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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)
  - *Optional* BIOPAC Hand Clench Force Pump Bulb (SS56L) may be used—pressure in bulb is proportional to clench force. For SS56L units, set the Clench Force Transducer Preference BEFORE starting calibration.
- BIOPAC Electrode Lead Set (SS2L)
- BIOPAC Disposable Electrodes (EL503,) 6 electrodes per Subject
- BIOPAC Electrode Gel (GEL1) and Abrasive Pad (ELPAD) *or* Skin cleanser or alcohol prep
- *Optional*: BIOPAC Headphones (OUT1/OUT1A for MP3X or 40HP for MP45)
- Biopac Student Lab System: BSL 4 software, MP36, MP35 or MP45 hardware
- Computer system (Windows 8, 7, Vista, XP, Mac OS X 10.5 – 10.8)

IV. EXPERIMENTAL METHODS

A. SETUP

FAST TRACK Setup

1. Turn your computer **ON**.
   - If using an MP36/35 unit, turn it OFF.
   - If using an MP45, make sure USB cable is connected and "Ready" light is **ON**.
2. **Plug the equipment in** as follows:

   Electrode Lead Set (SS2L) — CH 1

   Hand Dynamometer (SS25LA or SS25L) *or* Clench Force Pump Bulb (SS56L) — CH 2

   Headphones (OUT1 or OUT1A*) — back of unit

   **OUT1A is compatible with MP36 only.*
3. Turn **ON** the MP36/35 unit.

Setup continues...

Detailed Explanation of Setup Steps

Fig. 2.5 MP3X (top) and MP45 (bottom) equipment connections

4. Clean and abrade skin.
5. **Attach three electrodes** to each forearm (Fig. 2.6).
6. **Clip** the Electrode Lead Set (SS2L) to the **Subject's** dominant forearm, following the color code (Fig. 2.6).
7. Hold hand dynamometer with dominant hand.

If the skin is oily, clean electrode sites with soap and water or alcohol before abrading.

If the electrode is dry, apply a drop of gel.
For optimal electrode contact, place electrodes on the skin at least five minutes before the start of Calibration.

Clip the Lead Set (SS2L) to the **Subject's** dominant forearm (Fig. 2.6) for recordings 1 and 2.

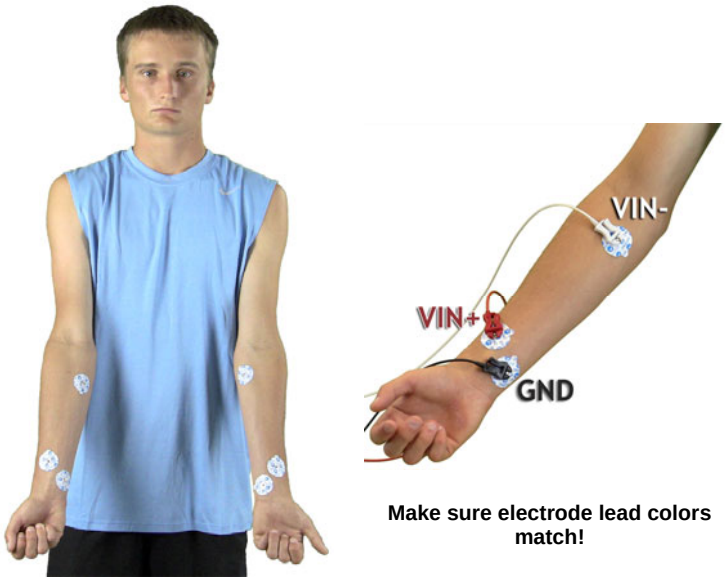


Fig. 2.6 Electrode Placement & Lead Attachment

- If **Subject** is right-handed, the right forearm is generally dominant; if the subject is left-handed, the left forearm is generally dominant.
- The pinch connectors work like a small clothespin and will only latch onto the nipple of the electrode from one side of the connector.

- **Subject** gets in a seated position, facing the monitor.

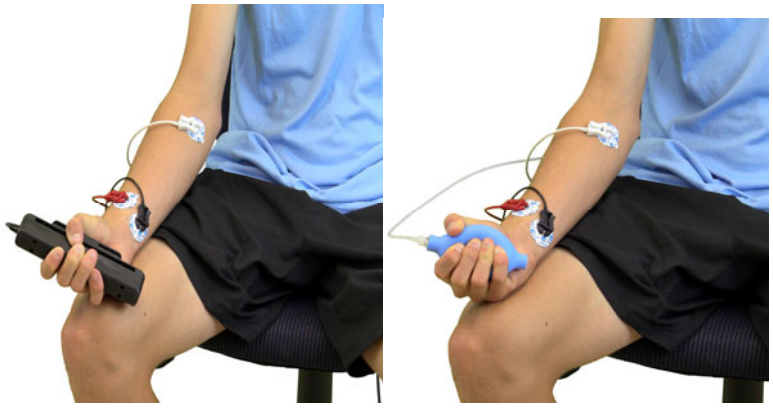


Fig. 2.7 Proper Seating Position

- Arm holding the hand dynamometer should rest on thigh to relax the muscles in the shoulder and upper arm.

Setup continues...

Fig. 2.8 Positioning

8. **Start** the BIOPAC Student Lab Program.

Start Biopac Student Lab by double-clicking the Desktop shortcut.

9. Choose lesson "**L02 – Electromyography (EMG) II**" and click **OK**.

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

10. Type in a unique **filename** and click **OK**.

A folder will be created using the filename. This same filename can be used in other lessons to place the **Subject's** data in a common folder.

11. Make sure the picture in the journal (Hardware tab) matches your setup. If it does not, you may need to change preference settings.

The SS25LA picture represents both the SS25LA and SS25L.

To change the preference, see next step.

This ends the Set Up procedure.

12. ***Optional***: Set Preferences.
    - Choose File > **Lesson Preferences**.
    - Select an option.
    - Select the desired setting and click **OK**.

This lesson has optional Preferences for data and display while recording. Per your Lab Instructor's guidelines, you may set:

Clench Force Transducer: Choose model SS25LA/L or SS56L (Bulb)

Lesson Recordings: Specific recordings may be omitted based on instructor preferences.

END OF SETUP

B. CALIBRATION

The Calibration procedure establishes the hardware's internal parameters (such as gain, offset, and scaling) and is critical for optimal performance. **Pay close attention to Calibration.** For a video example of proper Calibration procedure, click the Calibration tab in the Lesson > Set Up Journal.

FAST TRACK Calibration

1. Click **Calibrate**.
2. Set the hand dynamometer down and click **OK**.
3. Hold the BIOPAC hand dynamometer with dominant hand when prompted and click **OK**.

   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*.

   SS56L: WRAP your hand around the bulb with relaxed fingers—do NOT curl fingers into bulb.

   IMPORTANT
   Hold the dynamometer in the same position for all measurements from each arm. Note your hand position for the first recording and try to repeat it for the subsequent recordings.
4. When Calibration recording begins, **clench** the hand dynamometer as hard as possible for 2 sec. and then **release**.
5. **Wait** for Calibration to stop.
6. Verify recording resembles the example data.
   - If similar, click **Continue** and proceed to Data Recording.
   - If necessary, click **Redo Calibration**.

END OF CALIBRATION

Detailed Explanation of Calibration Steps

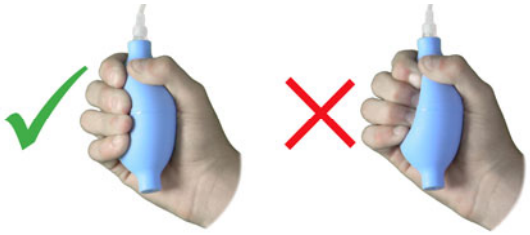
You will be prompted to remove any grip force from the hand dynamometer.

This will remove any clench force which is important for establishing a zero force baseline.

Clench with the hand of your dominant forearm.

SS25LA grip position

SS25L grip position



SS56L grip position

Fig. 2.9

The program needs a reading of your maximum clench to establish proper force increments (grid settings) used during the recordings.

Calibration lasts eight seconds.

Both channels should begin with a zero baseline and then there should be a clear EMG "burst" and simultaneous increase in Clench Force when the Subject clenched.

- If using SS25LA/L, units are kg; If using SS56L, units are kgf/m^2.

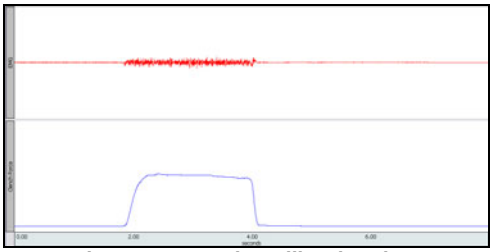


Fig. 2.10 Example Calibration data

If recording does not resemble the Example Data

- If the data is noisy or flatline, check all connections to the MP unit.
- If the hand dynamometer signal is not zero when relaxed, make sure all grip force is removed until prompted.
- Verify electrodes are making good contact and that leads are clipped to the correct color position with minimal cable strain.

C. DATA RECORDING

FAST TRACK Recording

1. Prepare for the **Dominant arm** recording.
   - Electrodes must be attached to **Subject's** dominant arm.
   - **Subject's** hand must be relaxed.
   - Grip the hand dynamometer with dominant hand.
   - **Review** recording steps.

Detailed Explanation of Recording Steps

Four data recordings* will be acquired, two on each arm:

a. Recordings 1 and 3 record Motor unit recruitment.

b. Recordings 2 and 4 record Fatigue

In order to work efficiently, read this entire section, or review onscreen **Tasks** to preview recording steps in advance.

***IMPORTANT**
This procedure assumes that all lesson recordings are enabled in Lesson Preferences, which may not be the case for your lab. Always match the recording title to the recording reference in the journal and disregard any references to excluded recordings.

Dominant arm: Increasing clench force

- **Calibrated grip force**

When **Continue** is clicked following Calibration, the display will change to show only the Clench Force channel, with grids displayed.

Based on maximum grip force during calibration, the software sets the grid as follows:

SS25L/LA Force calibration (kg)	Assigned Increment (kg)
0 – 25	5
25 – 50	10
50 – 75	15
>75	20

SS56L Max Clench (kgf/m^2) (kgf/m^2)	Assigned Increment
0 – 5,000	1,000
5,000 – 7,500	1,500
7,500 – 10,000	2,000
10,000 – 12.500	2,500
>12,500	3,000

2. Click **Record**.
3. Perform a series of Clench-Release-Wait cycles until maximum grip force is reached.
   - Hold clench for two seconds, release for two seconds.
   - Use sufficient grip force on each cycle to increase the force by one grid line per clench.

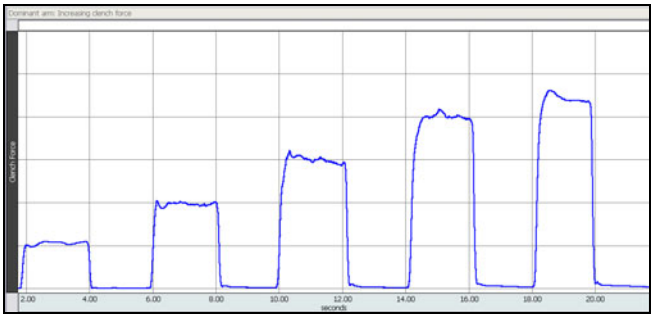


Fig. 2.11 Example Increasing Clench Force data

- Completely relax grip force between clenches.
- It is important to reach the first gridline on the first clench. Increase grip on subsequent clenches to advance the force signal one gridline per clench until maximum grip force is reached.
- A total of five clenches are used in the Example Data, but certain **Subjects** may require a lesser or greater number of clenches to attain maximum grip force.

Recording continues…

4. After maximum grip force is reached, click **Suspend**.
5. Verify recording resembles the example data above.
   - If similar, click **Continue** and proceed to Step 6.
   - If necessary, click **Redo**.
   - If all required recordings have been completed, click **Stop**.

- The data must show multiple peaks of increasing clench force.
- The data shown above (Fig. 2.11) 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 "flat."

If recording does not resemble the Example Data

- If the data is noisy or flatline, check all connections to the MP unit.

Click **Redo** and repeat Steps 2 – 5 if necessary. Note that once **Redo** is clicked, the most recent recording will be erased.

Dominant arm: Continued clench at maximum force

- **Review** recording steps.

6. Click **Record**.
7. Clench the hand dynamometer as hard as possible and try to maintain maximum force.
8. Continue clenching until force has decreased by 50%.

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.

9. Click **Suspend**.
10. Verify recording resembles the example data.
    - If similar to Fig. 2.12, click **Continue** and proceed to the next recording.
    - If necessary, click **Redo**.
    - If all required recordings have been completed, click **Stop**.

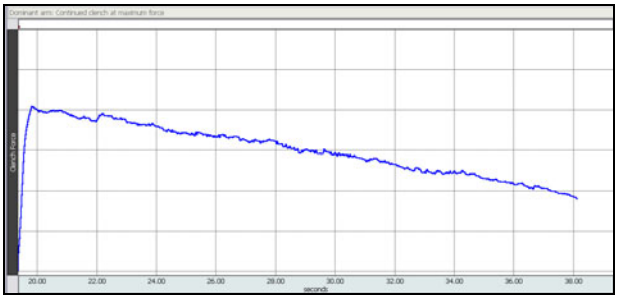


Fig. 2.12 Example Fatigue data

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

If recording does not resemble the Example Data

- If the data is noisy of flatline, check all connections to the MP unit..

Click **Redo** and have the **Subject** rest arm for a few minutes. When ready, repeat Steps 6 – 10. Note that once **Redo** is clicked, the most recent recording will be erased.

Recording continues…

Nondominant arm: Increasing clench force

11. Prepare for the **Nondominant arm** recording.
    - Clip electrode leads to **Subject's** nondominant arm.
    - **Subject's** hand must be relaxed.
    - Grip hand dynamometer with nondominant hand.
    - **Review** recording steps.

These recordings apply to the **nondominant forearm**, following the same procedure used for the dominant forearm.

Disconnect the lead set (SS2L) from the electrodes on the "dominant" forearm and connect to electrodes on "nondominant" forearm per Fig. 2.13.

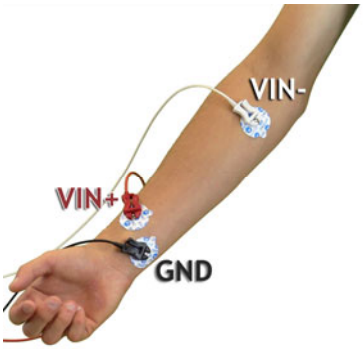


Fig. 2.13 Electrode lead attachment

Follow Color Code!

12. Click **Record**.
13. Perform a series of Clench-Release-Wait cycles.

Repeat a cycle of Clench-Release-Wait, holding for two seconds and waiting for two seconds after releasing before beginning the next cycle. Begin with your Assigned Increment of force (first grid) and increase by the Assigned Increment for each cycle until maximum clench force is obtained.

14. After maximum grip force is reached, click **Suspend**.
15. Verify recording resembles the example data.
    - If <u>similar</u>, click **Continue** and proceed to the next recording.
    - If necessary, click **Redo**.
    - If all required recordings have been completed, click **Stop**.

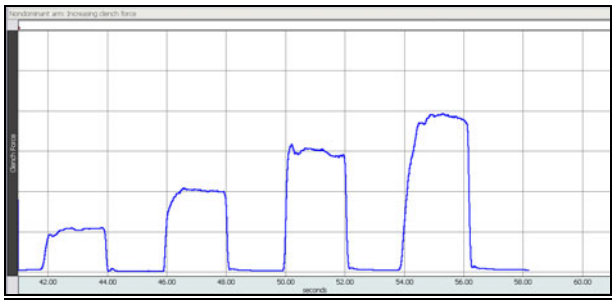


Fig. 2.14 Example Increasing Clench Force data

<u>If recording does not resemble the Example Data</u>

- If the data is noisy or flatline, check all connections to the MP unit.

Click **Redo** and repeat Steps 12 – 15 if necessary. Note that once **Redo** is clicked, the most recent recording will be erased.

Nondominant arm: Continued clench at maximum force

- **Review** recording steps.

16. Click **Record**.
17. Clench the hand dynamometer as hard as possible and try to maintain maximum force.

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.)

18. Continue clenching until force has decreased by more than 50%.

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

19. Click **Suspend**.

Recording continues…

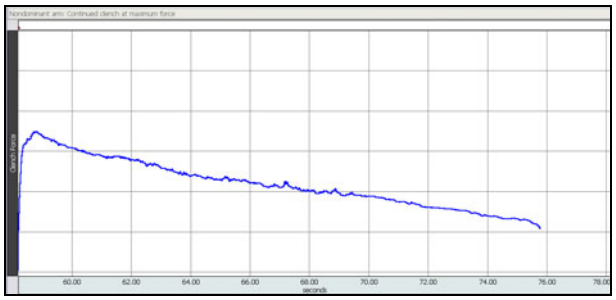


Fig. 2.15 Example Fatigue data

20. Verify recording resembles the example data.
    - If similar to Fig. 2.15, click **Continue** to proceed to the optional recording section, or click **Stop** to end the recording.
    - If necessary, click **Redo**.

If recording does not resemble the Example Data

- If the data is noisy or flatline, check all connections to the MP unit.

Click **Redo** and have the **Subject** rest arm for a few minutes. When ready, repeat Steps 16 – 20. Note that once **Redo** is clicked, the most recent recording will be erased.

OPTIONAL ACTIVE LEARNING PORTION

With this lesson you may record additional data by clicking **Continue** following the last recording. Design an experiment to test or verify a scientific principle(s) related to topics covered in this lesson. Although you are limited to this lesson's channel assignments, the electrodes may be moved to different locations on the **Subject**.

Design Your Experiment

Use a separate sheet to detail your experiment design, and be sure to address these main points:

A. ***Hypothesis***

Describe the scientific principle to be tested or verified.

B. ***Materials***

List the materials you will use to complete your investigation.

C. ***Method***

Describe the experimental procedure—be sure to number each step to make it easy to follow during recording.

Run Your Experiment

D. ***Set Up***

Set up the equipment and prepare the subject for your experiment.

E. ***Record***

Use the **Continue**, **Record** and **Suspend** buttons to record as much data as necessary for your experiment.

Click **Stop** when you have completed all of the recordings required for your experiment.

Analyze Your Experiment

F. Set measurements relevant to your experiment and record the results in a Data Report.

- To listen to the EMG signal, proceed to Step 21.
- To skip listening to the EMG signal and end the recording, proceed to Step 24.

Recording continues…

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. Data on screen is not saved.

21. Click **Listen** to record EMG data and hear it through the headphones.
22. Increase clench force and notice how the volume increases.

The EMG signal will be audible through the headphones as it is being displayed on the screen. The screen will display two channels:

CH 1 EMG and CH 41 Clench Force

The signal will run until **Stop** is clicked. If others in your lab group would like to hear the EMG signal, pass the headphones around before clicking **Stop** or click **Redo** and then **Stop** when done.

23. Click **Stop** when finished.
    - Click **Redo** to hear EMG again.

This will end listening to the EMG.

24. Click **Done** to end the lesson.
25. Choose an option and click **OK**.

If choosing the **Record from another Subject** option:

- Repeat Setup Steps 4 – 7 and proceed to Calibration.

26. Remove the electrodes.

Remove the electrode cable pinch connectors, and peel off all electrodes. Discard 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.

END OF RECORDING

V. DATA ANALYSIS

FAST TRACK Data Analysis

1. Enter the **Review Saved Data** mode
   - Note Channel Number (CH) designations:

Channel	*Displays*
CH 1	**EMG** (hidden*****)
CH 40	**Integrated EMG**
CH 41	**Clench Force**

   - Note measurement settings:

Channel	*Measurement*
CH 41	**Mean**
CH 40	**Mean**
CH 41	**Value**
CH 40	**Delta T**

Data Analysis continues….

Detailed Explanation of Data Analysis Steps

If entering Review Saved Data mode from the Startup dialog or Lessons menu, make sure to choose the correct file.

The data window should resemble Fig. 2.16.

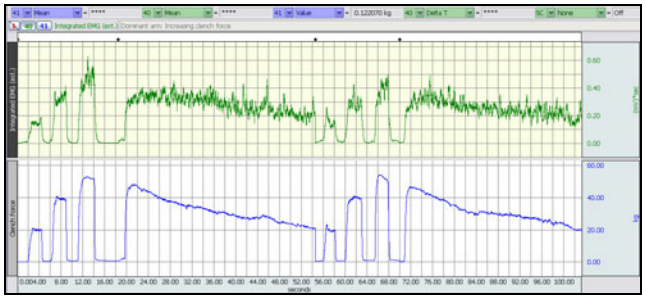


Fig. 2.16 Example data

The measurement boxes are above the event 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 clicked.

Brief definition of measurements:

Mean: Displays the average value in the selected area.

Value: Displays the amplitude value at the point selected by the I-beam cursor. If an area is selected, displays the value of the endpoint based on the direction the cursor was dragged.

Delta T: Measures the difference in time between the end and beginning of the selected area.

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

Analysis of Increasing Clench Force

2. Setup your display for optimal viewing of **"Dominant arm: Increasing clench force"** data.

Note: The append event markers mark the beginning of each recording. Click (activate) the event marker to display its label.

Useful tools for changing view:

Display menu: Autoscale Horizontal, Autoscale Waveforms, Zoom Back, Zoom Forward

Scroll Bars: Time (Horizontal); Amplitude (Vertical)

Cursor Tools: Zoom Tool

Buttons: Overlap, Split, Show Grid, Hide Grid, -, +

Hide/Show Channel: "Alt + click" (Windows) or "Option + click" (Mac) the channel number box to toggle channel display.

3. Read the journal and note your force increment in the Data Report.

A

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).

4. Use the **I-Beam** cursor to select an area on the plateau phase of the first clench (Fig. 2.17).

A

5. **Repeat** Step 4 on the plateau of each successive clench.

A

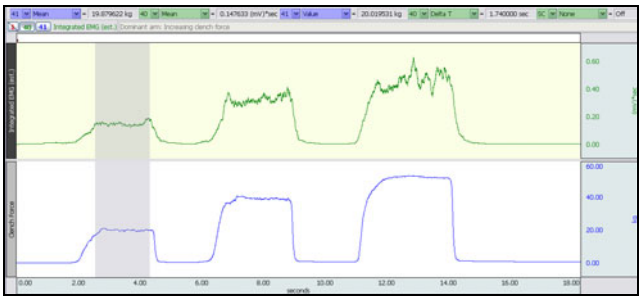


Fig. 2.17 Plateau of first clench selected

6. Scroll to marker labeled **"Nondominant arm: Increasing clench force"** and set up your display for optimal viewing.
7. **Repeat** Steps 3 – 4 for this recording.

Analysis of Continued Clench

8. Scroll to **"Dominant arm: Continued clench at maximum force"** and set up your display for optimal viewing.

This recording begins at the append event marker labeled "**Dominant arm: Continued clench at maximum force**."

9. Use the **I-Beam** cursor to select a point of maximal clench force immediately following the start of the recording (Fig. 2.18).

B

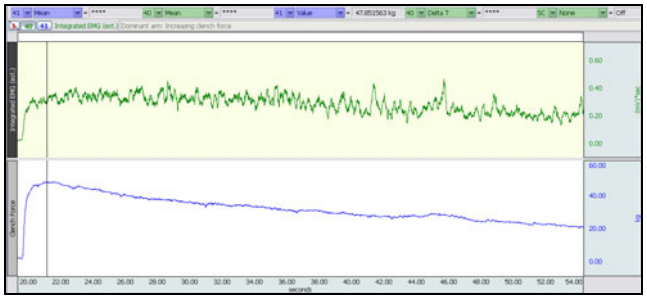


Fig. 2.18

The point selected should represent the maximal clench force at the start of continuous maximal clench recording, as shown in Fig. 2.18.

10. Calculate 50% of the maximum clench force from Step 9.

B

This number is necessary in order to complete Step 11.

Data Analysis continues….

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

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.

12. 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. 2.19). Note the time to fatigue measurement (CH 40 Delta T).

    B

    Scroll to marker labeled **"Non dominant arm: Continued clench at maximum force"** and set up your display for optimal viewing.

13. **Repeat** Steps 8 – 12 for this recording.

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.

Note: You do not need to indicate the Delta T polarity as it only 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.

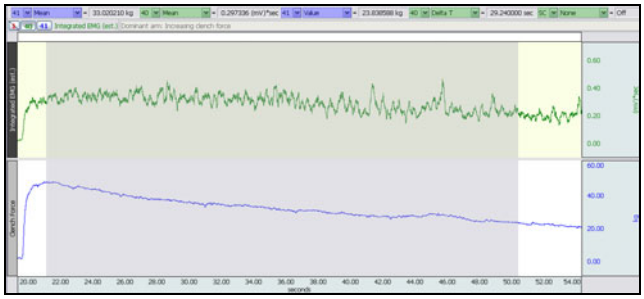


Fig. 2.19 showing area max-50%

14. Answer the questions at the end of the Data Report.
15. **Save** or **Print** the data file.
16. **Quit** the program.

END OF DATA ANALYSIS

An electronically editable **Data Report** is located in the journal (following the lesson summary,) or immediately following this Data Analysis section. Your instructor will recommend the preferred format for your lab.

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: _____

Subject Profile

Name:_____ Height:_____ Gender: Male / Female

Age:_____ Weight:_____ Dominant arm: Right / Left

I. Data and Calculations

Motor Unit Recruitment

A. **Complete Table 2.1 using *Dominant arm* and *Nondominant arm* 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., 500, 1000, 1500). You may not need eight peaks to reach max.

Table 2.1 Increasing Clench Force Data

Peak #	Assigned Force Increment SS25L/LA = Kg SS56L = kgf/m^2	*(Dominant arm)*		*(Nondominant arm)*	
		Force at Peak	Integrated EMG (mV)	Force at Peak	Integrated EMG (mV)
		41 Mean	40 Mean	41 Mean	40 Mean
1					
2					
3					
4					
5					
6					
7					
8					

Fatigue

B. **Complete Table 2.2 using *Dominant arm* and *Nondominant arm* data.**

Table 2.2 Maximum Clench Force Data

(Dominant arm)			*(Nondominant arm)*		
Maximum Clench Force	50% of Max Clench Force	Time to Fatigue	Maximum Clench Force	50% of Max Clench force	Time to fatigue
41 Value	*calculate*	40 Delta T	41 Value	*calculate*	40 Delta T

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**

III. OPTIONAL Active Learning Portion

A. ***Hypothesis***

B. ***Materials***

C. ***Method***

D. ***Set Up***

E. ***Experimental Results***

End of Lesson 2 Data Report