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

## Background

A motor unit is composed of a motor neuron and all the muscle fibers that are innervated by that motor neuron. In a persistent muscle contraction, multiple motor units are firing repetitively throughout the contraction of the muscle. The strength of a muscle contraction is related to the number of motor units in the muscle that are activated during the same time period. The electromyogram (EMG) recorded during the muscle contraction is seen as a burst of spike-like signals, and the duration of the burst is about equal to the duration of the muscle contraction.

The strength of a striated muscle contraction is directly proportional to the amount of electrical activity in the muscle. However, it is difficult to quantify the amount of electrical activity in a muscle unless the raw EMG data is mathematically transformed. One of the most common transformations used is the integration of the absolute values of the amplitudes of the EMG spikes. Through this transformation, it has been found that the area under the graph of the absolute integral of the EMG is linearly proportional to the strength of the muscle contraction.

In this experiment, students will use a hand dynamometer to measure a subject's grip strength as the EMG activity of the forearm muscles used to generate the subject's grip are recorded. The EMG activity will be related to the grip strength by plotting the maximum grip strength as a function the area under the absolute integral of the EMG activity during the muscle contraction. Data recordings will be made from the subject's dominant and non-dominant forearms, and the relative strength and electrical activity of each forearm will be compared to its diameter. Recordings of prolonged grip strength and forearm EMG activity will also be made to determine the rate of fatigue in the dominant and non-dominant forearms.

## Equipment Required

PC Computer

IWX/214 data acquisition unit

USB cable

IWX/214 power supply

C-AAMI-504 ECG cable and electrode lead wires

Disposable electrodes

FT-325 Hand Dynamometer

Alcohol swabs

Bathroom scale and 5 or 6 textbooks

String

Metric Ruler

## IWX/214 Setup

1 Place the IWX/214 on the bench, close to the computer.

2 Check Figure T-1-1 in the Tutorial Chapter for the location of the USB port and the power socket on the IWX/214.

3 Check Figure T-1-2 in the Tutorial Chapter for a picture of the IWX/214 power supply.

4 Use the USB cable to connect the computer to the USB port on the rear panel of the IWX/214.

5 Plug the power supply for the IWX/214 into the electrical outlet. Insert the plug on the end of the power supply cable into the labeled socket on the rear of the IWX/214. Use the power switch to turn on the unit. Confirm that the red power light is on.

## Start the Software

1 Click on the LabScribe shortcut on the computer's desktop to open the program. If a shortcut is not available, click on the Windows **Start menu**, move the cursor to **All Programs** and then to the listing for **iWorx**. Select **LabScribe** from the **iWorx submenu**. The LabScribe **Main window** will appear as the program opens.

1 On the **Main window**, pull down the **Settings menu** and select **Load Group.**

2 Locate the folder that contains the settings group, **IPLMv4.iwxgrp**. Select this group and click **Open**.

3 Pull down the **Settings menu** again. Select the **EMG-GripStrength-LS2** settings file.

4 After a short time, LabScribe will appear on the computer screen as configured by the **EMG-GripStrength-LS2** settings.

5 For your information, the settings used to configure the LabScribe software and the IWX/214 unit for this experiment are listed in Table HM-1-1 on page HM-1-2. These settings are programmed on the Preferences Dialog window which can be viewed by selecting Preferences from the Edit menu on the LabScribe Main window.

**Table HM-1-1: Settings on the Channel Window of the Preferences Dialog Used to Configure the iWorx Recording System for Experiment HM-1.**

| Parameter | Units/Title | Setting | Mode/ Function |
|---|---|---|---|
| Acquisition Mode | | Chart | |
| Start | | User | |
| Stop | | User | |
| Display Time | Sec | 10 | |
| Speed | Samples/Sec | 1000 | |
| Channel A1 | EMG | S | 3-10KHz |
| Channel A3 | Muscle Force | S | DIN8 |

## EMG Cable and Hand Dynamometer Setup

1 Locate the C-AAMI-504 EMG cable and electrode lead wires (Figure HM-1-1 on page HM-1-2), and FT-325 hand dynamometer (Figure HM-1-2 on page HM-1-2), in the iWorx kit.

*Figure HM-1-1: The C-AAMI-504 EMG cable with three lead wires attached.*

*Figure HM-1-2: The FT-325 hand dynamometer*

*Figure HM-1-3: The EMG cable and hand dynamometer connected to an IWX/214*

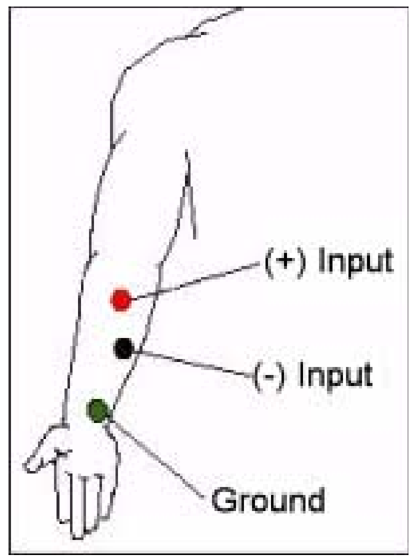


*Figure HM-1-4: Placement of EMG electrodes on the forearm.*

2 Plug the DIN8 connector to the FT-325 hand dynamometer into the Channel 3 input of the IWX/214 (Figure HM-1-3 on page HM-1-2).

3 Insert the black AAMI connector on the end of the EMG cable into the isolated inputs of Channels 1 and 2 of the IWX/214 (Figure HM-1-3 on page HM-1-2).

4 Insert the connectors on the red, black, and green electrode lead wires into the matching sockets on the lead pedestal of 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.

6 Use an alcohol swab to clean and scrub three regions on the inside of the subject's dominant forearm where the electrodes will be placed (Figure HM-1-4 on page HM-1-2). 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.

7 Let the areas dry before attaching the electrodes.

8 Remove the plastic disk from a disposable electrode and apply it to one of the scrubbed areas. Repeat for the other two areas.

9 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.

## Calibrating the Hand Dynamometer

1 Collect 5 textbooks. Weigh the stack of books on the bathroom scale. Record the weight of the stack in kilograms (kg) in the **Journal**. To open the **Journal**, click on the **Journal** button in the LabScribe toolbar. Use the keyboard to type the weight of the stack in the **Journal** window.

***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 stack the textbooks on the bulb of the hand dynamometer. Record for an additional ten seconds after the last book is placed on the stack. 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.

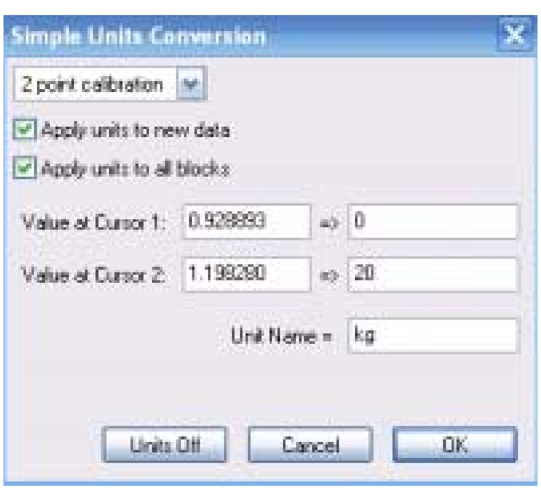


*Figure HM-1-5: The* ***Simple Units Conversion dialogue window****.*

6 Open the **Channel Menu** of the **Muscle Force** channel by clicking on the **down arrow** to the left of the channels's title. Select **Units** from this menu and **Simple** from the submenu to open the **Simple Units Conversion dialogue window** (Figure HM-1-5 on page HM-1-3).

7 Put check marks in the boxes next to **Apply Units to new data** and **Apply Units to all blocks**. Click on the **Units Off button** to remove any prior units conversion from this channel.

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.

## 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.

### *Procedure*

1 The subject should sit quietly with his or her dominant forearm resting on the table top. Explain the procedure to the subject. The subject will squeeze his or her fist around the hand dynamometer four times, each contraction is two seconds long followed by two seconds of relaxation. Each successive contraction should be approximately two, three, and four times stronger than the first contraction.

2 Type **Increasing Grip Force-Dominant** in the **Mark box** to the right of the **Mark button**. Click the **Record button** to begin the recording; then, press the **Enter** key on the keyboard 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.

4 Click the **AutoScale buttons** for the **EMG**, **Muscle Force**, and **EMG Integral** channels. The recording should be similar to Figure HM-1-6 on page HM-1-4.

5 Select **Save As** in the **File menu**, type a name for the file. Choose a destination on the computer in which to save the file, like your lab group folder). Designate the file type as ***.iwxdata**. Click on the **Save** button to save the data file.

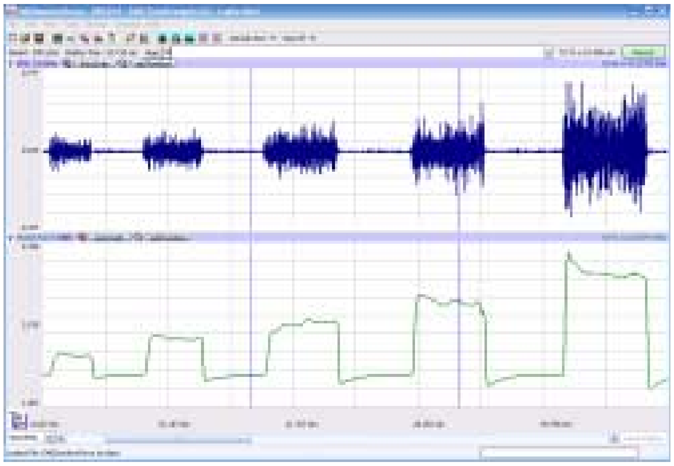

*Figure HM-1-6: The EMG (upper) and muscle force (lower) for four progressively stronger contractions displayed in the **Main** window.*

## Data Analysis

1 Use the **Display Time** icons to adjust the **Display Time** of the **Main window** to show the four progressive muscle contractions on the **Main window**. The four contractions can also be selected by:

- Placing the cursors on either side of a group of four contractions; and

- Clicking the **Zoom between Cursors** button on the LabScribe toolbar to expand the segment with the four contractions to the width of the **Main window**.

2 Click on the **Analysis window** icon in the toolbar (Figure HM-1-7 on page HM-1-4) or select **Analysis** from the **Windows menu** to transfer the data displayed in the **Main window** to the **Analysis window** (Figure HM-1-8 on page HM-1-4).

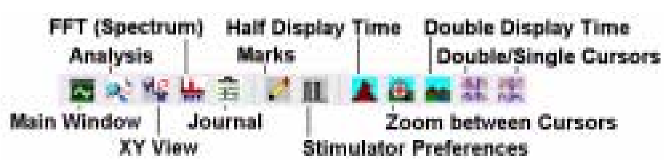


*Figure HM-1-7: The LabScribe toolbar.*

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** on each channel are seen in the table across the top margin of each channel.

4 Once the cursors are placed in the correct positions for measuring the absolute areas under the muscle contraction and the corresponding EMG activity, the values for the areas can be recorded in the on-line notebook of LabScribe by typing the names and values directly into the **Journal**.

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 areas to the **Journal**. To use these functions:

- Place the cursors at the locations used to measure the absolute areas.

- Transfer the name of the mathematical function used to determine the absolute areas to the **Journal** using the **Add Title to Journal** function in the **EMG channel pull-down menu**.

- Transfer the values for the absolute areas to the **Journal** using the **Add All Data to Journal** function in the **EMG channel pull-down menu**.

6 Use the mouse to click on and drag the cursors to the beginning and end of the first muscle contraction (Figure HM-1-8 on page HM-1-4). 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 the values for these areas in the **Journal** using the one of the techniques described earlier in this exercise, and on Table HM-1-2 on page HM-1-4.

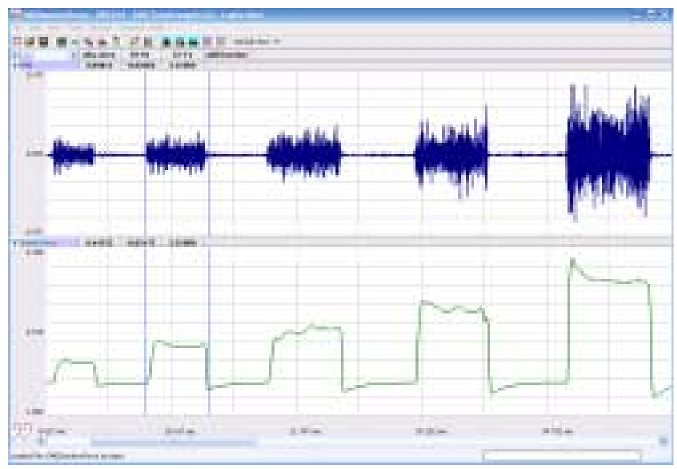

*Figure HM-1-8: The EMG and muscle force recordings displayed in the Analysis window. The cursors are placed on the margins of the first muscle contraction and the absolute area function is used to measure the area under the EMG spikes and the area under the force recording.*

7 Repeat Steps 4, 5, and 6 for the other three muscle contractions recorded in this exercise.

8 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 HM-1-2 on page HM-1-4.

**Table HM-1-2: The Effect of EMG Activity on the Relative Muscle Strength in the Dominant Forearm.**

| Dominant Forearm Diameter (mm):______ | | |
|---|---|---|
| Relative Grip Strength | Absolute Area of EMG Activity | Absolute Area under Force Curve |
| Lowest | | |
| Higher 1 | | |
| Higher 2 | | |
| Highest | | |

9 Select **Save** from the **File menu**.

### Questions

1 Plot the absolute area of muscle contraction as a function of the absolute area of the EMG signals for each muscle clinch.

2 Is there a linear relationship between the absolute area under EMG signals and the absolute area 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 areas, 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?

## 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.

### Procedure

1 The subject should sit quietly with his or her 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 a 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 or as long as a few minutes

3 Type **Fatigue-Dominant** in the **Mark box** to the right of the **Mark button**. Click the **Record** button, followed by pressing the **Enter** key on the keyboard. 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 buttons** for the **EMG** and **Muscle Force** channels. The recording should be similar to Figure HM-1-9 on page HM-1-5.

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 to halt the recording.

6 Select **Save** from the **File menu**.

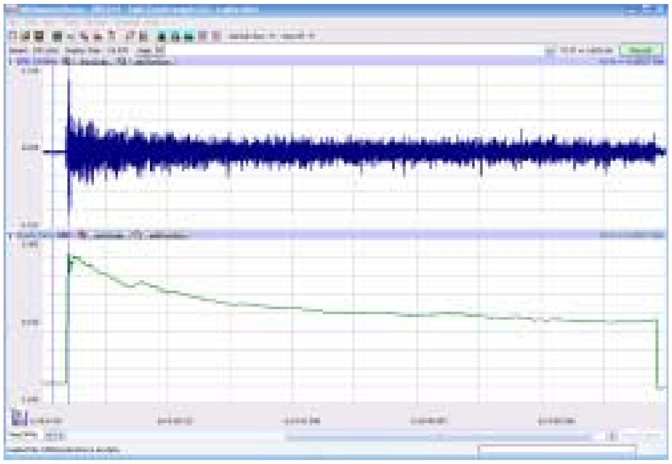

*Figure HM-1-9: EMG and muscle force during muscle fatigue recording.*

### 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**. The complete recording can also be selected by:

• Placing one cursor on the relaxation period just before the contraction and the other cursor on the relaxation period just after the subject releases the hand dynamometer; and

• Clicking the **Zoom between Cursors** button on the LabScribe toolbar to expand the muscle fatigue recording to the width of the **Main window**.

2 Click on the **Analysis window** icon in the toolbar (Figure HM-1-7 on page HM-1-4) or select **Analysis** from the **Windows menu** to transfer the data displayed in the **Main window** to the **Analysis window**.

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** on each channel are seen in the table across the top margin of each channel.

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.

• 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. Place one cursor on the peak 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-1-10 on page HM-1-6).

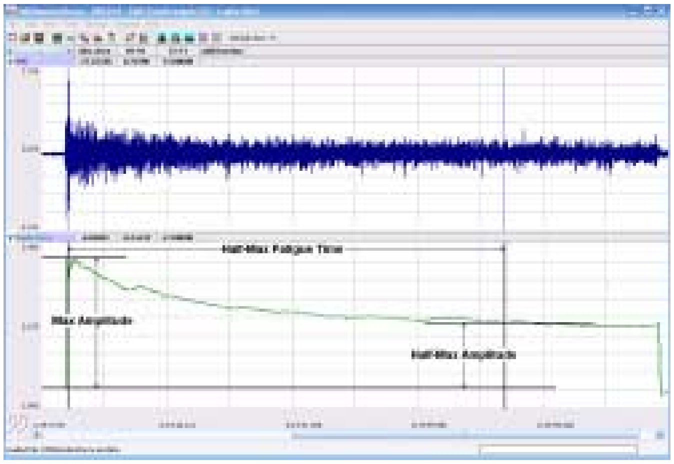


*Figure HM-1-10: The EMG (upper) and muscle force (lower) during a prolonged muscle contraction displayed in the Analysis window. The cursors are placed on the muscle force channel to measure the half-max fatigue time.*

## 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.

### *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.
2. Record the values for the parameters that were measured in the **Journal** using the one of the techniques described in Exercise 1, and on Table HM-1-3 on page HM-1-6.
3. Use a piece of string and a metric ruler to measure the circumference of the non-dominant forearm at approximately 3 centimeters below the elbow. Record this value in the **Journal** and on Table HM-1-3 on page HM-1-6.
4. Select **Save** from the **File menu**.

**Table HM-1-3: The Effect of EMG Activity on the Relative Muscle Strength in the Non-Dominant Forearm.**

| Non-Dominant Forearm Diameter (mm):______ | | |
|---|---|---|
| Relative Grip Strength | Absolute Area of EMG Activity | Absolute Area 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 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.

## 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.

### *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 diameter 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?

# Experiment HM-2: Electromyogram (EMG) Activity in Antagonistic Muscles

## Background

The movement of parts of the body is accomplished through a system of levers composed of skeletal muscles and bones. In a lever, the muscle attached to the bone provides the effort or force that moves the bone. As the muscle contracts and relaxes, the bone, functioning as the actual lever, rotates around a joint in the skeletal system. In relation to the muscle, the bone, and the body part being moved, the joint is the fixed point that functions as the fulcrum for the lever. The body part being moved is the load in the lever (Figure HM-2-1 on page HM-2-1).

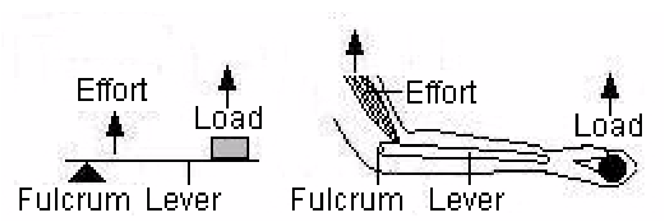


*Figure HM-2-1: A Third Class lever and a counterpart in the human body. The insertion of the muscle on the bone in the forearm places the effort between the elbow (fulcrum) and the hand (load).*

All levers, including the ones in the body, can be categorized into one of three classes, which are based on the position of the fulcrum in relation to the positions of the effort and the load:

- In First Class levers, the fulcrum is between the effort and the load, like on a see-saw. In the body, an example of this class is the extension of the forearm by the triceps muscle.
- In Second Class levers, the load is between the effort and the fulcrum, like a wheel barrow. In the body, an example of this class is standing on tiptoe by using the gastrocnemius muscle.
- In Third Class levers, the effort is between the fulcrum and the load, like tweezers. In the body, an example is the flexion of the forearm by the biceps muscle.

Body parts are moved in different directions by muscles that act on the same bone from different directions. A simple example is the movement of the forearm. When the biceps muscle contracts, the forearm and the hand move toward the shoulder in a motion called flexion. When the triceps muscle contracts, the forearm and hand move away from the shoulder in a motion called extension. Since these two muscles move the forearm in different directions, they are antagonistic muscles. These muscles relax and contract in a coordinated manner to place the forearm and hand in the desired position. If the effort exerted on the bone by each muscle is equal in magnitude and opposite in direction, the forearm remains stationary. Antagonistic muscles do not need to belong to the same class of lever to work in opposition. For example, the biceps and from two different classes of levers. The biceps and triceps are different classes of levers; the biceps is part of a third class lever, and the triceps is part of a first class lever.

By recording the EMG activity in a muscle during the movement or positioning of a body part, it can be determined if the muscle is involved. In this experiment, students will record EMG activity from muscles on the anterior and posterior sides of the forearm to determine which ones are responsible for flexion and extension of the hand. Recording of EMG activity from these muscles will also be done while a weight is lifted by the hand. In another exercise, students will record EMG activity from the anterior and posterior sides of the lower leg to determine which muscles are active during movements or positioning that are more complex, like leaning forward, standing on toes, or rocking on heels.

## Equipment Required

PC Computer

IWX/214 data acquisition unit

USB cable

IWX/214 power supply

C-AAMI-504 ECG cable and electrode lead wires

Disposable electrodes

Alcohol swabs

Small weight

## IWX/214 Setup

1. Place the IWX/214 on the bench, close to the computer.
2. Check Figure T-1-1 in the Tutorial Chapter for the location of the USB port and the power socket on the IWX/214.
3. Check Figure T-1-2 in the Tutorial Chapter for a picture of the IWX/214 power supply.
4. Use the USB cable to connect the computer to the USB port on the rear panel of the IWX/214.
5. Plug the power supply for the IWX/214 into the electrical outlet. Insert the plug on the end of the power supply cable into the socket on the rear of the IWX/214. Use the power switch to turn on the unit. Confirm that the power light is on.

## Start the Software

1. Click on the LabScribe shortcut on the computer's desktop to open the program. If a shortcut is not available, click on the Windows **Start menu**, move the cursor to **All Programs** and then to the listing for **iWorx**. Select **LabScribe** from the **iWorx submenu**. The LabScribe **Main window** will appear as the program opens.

1. On the **Main window**, pull down the **Settings menu** and select **Load Group.**
2. Locate the folder that contains the settings group, **IPLMv4.iwxgrp**. Select this group and click **Open**.
3. Pull down the **Settings menu** again. Select the **AntagonisticMuscles-LS2** settings file.
4. After a short time, LabScribe will appear on the computer screen as configured by the **AntagonisticMuscles-LS2** settings.
5. For your information, the settings used to configure the LabScribe software and the IWX/214 unit for this experiment are listed in Table HM-2-1 on page HM-2-2. These settings are programmed on the Preferences Dialog window which can be viewed by selecting Preferences from the Edit menu on the LabScribe Main window.

**Table HM-2-1: Settings on the Channel Window of the Preferences Dialog Used to Configure the iWorx Recording System for Experiment HM-2.**

| Parameter | Units/Title | Setting | Mode/ Function |
|---|---|---|---|
| Acquisition Mode | | Chart | |
| Start | | User | |
| Stop | | User | |
| Display Time | Sec | 10 | |
| Speed | Samples/Sec | 1000 | |
| Channel A1 | EMG Anterior | S | 3-10KHz |
| Channel A2 | EMG Posterior | S | 3-10KHz |

## EMG Cable Setup

1. Locate the C-AAMI-504 EMG cable and electrode lead wires (Figure HM-2-2 on page HM-2-2) in the iWorx kit.

*Figure HM-2-2: The C-AAMI-504 EMG cable with five lead wires attached.*

2. Insert the black AAMI connector on the end of the EMG cable into the isolated inputs of Channels 1 and 2 of the IWX/214 (Figure HM-2-3 on page HM-2-2).
3. Locate the muscles of the forearm over which the recording electrodes will be placed. Muscles can be located by flexing or extending the hand and noting the areas of the forearm where the muscles are tense during these hand positions:

• One pair of recording electrodes will be placed over the flexor muscles on the anterior surface of the forearm. The first electrode in this pair will be placed about 8 centimeters below the inside of the elbow and about 4 centimeters from the medial margin of the forearm. The second electrode in this pair will be placed about 8 centimeters below the other electrode along the midline of the anterior surface of the forearm.

• A second pair of electrodes will be placed over the extensor muscles on the posterior surface of the forearm. The first electrode in this pair will be placed about 9 centimeters below the tip of the elbow along the midline of the posterior surface of the forearm. The second electrode in this pair will be placed about 6 centimeters below the first electrode and about 3 centimeters from the lateral margin of the posterior surface of the forearm.

• A fifth electrode, used as the ground, is centered between the positions of the four recording electrodes.

*Figure HM-2-3: A five lead EMG cable connected to an IWX/214.*

4. Use an alcohol swab to clean and scrub the areas where the electrodes will be placed (Figure HM-2-4 on page HM-2-2). Let the areas dry before attaching the electrodes.

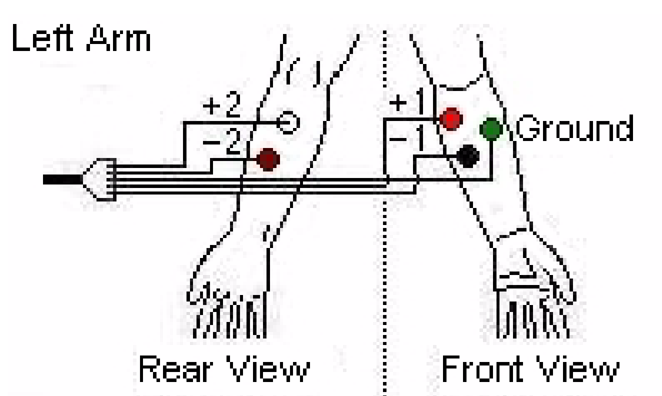


*Figure HM-2-4: Position of electrodes used to record EMG from muscles in the forearm during flexion and extension.*

5. Remove the plastic disk from a disposable electrode and apply it to one of the scrubbed areas. Attach an electrode to each of the other areas.

6 Snap the recording lead wires onto the electrodes, so that:

• the red "+1" lead is attached to the electrode on the anterior forearm that is nearest the elbow.

• the black "-1" lead is attached to the electrode on the anterior forearm closest to the middle of the forearm.

• the white "+2" lead is attached to the electrode on the posterior forearm that is nearest the elbow.

• the brown "-2" lead is attached to the electrode on the posterior forearm closest to the middle of the forearm.

• the green "C" lead (the ground) is attached to the electrode in the center of the box formed by the positions of the four recording electrodes.

## Exercise 1: Antagonistic Muscles in Forearm

Aim: To study the EMG activity in muscles that work in opposition to each other to flex or extend the hand.

### *Procedure*

1 Instruct the subject that he or she will be doing the following during this exercise:

• Before the recording begins, the subject extends his or her arm in front of their body with the palm facing upward. This position is defined as the **neutral position**.

• Keep his or her hand open during the recording.

• Move his or her hand upward (**flexion**) from the neutral position as far as possible and hold it in this position for four seconds (Figure HM-2-5 on page HM-2-3).

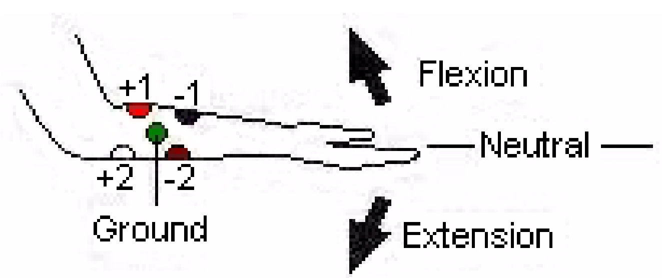


*Figure HM-2-5: Movements performed while recording from muscles of the forearm responsible for flexion and extension of the hand.*

• Return the hand to the neutral position for four seconds.

• Move the hand downward (**extension**) as far as possible and hold it in this position for four seconds.

• Return the hand to the neutral position for at least wo seconds.

• Repeat this cycle of flexion and extension two more times while recording.

2 Before the starting the recording, type **Neutral** in the **Mark box** to the right of the **Mark button**. Instruct the subject to place his or her hand in the **neutral position**.

3 Click the **Record button** in the upper right corner of the LabScribe **Main window**. Either click on the **Mark button** or press the **Enter key** on the keyboard to label the recording.

4 While the subject's hand is in the neutral position, type **Flexion** in the **Mark box**. When the subject flexes his or her hand, click on the **Mark button** or press the **Enter key** on the keyboard to label the recording.

5 While the subject's hand is in the flexed position, type **Neutral** in the **Mark box**. When the subject returns his or her hand to the neutral position, click on the **Mark button** or press the **Enter key** on the keyboard to label the recording.

6 While the subject's hand is in the neutral position, type **Extension** in the **Mark box**. When the subject extends his or her hand, click on the **Mark button** or press the **Enter key** on the keyboard to label the recording.

7 Repeat Steps 2 through 6 two more times.

8 Repeat Steps 2 through 6 three times while the subject has formed a fist.

9 When the last cycle is completed, click the **Stop** button.

10 Click **AutoScale** on all channels to amplify signals. The recording should be similar to Figure HM-2-6 on page HM-2-3.

11 Select **Save As** in the **File menu**, type a name for the file. Choose a destination on the computer in which to save the file, like your lab group folder). Designate the file type as ***.iwxdata**. Click on the **Save** button to save the data file.

*Figure HM-2-6: Recordings from anterior (top) and posterior (bottom) muscles of the forearm during flexion and extension of the hand while the subject's fingers are extended.*

### *Data Analysis*

1 Scroll through the recording and find the section of data recorded while the subject was flexing and extending his or her hand.

2 Use the **Display Time** icons to adjust the **Display Time** of the **Main window** so all three flexion-extension cycles appear on the **Main window**. The three flexion-extension cycles can also be selected by:

• Placing the cursors on either side of the three adjacent cycles; and

- Clicking the **Zoom between Cursors** button on the LabScribe toolbar to expand the segment with the three cycles to the width of the **Main window**.

3 Click on the **Analysis window icon** in the LabScribe **toolbar** (Figure HM-2-7 on page HM-2-4) or select **Analysis** from the **Windows menu** to transfer the data displayed in the **Main window** to the **Analysis window** (Figure HM-2-8 on page HM-2-4).

*Figure HM-2-7: The LabScribe toolbar.*

4 Look at the **Function Table** that is above the uppermost channel displayed in the **Analysis** window. The mathematical functions, **Abs. Area**, **Max-Min**, and **T2-T1** should appear in this table. The values for **Abs. Area**, **Max-Min**, and **T2-T1** on each channel are seen in the table across the top margin of each channel.

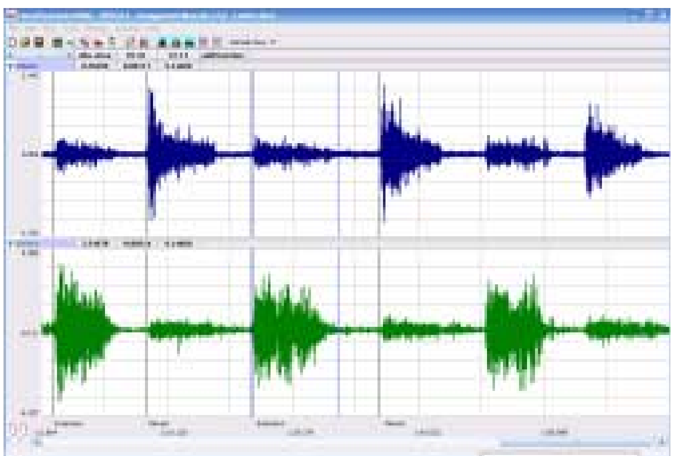
*Figure HM-2-8: EMG activity from opposing muscles. Cursors are placed to measure the EMG activity taking place simultaneously in flexors and extensors.*

5 Once the cursors are placed in the correct positions for measuring the three parameters of an EMG burst, the values for the parameters can be recorded in the on-line notebook of LabScribe by typing the names and values directly into the **Journal**, or on a data table.

6 The functions in the **channel pull-down menus** of the **Analysis window** can also be used to enter the names and values of the parameters to the **Journal**. To use these functions:

- Place the cursors at the locations used to measure the absolute areas.

- Transfer the name of the mathematical function used to determine the absolute areas to the **Journal** using the **Add Title to Journal** function in the **Anterior Channel pull-down menu**.

- Transfer the values for the absolute areas to the **Journal** using the **Add All Data to Journal** function in the **Anterior Channel pull-down menu**.

7 Use the mouse to click on and drag the cursors to the onset and offset of the EMG burst during the first flexion (Figure HM-2-8 on page HM-2-4). The values for **Abs. Area**, **Max-Min**, and **T2-T1** on the **Anterior channel** are the relative amounts of the EMG activity, the differences between maximum and minimum EMG amplitudes, and the durations of the EMG burst in the anterior muscle group during the flexion. The values for these parameters, listed in the table above the **Posterior channel**, are the same properties from the posterior muscle group during the same flexion.

8 Record the values from each muscle group during the first flexion in the **Journal**, or on a data table

9 Use the mouse to move the cursors to onset and offset of the next EMG burst, which is the first burst that occurs during extension. Measure and record the values for **Abs. Area**, **Max-Min**, and **T2-T1** from both groups of muscles during this extension.

10 Measure the **Abs.Area**, **Max-Min**, and **T2-T1** for the EMG bursts from the anterior and posterior muscles from the remaining flexions and extensions.

11 Average the values for each parameter taken from the anterior muscles during flexion. Find the average for each parameter from the anterior muscles during extension. Also, find the averages for the parameters from the posterior muscles during flexion and during extension. Enter the averages for each parameter, from each muscle group during flexion and during extension, on Table HM-2-2 on page HM-2-5.

12 Select **Save** from the **File menu**.

### *Questions*

1 Which muscles, anterior or posterior, had the most EMG activity during flexion?

2 Which muscles, anterior or posterior, had the most EMG activity during extension?

3 Does flexion or extension of the fingers affect the strength of EMG activity in either group of muscles?

## Exercise 2: Antagonistic Muscles Doing Work

Aim: To study the EMG activity in muscles that lift weight by flexion or by extension.

### *Procedure*

1 Use the same experimental setup used in Exercise 1.

2 Instruct the subject to rest his or her forearm, with the electrodes, on a flat surface with the palm up.

3 Place a weight (2-3kg) in the palm of the subject’s hand (Figure HM-2-9 on page HM-2-5).

4 Click **Record**. Record the EMG activity from the muscles of the forearm as the subject lifts the weight by the flexion. The subject should raise and hold the weight up for four seconds and then return the weight to the table top for four seconds. Repeat this cycle two more times.

5 Click **Stop** to halt the recording.

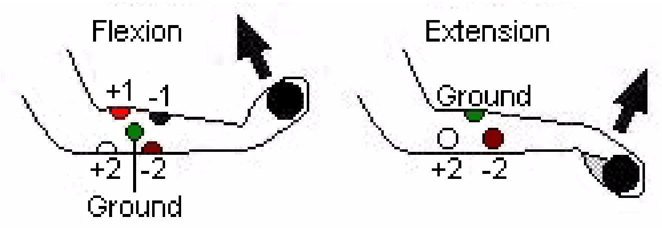


*Figure HM-2-9: Hand in the palm-up position for lifting the weight by flexion (on the left), and the hand in the palm-down position for lifting the weight by extension (on the right).*

6 Instruct the subject to rest his or her forearm on a flat surface with the palm down (Figure HM-2-9 on page HM-2-5).

7 Have the subject grip the same weight (2-3kg).

8 Click **Record**. Record the EMG activity from the muscles of the forearm as the subject lifts the weight by extension. The subject should raise and hold the weight up for four seconds and then return the weight to the table top for four seconds. Repeat this cycle two more times.

9 Click **Stop** to halt the recording.

10 Select **Save** in the **File** menu.

### *Data Analysis*

1 Scroll through the recording and find the section of data recorded while the subject was lifting a weight by flexion and extension.

2 Use the same procedures used in Exercise 1 to measure and record the **Abs. Area, Max-Min**, and **T2-T1** from each muscle group while the weight was lifted by flexion and by extension.

3 Average the values for each parameter taken from the anterior muscles while weight was lifted by flexion. Find the average for each parameter from the anterior muscles while weight was lifted by flexion. Also, find the averages for the parameters from the posterior muscles while weight was lifted by flexion and by extension. Enter the means for each parameter, from each muscle group during flexion and during extension, on Table HM-2-2 on page HM-2-5.

4 Select **Save** from the **File menu**.

### *Questions*

1 Does the strength of the EMG activity in the muscles of the anterior forearm differ between flexion with a weight and without a weight?

2 Does the strength of the EMG activity in the muscles of the posterior forearm differ between extension with a weight and without a weight?.

**Table HM-2-2: Relative EMG Activity in the Muscles of the Forearm during Flexion and Extension.**

| | Averages from Anterior Muscles | | | Averages from Posterior Muscles | | |
|---|---|---|---|---|---|---|
| Forearm Action | Abs.Area | V2-V1 (V) | T2-T1 (sec) | Abs.Area | V2-V1 (V) | T2-T1 (sec) |
| Flexion, Hand Open | | | | | | |
| Extension, Hand Open | | | | | | |
| Flexion, Hand Closed | | | | | | |
| Extension, Hand Closed | | | | | | |
| Flexion, Lifting Weight | | | | | | |
| Extension, Lifting Weight | | | | | | |

## Exercise 3: Antagonistic Muscles in Lower Leg

Aim: To study muscles working in opposition to each other to maintain balance while standing.

### *Procedure*

1 Locate the muscles of the lower leg over which the recording electrodes will be attached. Muscles can be located by performing dorsiflexion (lifting the toes towards the shin), or plantar flexion (pointing the toes toward the ground), and noting the areas of the lower leg where the muscles are tense during each flexion:

• One pair of recording electrodes will be placed over the anterior tibialis muscle. This muscle is located just lateral to the tibia (shinbone) in the upper part of the calf (Figure HM-2-10 on page HM-2-6). To locate the tibialis anterior, feel for the subject's tibia. Place your fingers 2 cm to the lateral side of the margin of the tibia and 8-12 cm below the kneecap. As the subject points his or her foot inward (supination) and upward (dorsiflexion) their foot, you should be able to see and feel the contraction of the anterior tibialis muscle beneath the skin. The first electrode in this pair will be placed about 10 centimeters below the knee on the midline of the muscle. The second electrode in this pair will be placed on the midline of the muscle, about 10 centimeters below the first electrode.

• A second pair of recording electrodes will be placed over the gastrocnemius (calf) muscle on the back of the lower leg. The first electrode in this pair will be placed about 8 centimeters below the back of the knee, along the midline of the calf muscle. The second electrode in this pair will be placed in the middle of the calf muscle along its midline, about 10 centimeters below the first electrode.

• A fifth electrode, used as the ground, is placed on the inside of the lower leg just above the ankle.

2 Use an alcohol swab to clean and scrub the areas where the electrodes will be placed (Figure HM-2-10 on page HM-2-6). Let the areas dry before attaching the electrodes.

3 Remove the plastic disk from a disposable electrode and apply it to one of the scrubbed areas.

4 Snap the recording lead wires onto the electrodes, so that:

- the red "+1" lead is placed on the electrode in the upper portion of the tibialis anterior.
- the black "-1" lead is placed on the electrode in the middle portion of the tibialis anterior.
- the white "+2" lead is attached to the electrode near the back of the knee.
- the brown "-2" lead is attached to the electrode in the middle of the calf muscle.
- the green "C" lead (the ground) is attached to the electrode above the ankle.

5 While the subject is sitting, click **Record**. Have the subject alternate between plantar flexion and dorsiflexion of their foot. **Click AutoScale** on all channels to amplify signals. Use the techniques explained in Exercise 1 to mark the recording with comments that identify the EMG activity associated with plantar flexion and dorsiflexion.

6 Have the subject stand erect. Click **Record**. Have the subject rock on their feet from heels to toes and back to heels, 4 times. Mark the recording with comments that identify the EMG activity that took place.

7 Determine which muscle group, gastrocnemius or anterior tibialis muscles, contract when the subject rocks forward or rocks backward.

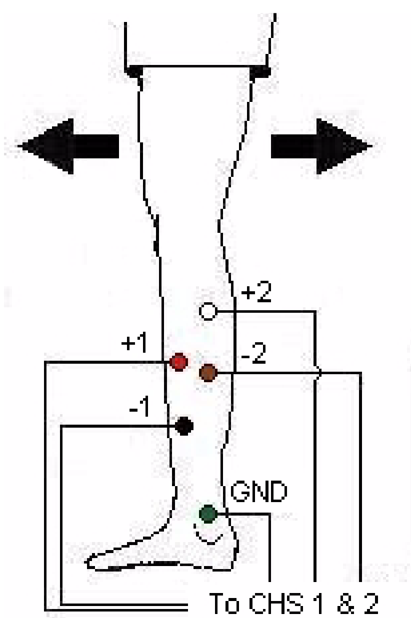


*Figure HM-2-10: Position of electrodes used to record EMG from muscles in the lower leg during plantar flexion and dorsiflexion.*

8 Have the subject rock backward and forward, 4 times, while putting more weight on the leg with the electrodes. Even though one muscle may dominate the record, the other muscle is also somewhat active. Mark the recording with comments that identify the EMG activity that took place.

9 Have the subject stand on one foot and remain motionless. Co-contraction of the antagonistic muscles mechanically stabilizes the joints when the subject is motionless. The stretch reflexes prevent twisting and slipping and help to maintain balance. Mark the recording with comments that identify the EMG activity that took place.

10 Joint stabilization is particularly important to leg and postural muscles involved in bipedal locomotion. Within the limits of artifacts induced by leg movement and cable lengths, explore the activity of the ankle flexors. Have the subject either squat or stretch upward on his/her toes. Mark the recording with comments that identify the EMG activity that took place. Click **Stop** to halt recording.

11 Select **Save** in the **File** menu.

### Data Analysis

1 Scroll to the data where EMG activity was recorded from the muscles of the anterior and posterior lower leg.

2 Use the same procedures used in Exercise 1 to measure and record the absolute area, difference in amplitudes, and durations of the EMG bursts from the anterior and posterior muscles of the lower leg while the subject moved his or her legs and body in different positions:

- Standing erect on both legs;
- Rocking back and forth on both legs;
- Rocking back and forth on the leg with the electrodes;
- Standing erect on the leg with the electrodes;
- Ankle flexing by squatting or standing on the toes

3 Enter the means for each parameter, from each muscle group during the various motions, on Table HM-2-3 on page HM-2-7

### Questions

1 Compare the parameters for the EMG bursts from the tibialis anterior during each of the activities. When was tibialis anterior activity the greatest? The least?

2 Compare the parameters for the EMG bursts from the gastrocnemius during each of the activities. When was gastrocnemius activity the greatest? The least?

3 How does EMG activity in the gastrocnemius correlate to EMG activity in the tibialis anterior?

**Table HM-2-3: Relative EMG Activity in the Muscles of the Lower Leg during Changes in Posture.**

| | Averages from Anterior Tibialis | | | Averages from Gastrocnemius | | |
|---|---|---|---|---|---|---|
| Leg Activity | Abs.Area | V2-V1 (V) | T2-T1 (sec) | Abs.Area | V2-V1 (V) | T2-T1 (sec) |
| Standing Erect, Both Legs | | | | | | |
| Rocking Forward, Both Legs | | | | | | |
| Rocking Backward, Both Legs | | | | | | |
| Rocking Forward, One Leg | | | | | | |
| Rocking Backward, One Leg | | | | | | |
| Standing Erect, One Leg | | | | | | |
| Ankle Flex, Squat | | | | | | |
| Ankle Flex, Standing on Toes | | | | | | |