



Physiology Lessons
for use with the
Biopac Student Lab

PC running Windows®
98SE, Me, 2000 Pro, XP Pro/Home/Media

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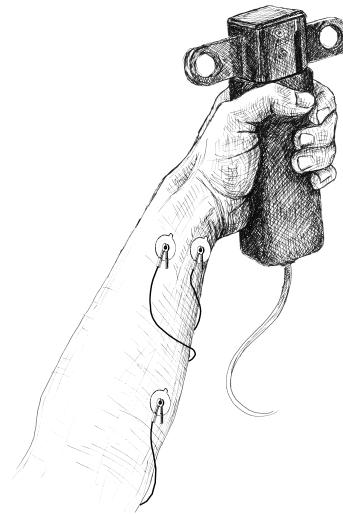
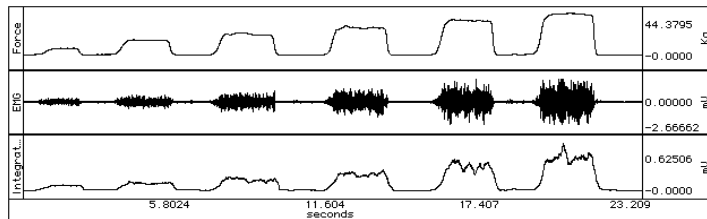
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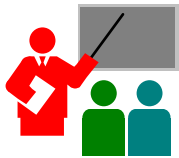
Lesson 2
ELECTROMYOGRAPHY II
Motor unit recruitment
Fatigue



I. INTRODUCTION

Mechanical **work**, in the physical sense, refers to the application of a force that results in the movement of an object. Skeletal muscle performs mechanical work when the muscle contracts and an object is moved, as in lifting a weight. To lift a weight, your muscles must exert a force great enough to overcome the weight. If you exert less force, then the weight does not move (Fig. 2.1).

Physiologically, skeletal muscle is stimulated to contract when the brain or spinal cord activates **motor units** of the muscle.



Motor units are defined as a motoneuron and all of the muscle fibers that the motoneuron innervates. An action potential (AP) in a human motoneuron always causes an action potential in all of the muscle fibers of the motor unit. As a matter of fact, humans generally do not send just one AP at a time down a motoneuron. Instead, a train of APs is sent — enough to induce **tetany** (the sustained fusion of individual muscle twitches) in the muscle fibers of the motor unit. [A discussion of motor units and their control was presented in Lesson 1.]

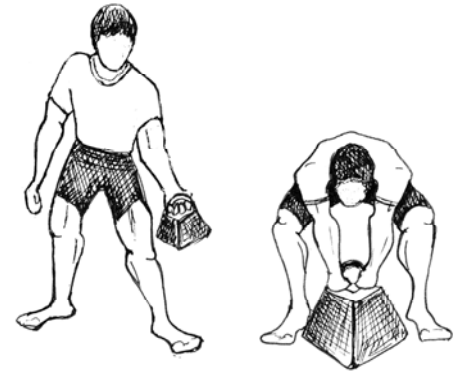


Fig. 2.1

Most human skeletal muscles are composed of hundreds of motor units (Fig. 2.2). When a skeletal muscle is called on to perform mechanical work, the number of motor units in the muscle activated by the brain is proportional to the amount of work to be done by the muscle; the greater the amount of work to be done, the greater the number of motor units activated. Thus, more motor units are simultaneously active when a skeletal muscle lifts 20 kilograms than when the same muscle lifts 5 kilograms.

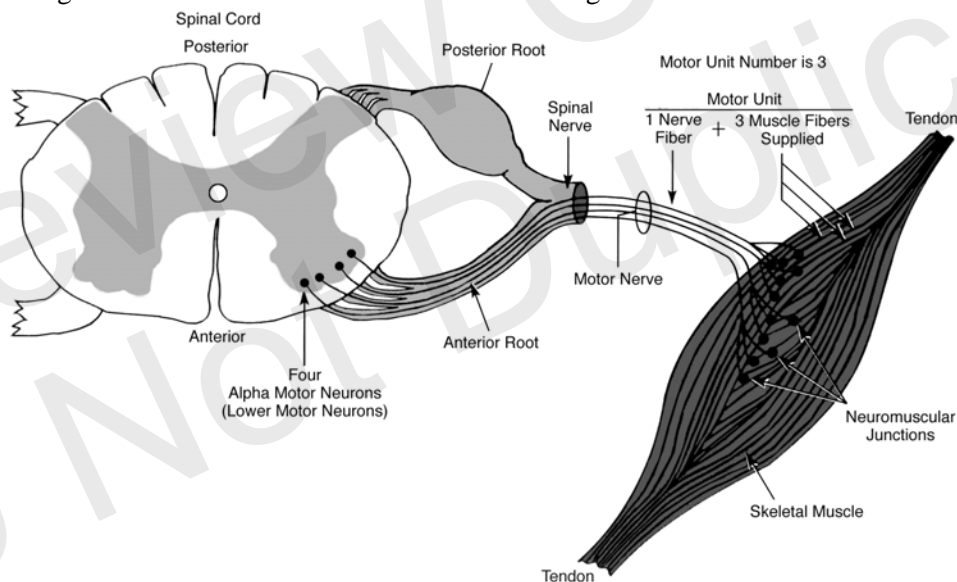


Fig. 2.2 Example of Motor Units

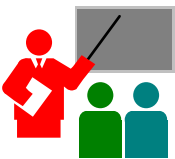
The brain determines the number of active motor units required for a muscle to perform a given task by utilizing sensory information from stretch receptors in the muscle and associated tendons and joint capsules. For example, when lifting a bucket of water from the ground, the brain first activates several motor units in the requisite skeletal muscles. If sensory information returning from the muscles indicates the muscles are contracting but not developing adequate power to lift the bucket, the brain activates additional motor units until the sensory information indicates the bucket is being lifted. The sequential activation of motor units to perform a designated task is called **motor unit recruitment**.

Once you have lifted a light object, the brain recruits approximately the same *number* of motor units to keep the object up, but cycles between *different* motor units. The muscle fibers consume stored energy available in the muscle, and generate a force by contracting. As the muscle fibers deplete this fuel source, more energy must be created in order to continue contracting. By recruiting different motor units, motor units can relax and replenish their fuel sources.

Skeletal muscles performing acute maximum work or chronic submaximum work of a repetitive nature will eventually **fatigue**. Fatigue is defined as a decrease in the muscle's ability to generate force. Fatigue is caused by a reversible depletion of the muscle's fuel supply. If the muscle uses its energy sources faster than they can be generated by cellular metabolism, fatigue occurs. During contraction, skeletal muscle cells convert chemical energy into thermal and mechanical energy, and, in the process, produce chemical waste products.

Normally the waste products are removed from the muscle by the circulatory system as the blood brings nutrients to the muscle for energy transformation. If certain waste products (metabolites) are not removed at an adequate rate, they will accumulate and chemically interfere with the contractile process, thereby hastening the onset of fatigue. Some accumulated waste products also stimulate pain receptors in surrounding connective tissue and induce cramping of skeletal muscle, a general sign of inadequate blood flow to the muscle.

In this lesson, you will examine motor unit recruitment and skeletal muscle fatigue by combining **electromyography** with **dynamometry**.



When a motor unit is activated, the component muscle fibers generate and conduct their own electrical impulses, which cause the fibers to contract. Although the electrical impulse generated and conducted by each fiber is very weak (less than 100 μ volts), many fibers conducting simultaneously induce voltage differences in the overlying skin which are large enough to be detected by a pair of surface electrodes.

The detection, amplification, and recording of changes in skin voltage produced by underlying skeletal muscle contraction is called electromyography, and the recording thus obtained is called an **electromyogram (EMG)**.

Power is defined as the amount of work done per unit of time. **Dynamometry** means the measurement of power (*dyno* = power, *meter* = measure), and the graphic record derived from the use of a dynamometer is called a **dynamogram**.

In this lesson, the power of contraction of clench muscles will be determined by a **hand dynamometer** equipped with an electronic transducer for recording.

The BIOPAC system will simultaneously record three bands of information:

- 1) The force you exert on the transducer,
- 2) The electrical signal produced by the muscle during contraction, and
- 3) The integrated waveform, which is an indication of the activity levels of the muscle.

II. EXPERIMENTAL OBJECTIVES

- 1) To determine the maximum clench strength for right and left hands and compare differences between male and female.
- 2) To observe, record, and correlate motor unit recruitment with increased power of skeletal muscle contraction.
- 3) To record the force produced by clench muscles, EMG, and integrated EMG when inducing fatigue.

III. MATERIALS

- BIOPAC Hand Dynamometer (SS25LA or SS25L)
- BIOPAC Headphones (OUT1)
- BIOPAC electrode lead set (SS2L)
- BIOPAC disposable vinyl electrodes (EL503), 6 electrodes per subject
- BIOPAC electrode gel (GEL1) and abrasive pad (ELPAD) *or* Skin cleanser or Alcohol prep
- Computer system
- Biopac Student Lab software PC 3.7.0 or Mac 3.0.7 or greater
- BIOPAC acquisition unit (MP35 or MP35/MP30) with associated cables
- BIOPAC wall transformer (AC300 or AC100A)

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 MP35/MP30 unit is **OFF**.
3. **Plug the equipment in** as follows:
Hand Dynamometer (SS25LA or SS25L) — CH 1
Electrode lead Set (SS2L) — CH 3
Headphones (OUT1) — back of unit
4. Turn **ON** the BIOPAC MP35/MP30 unit.
5. **Attach three electrodes** to each forearm (Fig. 2.4).
6. Attach the electrode lead set (SS2L) to the Subject's dominant forearm, following the color code (Fig. 2.4).

IMPORTANT

Make sure the electrode lead colors match Fig. 2.4.

Set Up continues...

Detailed Explanation


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



Fig. 2.3 Equipment Setup



Attach three electrodes to each forearm as shown in Fig. 2.4.



- For optimal electrode adhesion, place electrodes on the skin at least 5 minutes before the start of Calibration.

Attach the lead set (SS2L) to the **Subject's** dominant forearm (Fig. 2.4) for recording Segments 1 and 2 (forearm 1).

- If the subject is right-handed, the right forearm is generally dominant; if the subject is left-handed, the left forearm is generally dominant.
- You will switch the lead set to the **Subject's** non-dominant arm for recording Segments 3 and 4 (Forearm 2).

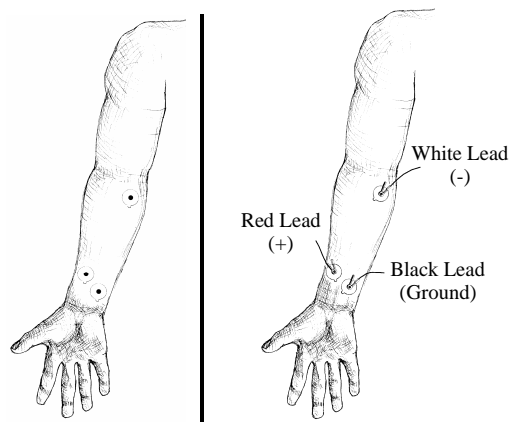


Fig. 2.4 Electrode Placement & Lead Attachment

- The electrode lead cables are each a different color and each must be attached to a specific electrode position, as shown in Fig. 2.4.
- The pinch connectors work like a small clothespin and will only latch onto the nipple of the electrode from one side of the connector.



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

This ends the Set Up procedure.

7. **Start** the BIOPAC Student Lab Program.
8. Choose lesson "**L02-EMG-2**" and click **OK**.
9. Type in a unique **filename**.
10. Click **OK**.

END OF SET UP

Review Copy
Do Not Duplicate

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 **Calibrate**.
2. Set the **hand dynamometer down** and click **OK**.
3. Grasp the BIOPAC hand dynamometer with your hand.

SS25LA: Place the short grip bar against the palm, toward the thumb, and wrap your fingers to center the force.

SS25L: Grasp as close to the dynagrip crossbar as possible *without actually touching the crossbar* (Fig. 2.6).

IMPORTANT

Hold the dynamometer in the same position for all measurements from each arm. Note your hand position for the first segment and try to repeat it for the other segments.

4. Follow the instructions in the successive pop-up windows and click **OK** when ready for each.
5. When Calibration recording begins, **wait** about two seconds, then **clench** the hand dynamometer as hard as possible, and then **release**.
6. **Wait** for Calibration to stop.
7. **Check** the Calibration data.
 - **If correct**, proceed to the data Recording Section.
 - **If incorrect**, **Redo Calibration**.

END OF CALIBRATION

Detailed Explanation of Steps for Calibration

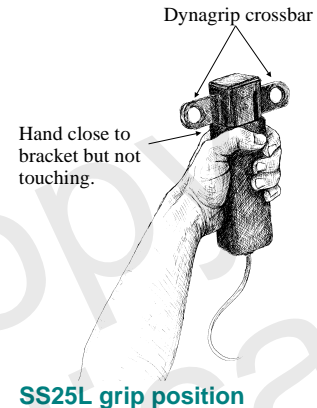
A pop-up window will tell you to remove any grip force from the hand dynamometer. To do so, set the hand dynamometer down.

Remove your hands from the transducer to ensure there is no force on the transducer. This establishes a zero-force calibration before you continue the calibration sequence.

Clench with the hand of your dominant forearm.



SS25LA grip position



SS25L grip position

Fig. 2.5

Pop-up windows will guide you through the initial calibration sequence. After you click OK on the third pop-up window, the Calibration recording will begin.

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

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

After the Calibration recording, the screen should resemble Fig.2.6.

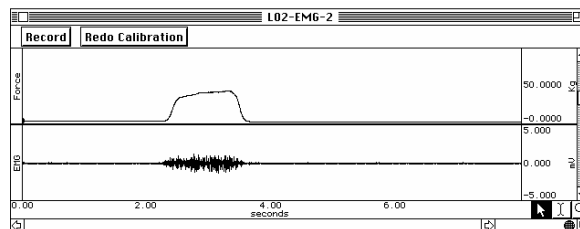


Fig. 2.6

If your recording does not begin with a zero baseline (Subject clenched before two seconds), repeat calibration to match Fig. 2.6.

C. RECORDING LESSON DATA

FAST TRACK RECORDING

1. Prepare for the recording.

SEGMENT 1

2. Note your Assigned Increment level from the journal.

3. Click **Record**.

4. Clench-Release-Wait and repeat with increasing clench force.

5. Click **Suspend**.


6. Review the data on the screen.
 - If correct, go to **Step 8**.

Recording continues...

Detailed Explanation of Steps for Recording Lesson Data

In order to work efficiently, read this entire section so you will know what to do before recording. You will record two segments on each forearm:

- a. Segments 1 and 3 record Motor unit recruitment.
- b. Segments 2 and 4 record Fatigue

Check the last line of the journal and note the total amount of time available for the recording. Stop each recording segment as soon as possible so you don't waste recording time (time is memory) .

Based on your calibrated grip force, the software determines the optimal grid display and force increments. Check the journal and use the indicated increment when directed to increase force throughout the recording. The grid display is set as follows:

<u>Force calibration</u>	<u>Assigned Increment</u>
0-25 kg	5kg
25-50 kg	10 kg
> 50 kg	20 kg

After you click **Record**, the recording will begin and an append marker labeled "Forearm 1, Increasing clench force" will automatically be inserted. The screen will change to display only the hand dynamometer channel, and a grid using your assigned increment as a division scale will appear so that you can visually review the force level.

Repeat a cycle of Clench-Release-Wait, holding for 2 seconds and waiting for two seconds after releasing before beginning the next cycle. Begin with your Assigned Increment of force (5, 10 or 20 kg) and increase by the Assigned Increment (5-10-15, 10-20-30, or 20-40-60 for example) for each cycle until maximum clench force is obtained.

The recording should halt, giving you time to review the data and prepare for the next recording segment of Forearm 1.

If all went well, your data should look similar to Fig. 2.7.

- The important aspect for you to review is that the data shows multiple peaks (indicating the clench cycles).
- The data shown is from a Subject who was able to maintain an even force throughout the clench. Your data may be correct even if your peaks are not smooth.

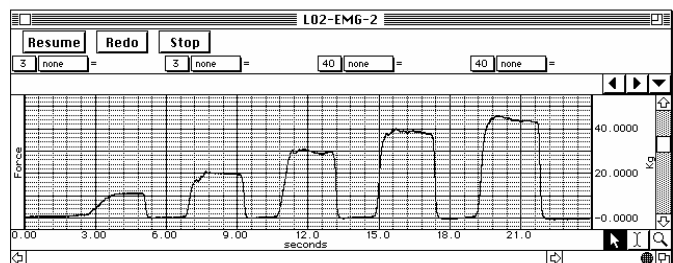


Fig. 2.7 Motor Unit Recruitment

➤ If incorrect, go to **Step 7**.

7. Click **Redo** if your data was incorrect and **repeat Steps 3-6**.

SEGMENT 2

8. Click **Resume**.

9. Clench the hand dynamometer with your maximum force. Note this force and try to maintain it.

10. When the maximum clench force displayed on the screen has **decreased by more than 50%**, click **Suspend**.

11. Review the data on the screen.

➤ If correct, go **Step 13**.

➤ If incorrect, go to **Step 12**.

12. Click **Redo** if your data was incorrect, and **repeat Steps 8-11**.

Connect the lead set (SS2L) to the Subject's non-dominant forearm and click **OK**.

Recording continues...

The data would be incorrect if the:

- Suspend** was clicked prematurely.
- Instructions were not followed.

Click "**Redo**" and repeat Steps 3-6 if necessary. Note that once you click **Redo**, the data you have just recorded will be erased.

When you click **Resume**, the recording will continue and an append marker labeled "Forearm 1, Continued clench at maximum force" will be automatically inserted.

Note the maximum clench force so you can determine when the force has decreased by 50% (the maximum force may scroll out of view). Try to maintain the maximum clench force (the forearm will fatigue and the force will decrease).

The time to fatigue to 50% of maximal clench force will vary greatly among individuals.

When you click **Suspend**, 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. 2.8.

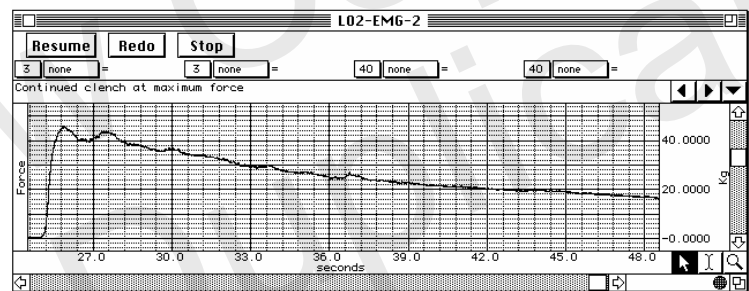


Fig. 2.8 Fatigue

Note that the peak found immediately following the start of the Segment represents the maximal clench force. This example shows the point of fatigue to 50% maximal clench force captured on the same screen, but your maximum force may scroll out of view. You may use the horizontal (time) scroll bar to view your entire recording.

The data would be incorrect if:

- You didn't record to the point of 50% maximal clench force.
- Suspend** was clicked prematurely.
- The instructions were not followed.

Click "**Redo**" and have the Subject rest so the arm muscles recover and the fatigue data will be meaningful. When ready repeat Steps 8-11. Note that once you click **Redo**, the data you have just recorded will be erased.

Connect the lead set (SS2L) to the Subject's non-dominant forearm for the next recording segment. Click **OK**.

SEGMENT 3

13. To record Forearm 2, connect to the electrodes that are attached (per Set Up Step 5) to the **Subject's non-dominant forearm**.

IMPORTANT
Make sure the electrode lead colors match Fig. 2.9.

14. Note your Assigned Increment level from the journal.
15. Click **Resume**.
16. Clench-Release-Wait and repeat with increasing clench force.
17. Click **Suspend**.
18. Review the data on the screen.
- If correct, go to **Step 21**.
 - If incorrect, go to **Step 20**.
19. Click **Redo** if your data was incorrect and **repeat Steps 15-19**.

Recording continues...

In Segments 3 and 4, you will record **Forearm 2, the non-dominant forearm**, following the same procedure you used for Forearm 1.

Disconnect the lead set (SS2L) from the electrodes on Forearm 1 and connect to the electrodes on Forearm 2 per Fig. 2.9

- If you have not already attached electrodes to Forearm 2, refer to Set Up Step 5 for proper placement.

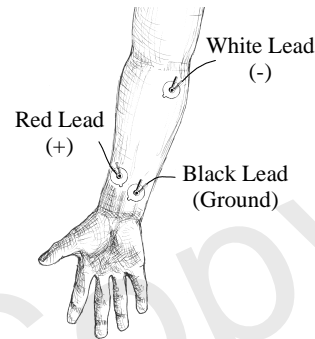


Fig. 2.9 Electrode lead attachment

Based on your calibrated grip force, the software determines the optimal grid display and force increments. Check the journal and use the indicated increment when directed to increase force throughout the recording.

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

Note that the hand dynamometer channel grid uses your assigned increment as a division scale so that you can visually review the force level.

Repeat a cycle of Clench-Release-Wait, holding for 2 seconds and waiting for two seconds after releasing before beginning the next cycle. Begin with your Assigned Increment of force (5, 10 or 20 kg) and increase by the Assigned Increment (5-10-15, 10-20-30, or 20-40-60 for example) for each cycle until maximum clench force is obtained.

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. 2.7.

The data would be incorrect if the:

- a. **Suspend** was clicked prematurely.
- b. Instructions were not followed.

Click **Redo** and repeat Steps 15-19 if necessary. Note that once you click **Redo**, the data you have just recorded will be erased.

SEGMENT 4

20. Click **Resume**.
- When you click **Resume**, the recording will continue and an append marker labeled “Forearm 2, Continued clench at maximum force” will be automatically inserted.
21. Clench the hand dynamometer with your maximum force. Note this force and try to maintain it.
- Note the maximum clench force so you can determine when the force has decreased by 50% (the maximum force may scroll out of view). Try to maintain the maximum clench force (the forearm will fatigue and the force will decrease).
22. When the maximum clench force displayed on the screen has **decreased by more than 50%**, click **Suspend**.
- The time to fatigue to 50% of maximal clench force will vary greatly among individuals.
- When you click **Suspend**, the recording should halt, giving you time to review the data from the last recording segment.
23. Review the data on the screen.
- If all went well, your data should look similar to Fig. 2.8.
- If correct, go **Step 26**.
 - If incorrect, go to **Step 25**.
- The data would be incorrect if:
- a) You didn’t record to the point of 50% maximal clench force.
 - b) **Suspend** was clicked prematurely.
 - c) The instructions were not followed.
24. Click **Redo** if your data was incorrect, and **repeat Steps 21-24**.
- Click **Redo** and have the **Subject** rest so the arm muscles recover and the fatigue data will be meaningful. When ready, repeat Steps 21-24. Note that once you click **Redo**, the data you have just recorded will be erased.
25. Click **Stop**.
- When you click **Stop**, a dialog box is generated, asking if you are finished with both Forearm recordings. This is simply one last chance to confirm that you don’t need to redo the last recording segment. Click “Yes” to end data recording and automatically save the data. Click “No” to return to a display with a **Redo** option.
26. If you want to listen to the EMG signal, go to Step 28.
- Listening to the EMG is optional.*
- Listening to the EMG can be a valuable tool in detecting muscle abnormalities, and is performed here for general interest.*
- or*
- To skip listening and end the recording, go to Step 33.
27. Subject puts on the headphones.
- Note:** When you click **Listen** in the next step, the volume through the headphones may be very loud due to system feedback. The volume cannot be adjusted, but you can position the headphones slightly off the ear to reduce the sound.
28. Click **Listen**.

Recording continues...

29. As you listen, try a variety of Clench-Release-Wait cycles and watch how the data changes on the screen.

30. Click **Stop**.

31. To listen again, click **Redo**.

32. Click **Done**.

33. Remove the electrodes from each forearm.

END OF RECORDING

You will hear the EMG signal through the headphones as it is being displayed on the screen. The screen will display three channels: CH 1 Force, CH 3 EMG, and CH 40 Integrated EMG. The data on the screen will not be saved. The signal will run until you click **Stop**.

If others in your lab group would like to hear the EMG signal, pass the headphones around before clicking **Stop**.

This will end listening to the EMG.

Another person may want to listen to the EMG.

A pop-up window with four 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.

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 the skin, using soap and water. The electrodes may leave a slight ring on the skin for a few hours, which is quite normal.

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 1 **Force**

CH 3 **EMG (raw data)**

CH 40 **Integrated EMG**

Analysis of Increasing Clench Force

2. Setup your display for optimal viewing of Segment 1 data.
3. Read the journal and note your force increment in the Data Report.



4. Set up the measurement boxes as follows:

<i>Channel</i>	<i>Measurement</i>
CH 1	mean
CH 3	p-p
CH 40	mean

Data Analysis continues...

Detailed Explanation of Data Analysis Steps



Enter **Review Saved Data** from the **Lessons** menu.

- For the first part of the analysis, use the data labeled **“Increasing clench force”** recorded in Segment 1 for Forearm 1 and Segment 3 for Forearm 2. Note your findings in Table 2.1.
- For the second part of the analysis, use the data labeled **“Continued clench at maximum force”** recorded in Segment 2 for Forearm 1 and Segment 4 for Forearm 2. Note your findings in Table 2.2.

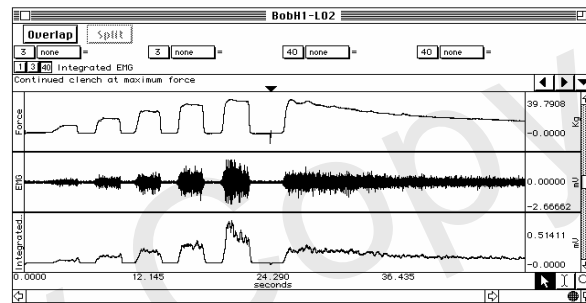


Fig. 2.10

The first data segment was the recording before the first marker. See Fig. 2.11.



The following tools help you adjust the data window:

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

The Journal summary shows the force increment used in your recordings. The grid divisions should use the same increment. Note this increment in Table 2.1 in the second column, **Force (kg) Increments for Peak #1**. For subsequent peaks, add the increment (i.e., 5, 10, 15 kg or 10, 20, 30 kg).

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 them. The following is a brief description of these specific measurements.



mean: displays the average 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.

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

- Use the **I-Beam** cursor to select an area on the plateau phase of the first clench (Fig. 2.11).



- Repeat** Step 5 on the plateau of each successive clench.



- Scroll to **Segment 3** and set up your display for optimal viewing.
- Repeat** Steps 5 and 6 for Segment 3.

Analysis of Continued Clench ...

- Scroll to **Segment 2** and set up your display for optimal viewing.
- Set up the measurement boxes as follows:

Channel	Measurement
CH 1	value
CH 40	delta T

- Use the **I-Beam** cursor to select a point of maximal clench force immediately following the start of the segment (Fig. 2.12).



- Calculate 50% of the maximum clench force from Step 11.



Data Analysis continues...

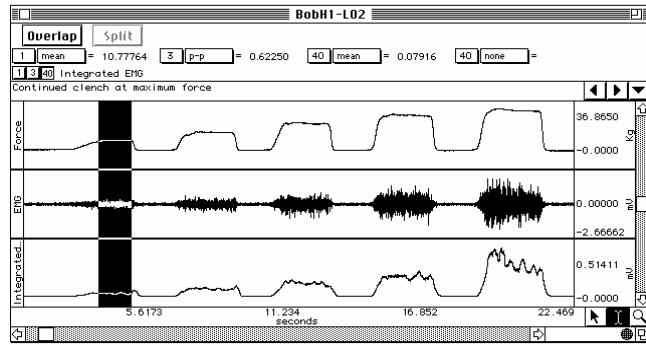


Fig. 2.11 Plateau of first clench selected

Segment 3 begins at the third append marker, labeled “Forearm 2, Increasing clench force.”

Enter your measurement findings in Table 2.1.

Segment 2 begins at the second append marker, labeled “Forearm 1, Continued clench at maximum force.”



The following is a brief description of the specific measurements not previously covered.

value: displays the amplitude value for the channel at the point selected by the I-beam cursor. If a single point is selected, the value is for that point, if an area is selected, the value is the endpoint of the selected area.

delta T: displays the amount of time in the selected segment (the difference in time between the endpoints of the selected area).

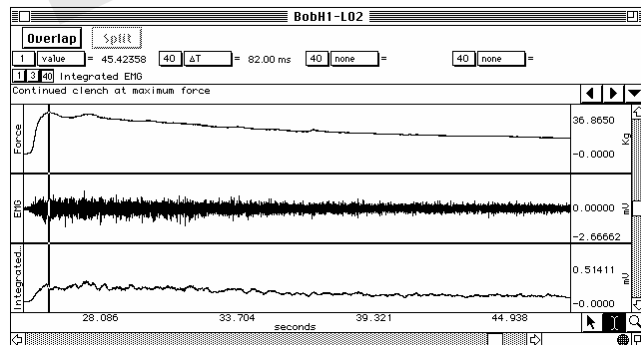


Fig. 2.12

The point selected should represent the maximal clench force at the start of Segment 2 (continuous maximal clench), as shown in Fig. 2.12.

You will need this number to complete Step 14.

13. Find the point of 50% maximum clench force by using the I-beam cursor and leave the cursor at this point.

14. Select the area from the point of 50% clench force back to the point of maximal clench force by using the I-beam cursor and dragging. (Fig. 2.13). Note the time to fatigue (CH 40 delta T) measurement.



15. Scroll to **Segment 4** and set up your display for optimal viewing.
16. **Repeat** Steps 11 to 14 for Segment 4.

17. Save or print the data file.

18. Exit the program.

END OF DATA ANALYSIS

Make an eyeball approximation of the point that is 50% down from the maximal clench point. Then, use the I-beam cursor to click points near this region, noting the value displayed in the measurement box, until you are on a point within 5% of the maximal clench force. Leave the cursor at this point.

One way to select the area is as follows:

The cursor should be flashing on the point of 50% maximal clench force. Hold down the mouse button and drag to the left of this point until you reach the point of maximal clench force, then release the mouse button.

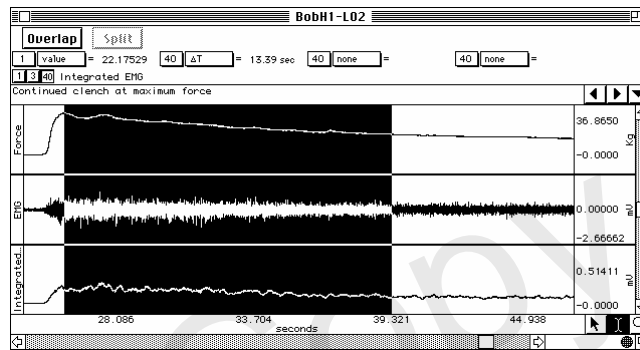


Fig. 2.13 showing area max-50%

Segment 4 begins at the fourth append marker, labeled “Forearm 2, Continued clench at maximum force.”

Enter your measurement findings in Table 2.2.



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

END OF LESSON 2

Complete the Lesson 2 Data Report that follows.

ELECTROMYOGRAPHY II

Motor unit recruitment and Fatigue

DATA REPORT

Student's Name: _____

Lab Section: _____

Date: _____

I. Data and Calculations

Motor Unit Recruitment

Subject Profile

Name _____

Height _____

Age _____

Weight _____

Gender: Male / Female

Dominant forearm: Right / Left

- A.** Complete Table 2.1 using *Segment 1* and *Segment 3* data. In the "Force (kg) Increments" column, note the force increment assigned for your recording under Peak #1; the increment was pasted to the Journal and should be noted below from Data Analysis—Step 2. For subsequent peaks, add the increment (i.e., 5, 10, 15 or 10, 20, 30). You may not need nine peaks to reach max.

Table 2.1 Segment 1 Data

		<i>Seg. 1 Forearm 1 (Dominant)</i>			<i>Seg. 2 Forearm 2</i>		
		Force at Peak [CH 1] mean (kg)	Raw EMG [CH 3] p-p (mV)	Int. EMG [CH 40] mean (mV)	Force at Peak [CH 1] mean (kg)	Raw EMG [CH 3] p-p (mV)	Int. EMG [CH 40] mean (mV)
Peak #	Force (kg) Increments Assigned						
1	kg						
2	kg						
3	kg						
4	kg						
5	kg						
6	kg						
7	kg						
8	kg						
9	kg						

Fatigue

B. Complete Table 2.2 using *Segment 2* and *Segment 4* data.

Table 2.2 Segment 2 data

Seg. 2 Forearm 1 (Dominant)			Seg. 4 Forearm 2		
Maximum Clench Force	50% of max clench force	Time to Fatigue	Maximum Clench Force	50% of max clench force	Time to fatigue
CH 1 value	<i>calculate</i>	CH 40 delta T*	CH 1 value	<i>calculate</i>	CH 40 delta T*

***Note:** You do not need to indicate the delta T (time to fatigue) polarity. The polarity of the delta T measurement reflects the direction the "I-beam" cursor was dragged to select the data. Data selected left to right will have a positive ("+") polarity, while data selected right to left will have a negative ("-") polarity.

II. Questions

C. Is the strength of your right arm different than your left arm? Yes No

D. Is there a difference in the absolute values of force generated by males and females in your class?

Yes No

What might explain any difference?

E. When holding an object, does the number of motor units remain the same?

Are the same motor units used for the duration of holding the object?

F. As you fatigue, the force exerted by your muscles decreases. What physiological processes explain the decline in strength?

G. Define **Motor unit**

H. Define **Motor unit recruitment**

I. Define **Fatigue**

J. Define **EMG**

K. Define **Dynamometry**

End of Lesson 2 Data Report

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