Experiment HM-1: Grip Strength and Electromyogram (EMG) Activity

Equipment Required

PC or Mac Computer

IXTA, USB cable, IXTA power supply

iWire-B3G EMG cable and electrode lead wires

Disposable electrodes

FT-220 Hand Dynamometer

Bathroom scale and 5 or 6 textbooks or a weight (optional)

String

Metric Ruler

Note – You must connect the iWire-B3G prior to turning on the IXTA.

EMG Cable and Hand Dynamometer Setup

1. Locate the iWire-B3G EMG cable and electrode lead wires and FT-220 hand dynamometer.
2. Plug the connector for the FT-220 hand dynamometer into Channel A2.
3. Insert the connector on the end of the EMG cable into the iWire 1 input on the front of the IXTA.
4. Insert the connectors on the red, black, and green electrode lead wires into the matching sockets on the EMG cable.
5. The subject should remove all jewelry from their wrists. For the first exercises in this lab, record EMGs and muscle forces from the subject's dominant arm, the arm used most often.

Figure HM-1-S1: The FT-220 hand dynamometer

iWorx Sample Lab

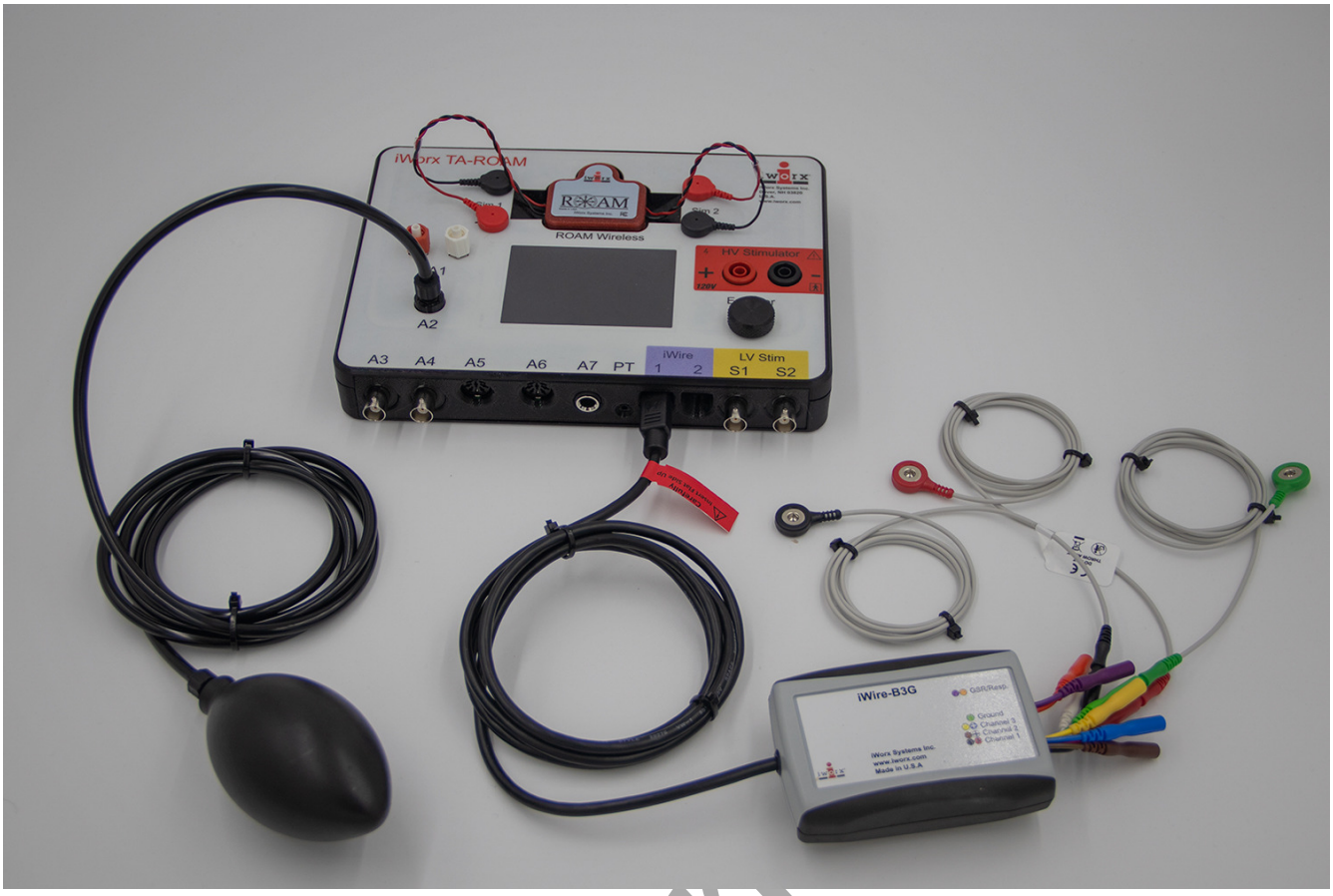

Figure HM-1-S2: The EMG cable and hand dynamometer connected to an IXTA.

6. Remove the plastic disk from a disposable electrode and apply it to one of the scrubbed areas. Repeat for the other two areas.
7. Snap the lead wires onto the 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.

iWorx Sample

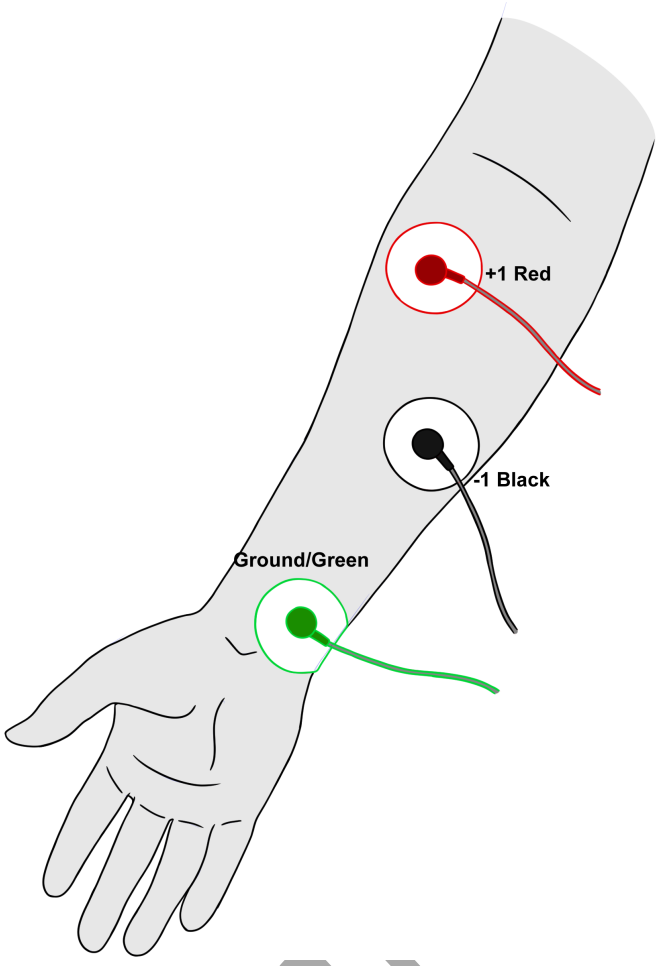

Figure HM-1-S3: Placement of EMG electrodes on the forearm.

OPTIONAL - Calibrating the Hand Dynamometer

Note – the hand dynamometer is pre-calibrated to PSI and no calibration is necessary unless you would like to change the units to something other than PSI.

Method 1:

1. Record about 10 seconds of data with no pressure on the FT-220 force transducer.
2. Scroll to the beginning of the calibration data for the FT-220 force transducer. Position the two vertical cursors so they span a flat-lined section of data – about 5 seconds apart.
3. To convert the voltages at the positions of the cursors to the correct pressure values, use the Units Offset dialogue window. Click V2-V1 on the force channel, then select Units, and select Set Offset.
4. On the units conversion window, put a check mark in the box next to Apply the calculated offset for this block to all blocks. Enter "0" in the box at the top. Click on the OK button in the lower right corner of the window to activate the units conversion.

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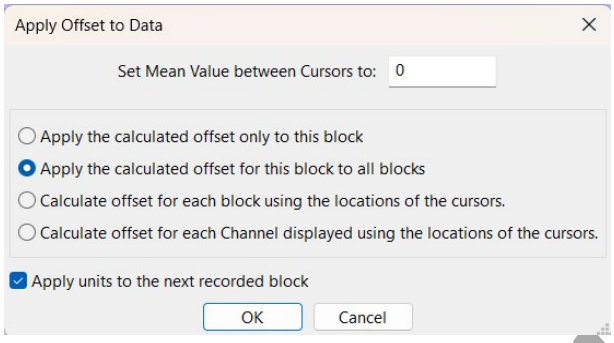

Figure HM-1-S4: Units Offset dialogue window.

Method 2:

1. Collect 5 text books. Weigh the stack of books on the bathroom scale.
   A barbell weight is also a good alternative to the stack of text books.
   Note: *Remember that 1 kilogram is equal to 2.2 pounds.*
2. Lay the hand dynamometer down on the bench top. Click the Record button on the LabScribe Main window and record for ten seconds.
3. Continue to record as you place the textbooks on the bulb of the hand dynamometer. Record for an additional ten seconds while you balance the books. Click the Stop button.
4. Click the AutoScale button on the Muscle Force channel. Use the Double Display Time icon to adjust the Display Time of the Main window to display the force recording before and after the books were placed on the hand dynamometer.
5. Click on the Double Cursors button on the LabScribe toolbar. Place one cursor on the force recording made before the books were placed on the bulb. Place the other cursor on the recording after the books were placed on the bulb.
6. To convert the voltages at the positions of the cursors to correct values, use the Simple Units Conversion dialogue window. Click V2-V1 on the force channel, then select Units, and select Simple.

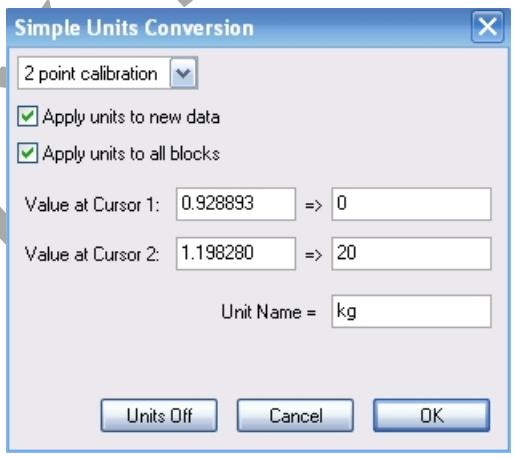

Figure HM-1-S5: The Simple Units Conversion dialogue window.

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7. Put check marks in the boxes next to Apply Units to new data and Apply Units to all blocks.
8. In the middle of the window is an array of four boxes. For each cursor, the value in the box on the left is the voltage at the position of the cursor on the recording window. In the box on the right, enter the value of the unit that equals the voltage on the left:
    - For Cursor 1, type zero (0) in the box on the right. this cursor is on the portion of the recording when no weight was placed on top of the hand dynamometer.
    - For Cursor 2, type the weight of the stack of books in the box on the right.
    - Type the name of the unit, kilogram or kg, in the Unit Name box. Click the OK button.

Note: For more accuracy in calibration, users may choose Advanced Units Conversion and follow the directions provided.

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Experiment HM-1: Grip Strength and Electromyogram (EMG) Activity

Exercise 1: EMG Intensity and Force in Dominant Arm

Aim: To determine the relationship between the intensity of EMG activity and the force of a muscle contraction in the subject's dominant arm.

Approximate Time: 30 minutes

Procedure

1. The subject should sit quietly with their dominant forearm resting on the table top. Explain the procedure to the subject.

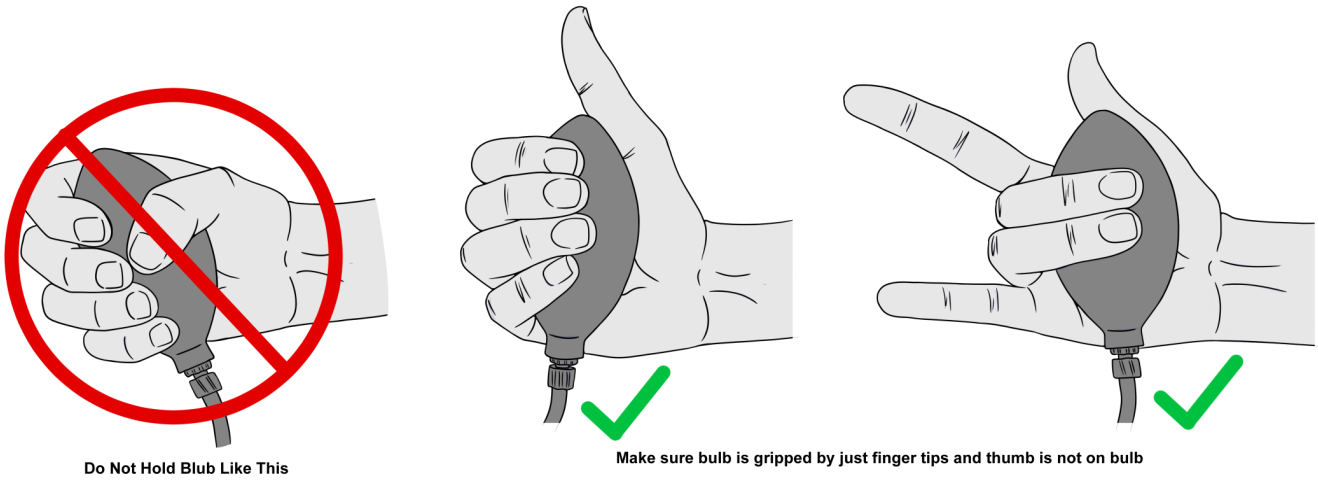

Figure HM-1-L1: The correct position for holding the grip sensor.

- The subject will squeeze their hand (without using the thumb) around the dynamometer five times, each contraction is two seconds long followed by two seconds of relaxation.
    - Hold the dynamometer with the thumb out, just squeezing with the fingers. This uses only the forearm muscles and does not bring in the upper arm muscles.
- Each successive contraction should be approximately two, three, and four times stronger than the first contraction; the final contraction should be full strength.

NOTE - If you max out the pressure and the signal flat lines - squeeze the bulb using ONLY your middle and ring fingers.

2. Type **Grip Force-Dominant** in the Mark box. Click the Record button to begin the recording; then, click the mark button to mark the beginning of the recording. After the recording is marked, tell the subject to begin squeezing the hand dynamometer following the procedure outlined in the step above.
3. In the relaxation period after the last contraction, click the Stop button.

WorkSafe Lab

4. Click the AutoScale All button. The recording should be similar to the image below.
5. Select Save As in the File menu, type a name for the file. Click OK.

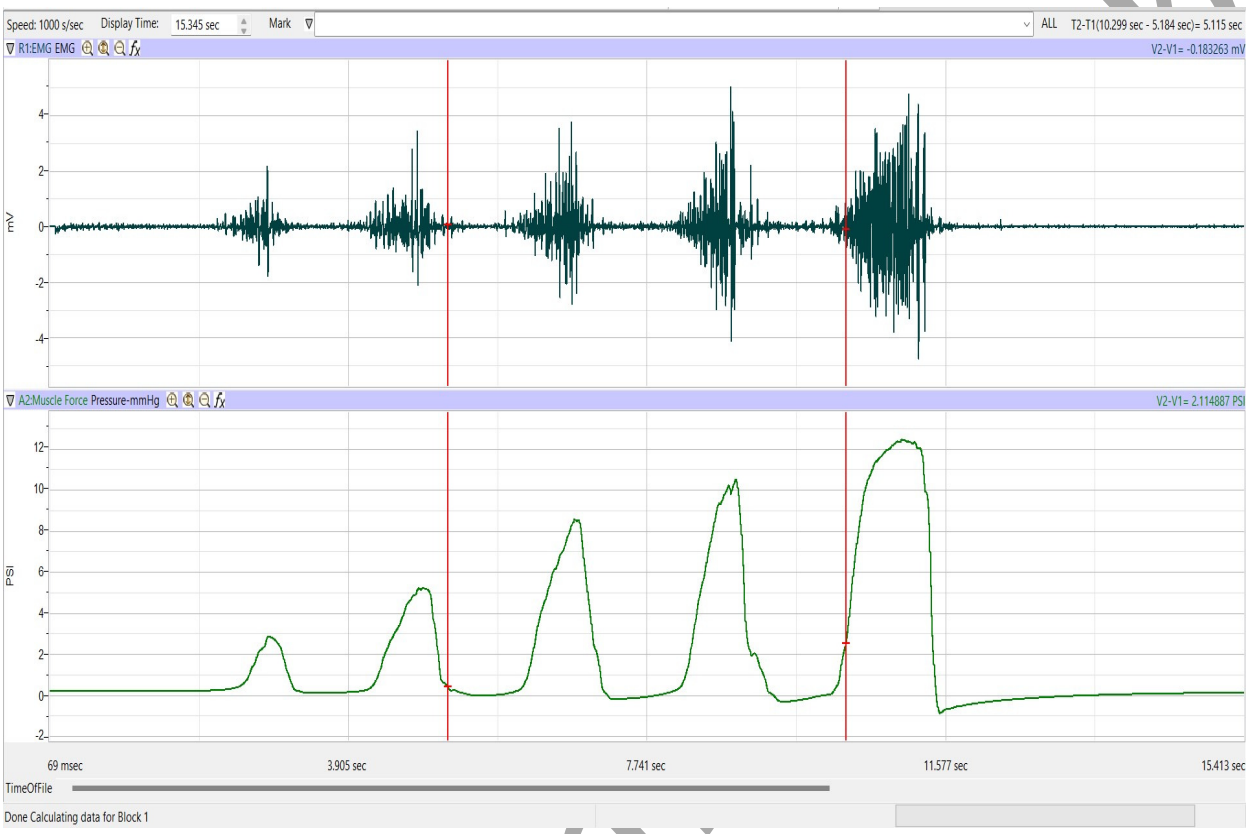

Figure HM-1-L2: The EMG (upper) and muscle force (lower) for four progressively stronger contractions displayed in the Main window.

Data Analysis

1. Use the Display Time icons to adjust the Display Time of the Main window to show the progressive muscle contractions on the Main window.
2. Click on the Analysis window icon in the toolbar.

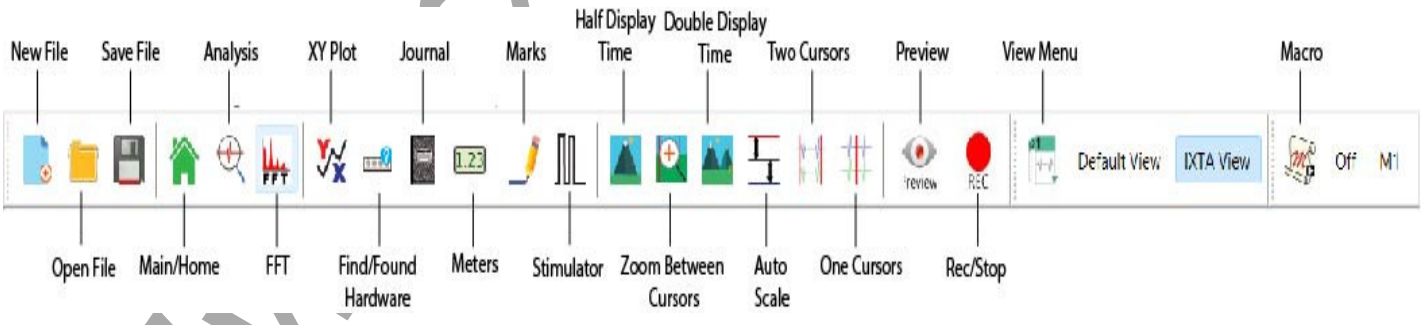

Figure HM-1-L3: The LabScribe toolbar.

4. Look at the Function Table that is above the uppermost channel displayed in the Analysis window. The mathematical functions, Abs. Int., V2-V1, and T2-T1 should appear in this table. The values for Abs. Int., V2-V1, and T2-T1 on each channel are seen in the table across the top margin of each channel.
5. The functions in the channel pull-down menus of the Analysis window can also be used to enter the names and values of the absolute integrals to the Journal. To use these functions:
    - Place the cursors at the locations used to measure the absolute integrals.
    - Transfer the name of the mathematical function used to determine the absolute integrals to the Journal using the Add Title to Journal function in the EMG channel pull-down menu.
    - Transfer the values for the absolute integrals to the Journal using the Add All Data to Journal function in the EMG channel pull-down menu.
6. Once the cursors are placed in the correct positions for measuring the absolute integrals under the muscle contraction and the corresponding EMG activity, the values for the integrals can be recorded in the on-line notebook of LabScribe by typing the names and values directly into the journal.

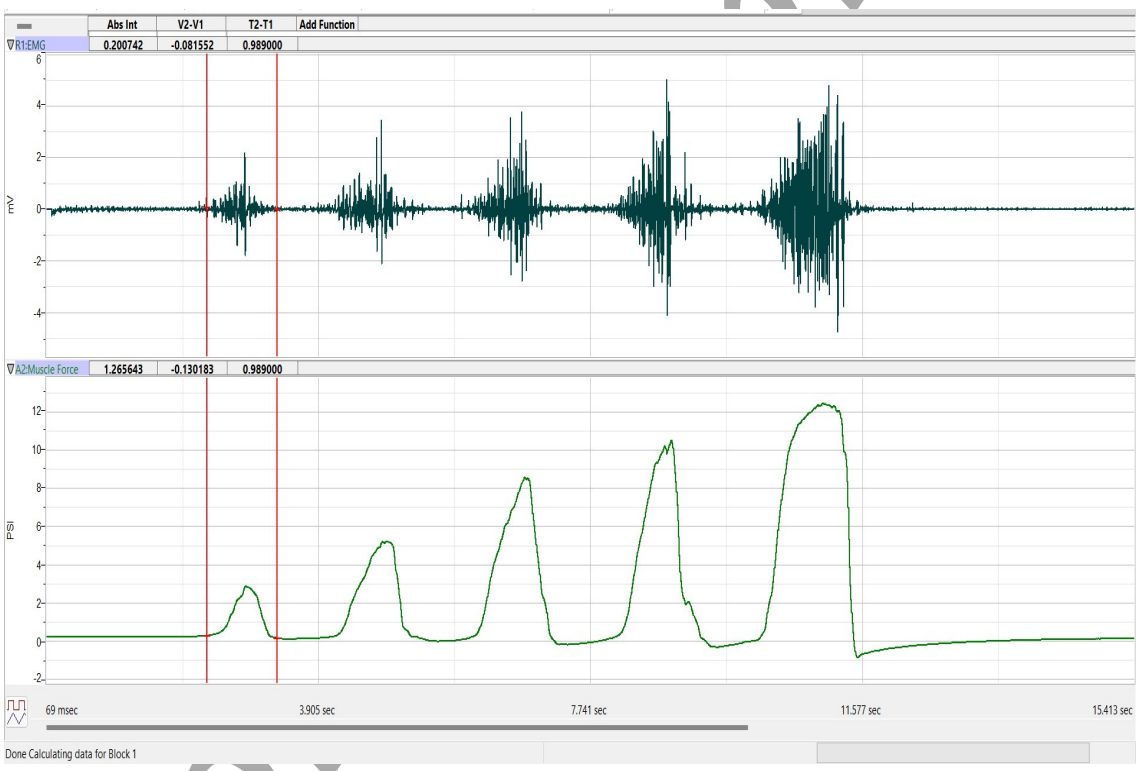

Figure HM-1-L3: The EMG and muscle force recordings displayed in the Analysis window. The cursors are placed on the margins of the 2nd muscle contraction and the absolute integral function is used to measure the area under the EMG spikes and the area under the force recording.

Workbook Lab

7. Use the mouse to click on and drag the cursors to the beginning and end of the first muscle contraction. The values for Abs. Int. on the EMG and Muscle channels are the relative amount of the electrical activity causing the contraction and relative strength of the muscle, respectively. Record the values for these integrals in the Journal using the one of the techniques described earlier in this exercise, and on Table 1.
8. Repeat Steps 4, 5, and 6 for the other muscle contractions recorded in this exercise.
9. Use a piece of string and a metric ruler to measure the circumference of the dominant forearm at approximately 3 centimeters below the elbow. Record this value in the Journal and on Table 1.
10. Select Save from the File menu.

Questions

1. Using Excel, plot the absolute integral of muscle contraction as a function of the absolute integral of the EMG signals for each muscle clinch. EMG will be the x-axis.
2. Is there a linear relationship between the absolute integral under EMG signals and the absolute integral under the muscle contraction?
3. Do muscle fibers have a refractory period like nerve fibers?
4. Does the amplitude of the EMG signal and the force of contraction, as measured by the absolute integrals, increase because a finite number of fibers are firing more often, or because more fibers are recruited to fire as the intensity of signals in the motor neurons increases, or a combination of these two?

Table HM-1-L1:The Effect of EMG Activity on the Relative Muscle Strength in the Dominant Forearm.

Dominant Forearm Circumference (mm):_____		
Relative Grip Strength	Absolute Int. of EMG Activity	Absolute Int. under Force Curve
Lowest		
Higher 1		
Higher 2		
Highest		

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Exercise 2: EMG Intensity and Fatigue in Dominant Arm

Aim: To observe the relationship between the length and strength of a muscle contraction and EMG activity in the dominant forearm.

Approximate Time: 15 minutes

Procedure

1. The subject should sit quietly with their dominant forearm on the table top.
2. Explain the experimental procedure of this exercise to the subject:
    - The subject will squeeze the bulb of the hand dynamometer as tightly and as long as possible in an attempt to fatigue the muscles of the forearm.
    - As time passes, the subject's muscle force will decrease, but at a rate that is dependent on the fitness of the subject.
    - When the subject's muscle strength drops to a level that is below half of the subject's maximum muscle force at the beginning of the recording, the recording will be stopped. This could take as little as 20 seconds or as long as a couple of minutes.
3. Type **Fatigue-Dominant** in the Mark box. Click the Record button, followed by clicking the mark button. Record a baseline for ten seconds, then instruct the subject to squeeze and hold the hand dynamometer with as much force as possible. Continue to record.
4. Click the AutoScale All button. The recording should be similar to the image below.
5. When the subject's muscle strength decreases to a level that is below 50% of the maximum muscle strength that was recorded at the beginning of this exercise, instruct the subject to release the bulb. NOTE: DO NOT click stop until the recording is 50% of the starting squeeze strength.
6. Click the Stop button to halt the recording.
7. Select Save from the File menu.

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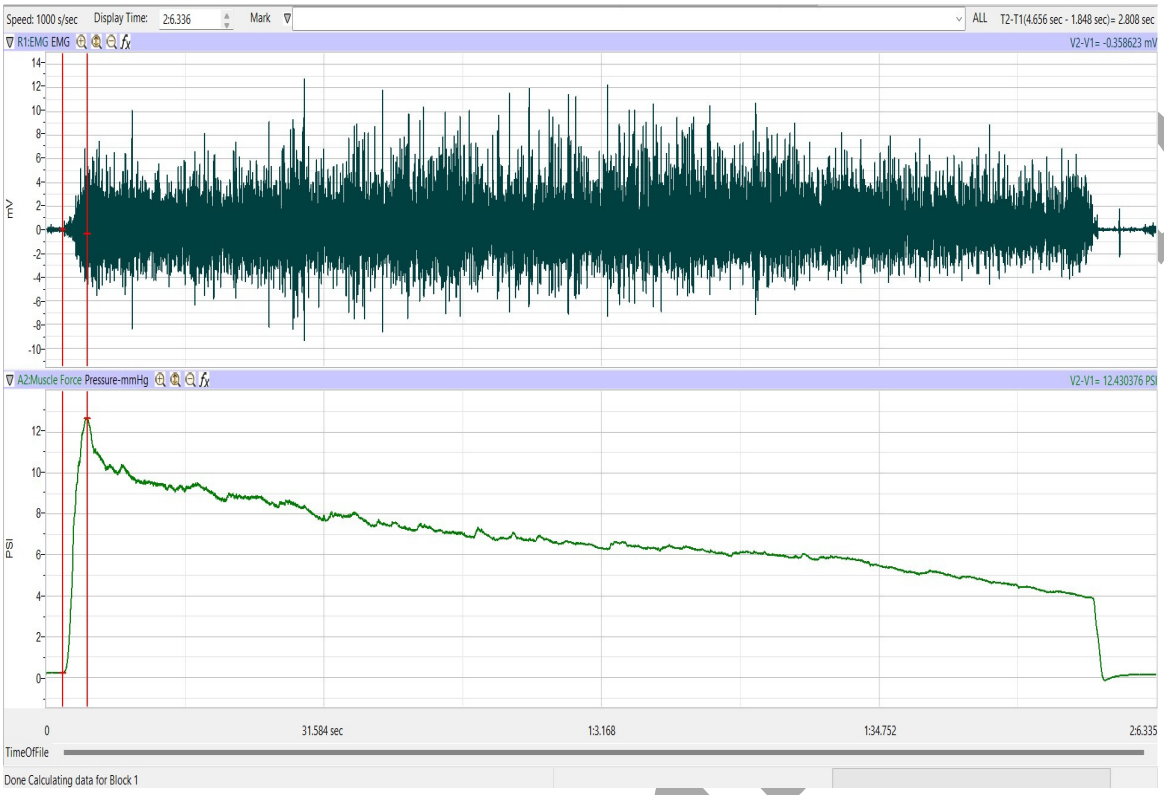

Figure HM-1-L4: EMG and muscle force during muscle fatigue recording.

Data Analysis

1. Use the Display Time icons to adjust the Display Time of the Main window to show the complete muscle fatigue recording on the Main window.
2. Data can be collected from the Main window or the Analysis window. If you choose to use the Analysis window, click on the Analysis window icon in the toolbar.
3. The mathematical functions, V2-V1 and T2-T1 should appear on screen. Values for V2-V1 and T2-T1 on each channel are seen in the table across the top margin of each channel, or to the right of each graph.
4. Use either of the two techniques described in Exercise 1 to record the names and values of parameters in the Journal.
5. On the Muscle Force channel, use the mouse to click on and drag the cursors to specific points on the recording to measure the following:
    - The maximum muscle force. To measure this force, place one cursor on the baseline before the muscle contraction and the second cursor on the peak muscle force near the beginning of the contraction. The value for V2-V1 on the Muscle Force channel is this amplitude.
    - The half-max muscle force. Divide the maximum muscle force by 2. Note this value.

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- The half-max fatigue time, which is the time it takes the muscle force to decrease to 50% of the maximum during the fatigue experiment. Keep one cursor on the peak of the muscle force. Move the second cursor to the right of the peak muscle force until the absolute value for V2-V1, seen on the Muscle Force channel, is equal to the half-max muscle force.

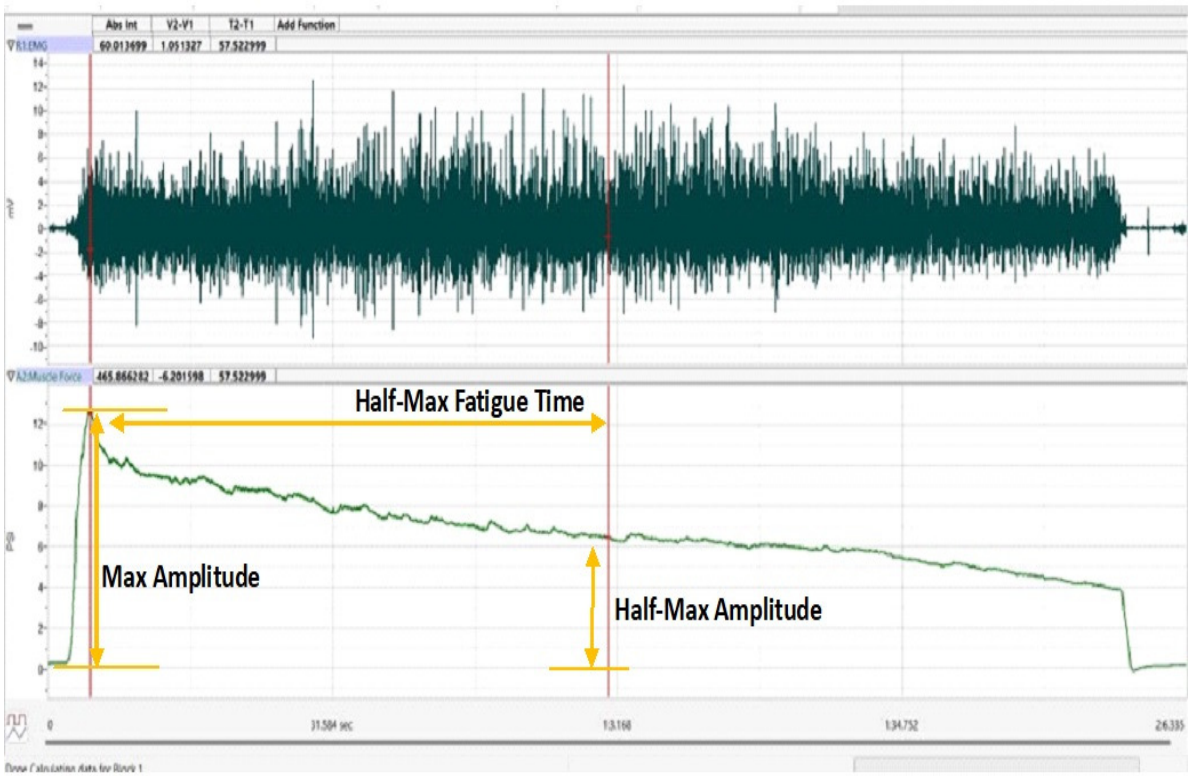

Figure HM-1-L5: The EMG (upper) and muscle force (lower) during a prolonged muscle contraction displayed in the Analysis window. The cursors are placed on the muscle force channel to measure the half-max fatigue time.

Exercise 3: EMG Intensity and Force in the Non-Dominant Arm

Aim: To determine the relationship between the intensity of EMG activity and the force of a muscle contraction in the subject's non-dominant forearm.

Approximate Time: 15 minutes

Procedure

Follow the same directions used in Exercise 1 to record data from the subject's non-dominant forearm.

Data Analysis

1. Analyze the data from the subject's non-dominant forearm as it was done in Exercise 1.

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2. Record the values for the parameters that were measured in the Journal using one of the techniques described in Exercise 1, and on Table 2.
3. Use a piece of string and a metric ruler to measure the circumference of the non-dominant forearm.
4. Select Save from the File menu.

Table HM-1-L2: The Effect of EMG Activity on the Relative Muscle Strength in the Non-Dominant Forearm.

Non-Dominant Forearm Circumference (mm):_____		
Relative Grip Strength	Absolute Int. of EMG Activity	Absolute Int. under Force Curve
Lowest		
Higher 1		
Higher 2		
Highest		

Questions

Use the information from Exercises 1 and 3 to answer the following questions.

1. Is one of the subject's forearms stronger than the other? Use the maximum grip strength from each arm to determine this answer. Calculate the percent difference in maximum grip strength from each arm.
2. Does the stronger forearm have a higher ratio of average maximum grip strength compared to the area of the EMG absolute integral than the weaker forearm? Use the slopes of the force-EMG activity graphs for each forearm to determine this answer. Calculate the percent difference in the slope of the force-EMG activity graph from each arm.

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Exercise 4: EMG Intensity and Fatigue in Non-Dominant Arm

Aim: To observe the relationship between the length and strength of a muscle contraction and EMG activity in the non-dominant forearm.

Approximate Time: 15 minutes

Procedure

Follow the same directions used in Exercise 2 to record fatigue data from the subject's non-dominant forearm.

Data Analysis

Analyze the fatigue data from the subject's non-dominant forearm as it was done in Exercise 2. Use the information from Exercises 2 and 4 to answer the following questions.

Questions

1. Is there a difference in the maximum forces generated by the dominant and the non-dominant forearms? Calculate the percent difference between the forces.
2. Is there a difference between the circumference of the dominant and non-dominant forearms? Calculate the percent difference between the circumferences.
3. Is there a relationship between the circumference of the forearm and the maximum force developed? If there is, what is it?
4. If there is a difference in the circumference of the forearms is it caused by a difference in the number of muscle fibers in the forearm or the circumference of each muscle fiber in the forearm? Explain.
5. How does the time to fatigue to half-strength in the dominant forearm compare to the same parameter for the non-dominant forearm?

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