Grip Strength and Electromyogram (EMG) Activity

Objective:

To explain, in words or with diagrams, the relationship between the strength of muscle contraction and the amount of electrical activity in the muscle, measured as the electromyogram, (EMG), at the level of 85% proficiency for each student.

In order to achieve this objective, you will need to be able to:
1. Explain the organization of motor units and the mechanisms of muscle contraction.
2. Measure the electromyogram (EMG) quantitatively using integration of the absolute values of the amplitudes of the EMG spikes.
3. Measure grip strength quantitatively using a hand dynamometer.
4. Relate the grip strength to the EMG activity.

Materials:

PC Computer	FT-325 Hand Dynamometer	ECG/EMG electrode lead wires
IWX/214 data acquisition unit	Bathroom scale	Disposable electrodes
USB cable	5 or 6 textbooks	Alcohol swabs
IWX/214 power supply	C-AAMI-504 ECG/EMG cable	String / Metric Ruler

Methods:

Setup
1. Plug the power supply into the data recording unit and connect the USB cable between the unit and the computer. Make sure the computer is on.
2. Use the power switch on the back of the data recording unit to turn the unit on. Confirm that the **red power light is on**.
   THIS MUST BE DONE IN ORDER FOR THE PROGRAM TO START UP PROPERLY!!!!!

Starting the Software

1. Click on the LabScribe2 shortcut on the computer's desktop to open the program. The LabScribe **Main window** will appear as the program opens.
2. An information box will appear if the computer recognizes the data recording unit, "hardware found". Click OK.
3. Pull down the **Settings Menu** and select **Human Muscle** and then **EMGGripStrength-LS2**. The iWorx instructions for the EMG lab will appear on the computer screen (Adobe Reader). Click the **X** on this window to close.
4. After a short time, LabScribe set up for the ECG lab will appear on the computer screen.

Connecting the Hand Dynamometer

1. Plug the hand dynamometer into CH3 input of the data acquisition unit, as shown below


Calibrating the Hand Dynamometer

1 Collect 3 textbooks. Weigh the stack of books on the bathroom scale (kg). Record the weight of the stack in kilograms (kg) on the Data Sheet.
2 If the Record button is not displayed, click on the **Main window** icon in the toolbar.
3 Lay the hand dynamometer down on your bench top. Click the **Record** button on the LabScribe Main window. After 10 seconds stack all of the textbooks on the bulb of the hand dynamometer. Record for an additional 10 seconds and then 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 the **first cursor** on the force recording made before the books were placed on the bulb. Place the **second cursor** on the recording after the books were placed on the bulb
6 Open the **Channel Menu** of the **Muscle Force** channel by clicking on the **down arrow** to the left of the channel's title. Select **Units** from this menu and **Simple** from the submenu to open the **Simple Units Conversion** window, as shown below.

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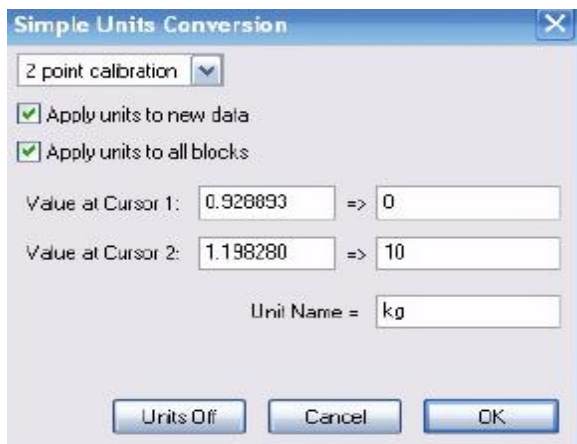
7   Put check marks in the boxes next to **Apply Units to new data** and **Apply Units to all blocks**.

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.

- For Cursor 1, <u>no</u> books on dynamometer, type zero (0) in the box on the right.
- For Cursor 2, books on dynamometer, type the weight of the books in the box on the right (≈10 kg).
- Type the name of the unit, **kg** or **kilogram**, in the **Unit Name** box. Click the **OK** button.

Connecting the EMG Cable and EMG Electrodes

1. Insert the EMG cable into the isolated inputs of CH1 & CH2 as shown on the previous page.
2. Insert the connectors on the red, black, and green electrode lead wires into the matching sockets on the lead pedestal of the EMG cable.
3. ***The EMG cables and connectors must be kept as far as possible away from electrical outlets, power sources, and power supplies and cables, including cell phone chargers.***
4. The subject should remove all jewelry from their wrists. For the first exercises in this lab, EMG and muscle force are recorded from the subject's dominant arm, the arm used most often.
5. Use an alcohol swab to clean three regions on the inside of the subject's dominant forearm where the electrodes will be placed (see figure below)
   - One area is near the wrist, the second is in the middle of the forearm, and the third area is about 2 inches from the elbow.
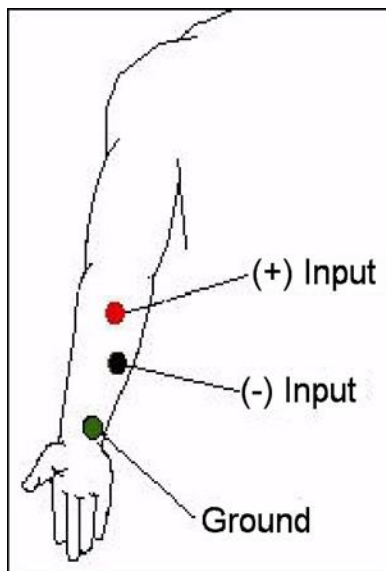

6. Let the areas dry before attaching the electrodes.
7. Remove the plastic disk from a disposable electrode and apply it to one of the scrubbed areas. Repeat for the other two areas.
8. Snap the lead wires onto the electrodes, so that:
   b. the red "+1" lead is attached to the electrode near the elbow.
   c. the black "-1" lead is attached to the electrode in the middle of the forearm.
   d. the green "C" lead (the ground) is attached to the electrode on the wrist.

Procedures:

Exercise 1: EMG Intensity and Force in Dominant Arm

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

1. The subject should sit quietly with his or her dominant forearm resting on the table top. The subject will squeeze his or her fist around the hand dynamometer four times.

   - The first squeeze should be mild and each successive squeeze should be approximately two, three, and four times stronger than the first squeeze.
   - Each squeeze should be two seconds long followed by two seconds of relaxation.

2. If the Record button is not displayed, click on the **Main window** icon in the toolbar.
3. Click the **Record button** to begin the recording. Tell the subject to begin squeezing the hand dynamometer following the procedure outlined in step 1 above.
4. In the relaxation period after the last squeeze, click the **Stop** button.
5. Click the **AutoScale** buttons for the **EMG Channel** and for the **Muscle Force Channel**. The recording should be similar to that shown below.
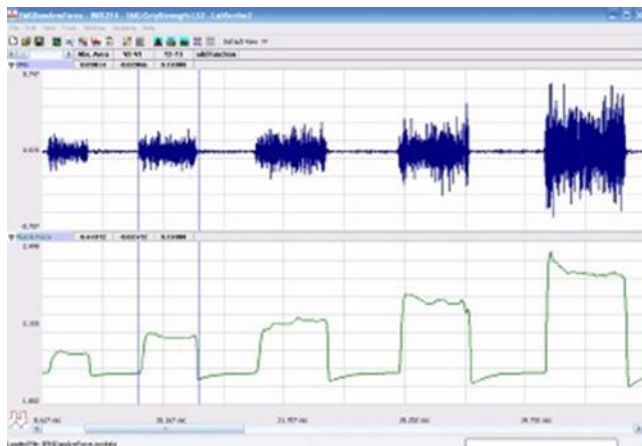
Data Analysis

1. Use the **Display Time** icons, as necessary, to adjust the **Display Time** of the **Main window** to show the four progressive muscle contractions on the **Main window**.
2. Click on the **Analysis window** icon in the toolbar to switch from the **Main window** to the **Analysis window**, as shown above.
3. Look at the **Function Table** that is above the uppermost channel displayed in the **Analysis** window. The mathematical functions, **Abs. Area**, **V2-V1**, and **T2-T1** should appear in this table. The values for **Abs. Area**, **V2-V1**, and **T2-T1** are seen across the top margin of each channel. If any of these are missing, ask for assistance to add them.

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4. Use the mouse to click on and drag the cursors to the beginning and end of the first muscle contraction. The values for **Abs. Area** 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 these values in Table 1.
5. Repeat Step 4 for the other three muscle contractions recorded in this exercise. Record these values in Table 1.
6. 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 Table 1.

Table 1. EMG Activity and Force in Dominant Arm

	Dominant Forearm	
Relative Grip Strength	Absolute Area of EMG Activity	Absolute Area of Muscle Force
Lowest		
2nd		
3rd		
Highest		
Circumference	= _____ cm	

Exercise 2: EMG Activity, Muscle Force and Fatigue Time in Dominant Arm

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

1. The subject should sit quietly with his or her dominant forearm on the table top. The subject will squeeze the bulb of the hand dynamometer <u>as strongly as possible</u> until told to stop.

   - 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 few minutes

2. Click on the **Main window** icon in the toolbar.
3. Click the **Record** button. After ten seconds, while continuing to record, instruct the subject to squeeze and hold the hand dynamometer with as much force as possible until told to stop.
4. Click the **AutoScale buttons** for the **EMG** and **Muscle Force** channels. The recording should be similar to the Figure on the next page.
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. Click the **Stop** button.
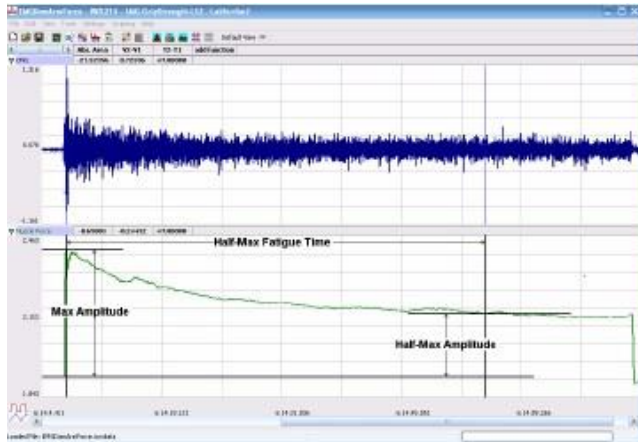
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Data Analysis

1. Use the **Display Time** icons, as necessary, to adjust the **Display Time** of the **Main window** to show the complete muscle fatigue recording on the **Main window**, as shown above.
2. Click on the **Analysis window** icon in the toolbar to switch from the **Main window** to the **Analysis window**, as shown above.
3. Look at the **Function Table** that is above the uppermost channel displayed in the **Analysis** window. The mathematical functions, **Abs. Area**, **V2-V1**, and **T2-T1** should appear in this table. The values for **Abs. Area**, **V2-V1**, and **T2-T1** are seen across the top margin of each channel.
4. 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:

   - **Maximum muscle 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. Record in Table 2.
   - **Half-max muscle force**. Divide the maximum muscle force by 2. Record in Table 2.
   - **Half-max fatigue time**. Place one cursor on the peak muscle force. Move the second cursor to the right of the peak muscle force until the <u>absolute</u> value for **V2-V1**, seen on the **Muscle Force** channel, is equal to the half-max muscle force (see Figure above). **T2-T1** will be the half-max fatigue time. Record in Table 2.

Table 2. Muscle Force and Fatigue time in Dominant Arm

	Dominant Forearm
Maximum muscle force V_2-V_1	
Half-max muscle force $(V2-V1)/2$	
Half-max fatigue time T2-T1	

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Discussion

1. Plot the absolute area of muscle contraction vs. the absolute area of the EMG signals for each muscle clinch *in the dominant arm*. Is there a linear relationship between the two variables? Describe the relationship in words.
2. Explain the relationship between increasing EMG signals and increasing force of contraction in terms of muscle cells and motor units.
3. During muscle fatiguing, does the decrease in grip strength parallel the decrease in EMG activity? Speculate on the cause(s) of muscle fatigue.