled "Forearm 2" and represents the non-dominant arm.

7. Repeat Steps 4 and 5 for the Forearm 2 data.

8. Scroll to the first recording segment and select for measurement areas of tonus (between clenches) for Forearm 1, the dominant arm.

Tonus is the resting state, and is represented by the area between clenches (clusters). Measure for Forearm 1, the dominant arm.



9. Scroll to the second recording segment and select for measurement areas of tonus (between clenches) for Forearm 2, the non-dominant arm.

Tonus is the resting state, and is represented by the area between clenches (clusters). Measure for Forearm 2, the non-dominant arm.



10. Save or print the data file.



You may save the data to a drive, save notes that are in the journal, or print the data file.

11. Exit the program.



**END OF DATA ANALYSIS**

## END OF LESSON 1

Complete the Lesson 1 Data Report that follows.

# ELECTROMYOGRAPHY I

## Standard and Integrated EMG

### DATA REPORT

Student's Name: \_\_\_\_\_

Lab Section: \_\_\_\_\_

Date: \_\_\_\_\_

### I. Data and Calculations

#### Subject Profile

Name \_\_\_\_\_

Height \_\_\_\_\_

Age \_\_\_\_\_

Weight \_\_\_\_\_

Gender: Male / Female

#### A. EMG Measurements

Cluster #	Forearm 1 (Dominant)				Forearm 2			
	Min [3 min]	Max [3 max]	P-P [3 p-p]	Mean [40 mean]	Min [3 min]	Max [3 max]	P-P [3 p-p]	Mean [40 mean]
1								
2								
3								
4								

Note: "Clusters" are the EMG bursts associated with each clench.

B. Use the mean measurement from the table above to compute the percentage increase in EMG activity recorded between the weakest clench and the strongest clench of Forearm 1.

Calculation:

\_\_\_\_\_

Answer: \_\_\_\_\_%

#### Tonus Measurements

Cluster #	Forearm 1 (Dominant)		Forearm 2	
	P-P [3 p-p]	Mean [40 mean]	P-P [3 p-p]	Mean [40 mean]
1				
2				
3				
4				

## II. QUESTIONS

C. Compare the mean measurement for the right and left maximum clench EMG cluster.  
Are they the same or different?     Same     Different

Which one suggests the greater clench strength?     Right     Left     Neither

Explain.

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D. What factors in addition to sex contribute to observed differences in clench strength?

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E. Does there appear to be any difference in tonus between the two forearm clench muscles?     Yes     No

Would you expect to see a difference? Does subject's sex influence your expectations? Explain.

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F. Explain the source of signals detected by the EMG electrodes.

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G. What does the term "motor unit recruitment" mean?

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H. Define skeletal muscle tonus.

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I. Define electromyography.

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