Experiment HM-5: Flexibility and Range of Motion (ROM)

Equipment Required

PC or Mac Computer

IXTA, USB cable, IXTA power supply

GN-100 Single-axis goniometer

Velcro straps

Protractor

Small weight (optional)

Goniometer Set Up and Calibration

1. Locate the GN-100 single-axis goniometer.
2. Insert the DIN-8 connector on the GN-100 goniometer into Channel A5 of the IXTA.
3. Place the GN-100 Goniometer on the table with the 2 arms in the closed position. Use a protractor to measure the angle between each arm.

Figure HM-5-S1: The GN-100 goniometer.

4. Type **Closed** and the angle (in degrees) between the two arms in the Mark box.
5. Make sure the GN-100 goniometer arms are in the closed position. Click the Record button.
6. Record with the GN-100 goniometer in the closed position for 5 seconds. Click on the Mark button to label the recording. Continue recording.
7. Open the arms of the GN-100 as far as possible. Use a protractor to measure the angle between each arm.
8. Type **Open** and the angle (in degrees) between the two arms in the Mark box. The open angle should be 180 degrees or greater.
9. Make sure the GN-100 goniometer arms are in the fully open position. Record for 5 seconds. Click on the Mark button when the trace reaches a plateau.

10. Click the Stop button.
11. Select Save As in the File menu, type a name for the file. Click on the Save button to save the data file.

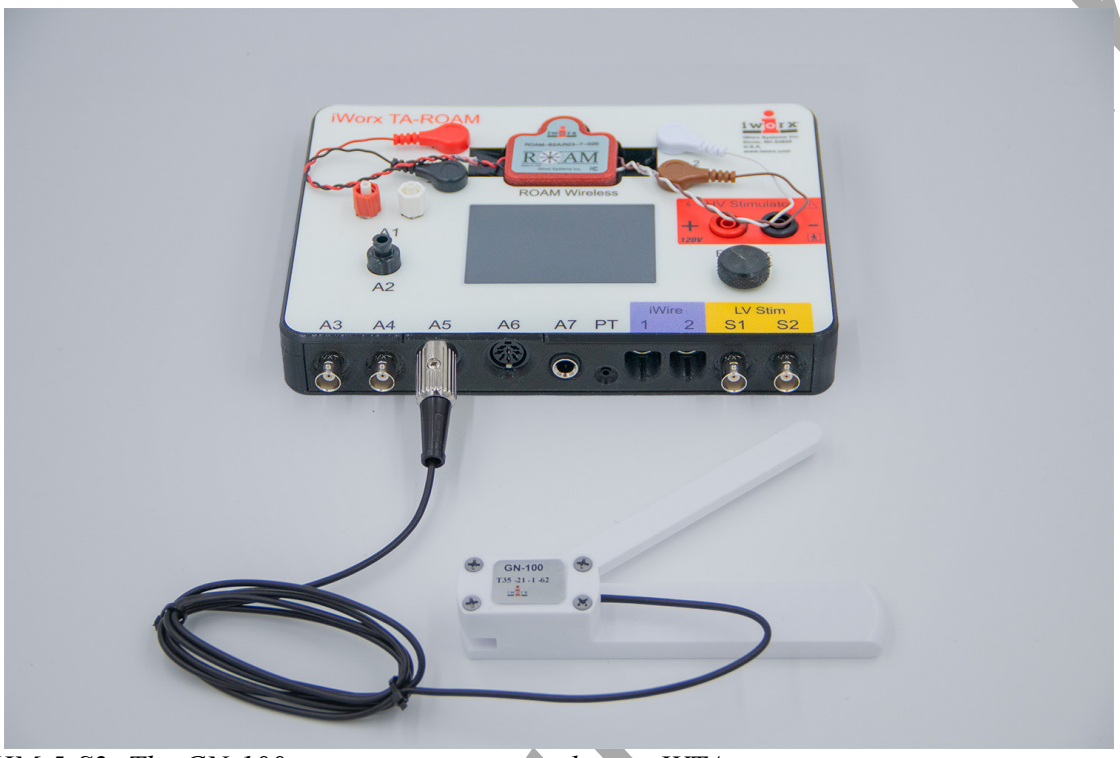

Figure HM-5-S2: The GN-100 goniometer connected to an IXTA.

Units Conversion

1. Scroll to the beginning of the calibration data for the GN-100 single-axis goniometer.
2. Use the Display Time icons to adjust the Display Time of the Main window to show the complete calibration data on the same window. The required data can also be selected by:
    - Placing the cursors on either side of data required;
    - Clicking the Zoom between Cursors button on the LabScribe toolbar to expand the calibration data to the width of the Main window.
6. Click the 2-Cursor icon on the LabScribe toolbar so that two cursors appear.

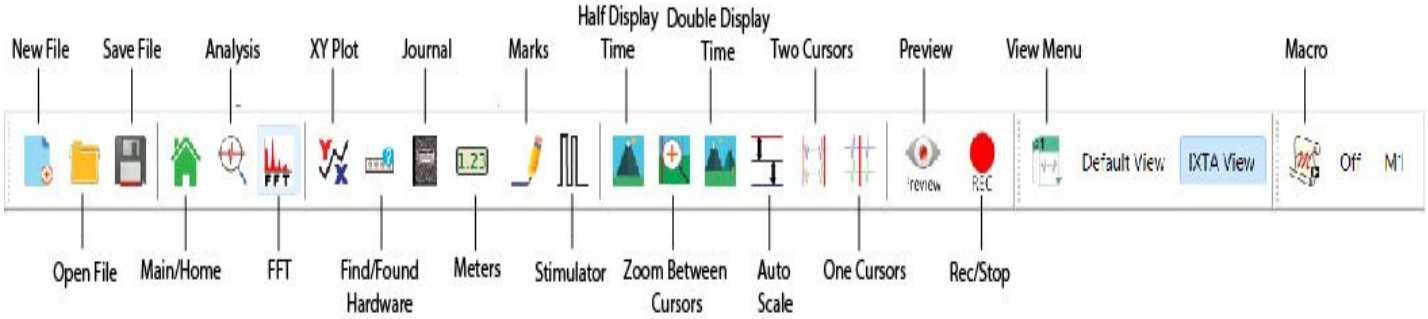

Figure HM-5-S3: The LabScribe Toolbar.

7. Place one cursor on the section of data collected when the goniometer was in the closed position, and the second cursor on the section of data collected when the goniometer was in the open position.

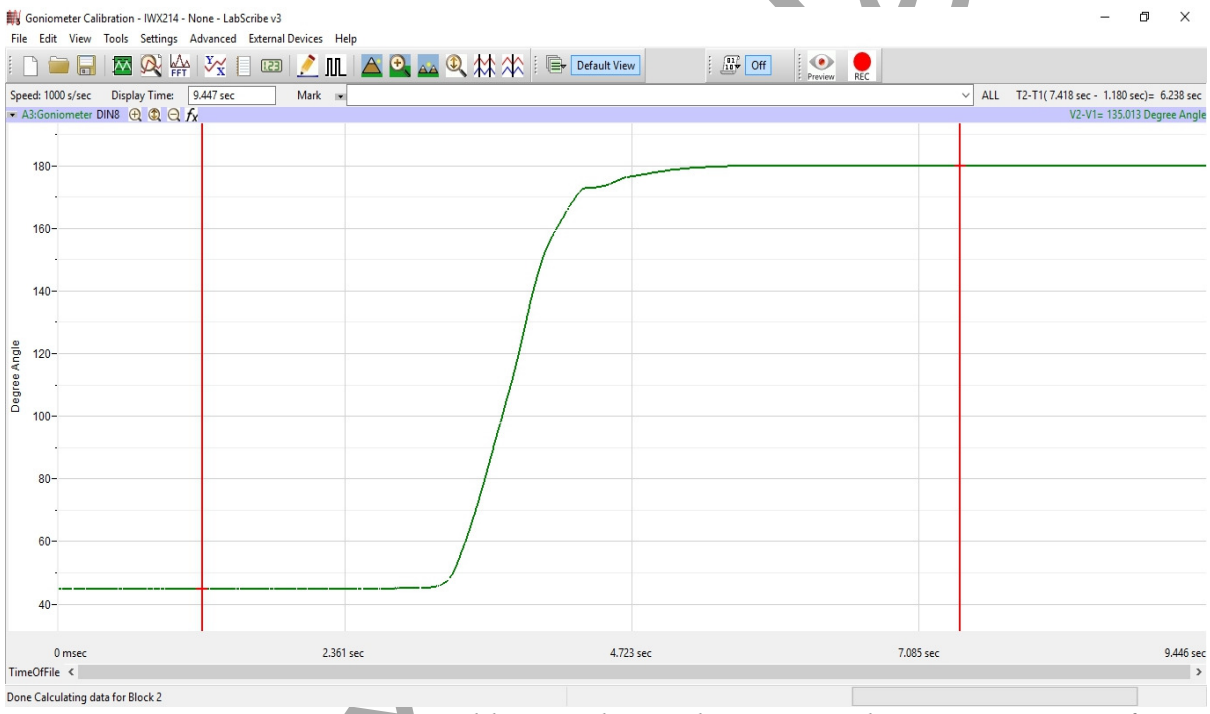

Figure HM-5-S4: GN-100 goniometer calibration data with cursors in the correct positions for converting the Y-axis angle of deflection (in degrees).

5. Open the Channel menu of the Goniometer Angle channel by clicking V2-V1 to the right of the channel. Select Simple.

6. On the Simple Units Conversion dialogue window, make sure 2 point calibration is selected in the pull-down menu in the upper left corner of the window. Put check marks in the boxes next to Apply Units to new data and Apply Units to all blocks.
7. Notice that the voltages from the positions of the cursors are automatically entered into the value equations. Enter the values for the two angles used in the calibration recording in the corresponding boxes on the right side of the conversion equations.
    - For Cursor 1, the value is the angle when the goniometer is closed.
    - For Cursor 2, the value is the angle when the goniometer is fully open.
    - Enter the name of the units, Degrees, in box below the values.
    - Click on the OK button in the lower right corner of the window to activate the units conversion.

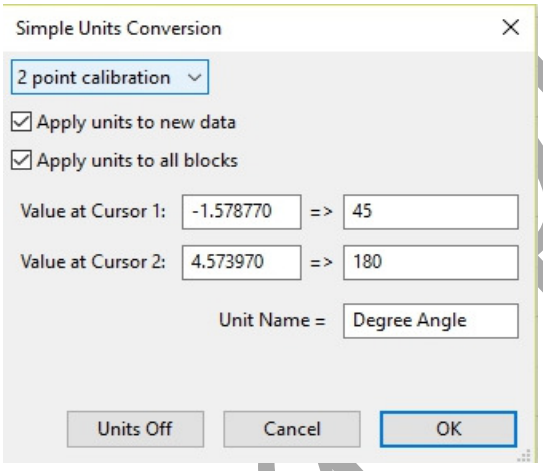

Figure HM-5-S5: The Simple Units Conversion dialogue window with the voltages at the cursors set to equal the closed and open angles of the GN-100 goniometer.

8. Click on the Save button to save the data file.

Experiment HM-6: M Waves and Range of Motion (ROM)

WARNING - The Stimulator should only be used for the method of application for which the Stimulator is intended as shown in the directions below.

Note: Disconnect the subject from the IXTA prior to powering off the device.

NOTE: When using the IXTA and built in HV stimulator – all changes in Amplitude are entered directly into the Stimulator Control Panel. Click "APPLY" to make any changes.

Exercise 1: Recruitment and the Maximum Response of the Tibialis Anterior Muscle

Aims: To determine the minimum stimulus amplitude needed to cause the maximum response of the tibialis anterior muscle.

Approximate Time: 20 minutes

Procedure

1. Instruct the subject to sit on a bench or chair and relax. The bench or chair should be tall enough that the subject's foot does not touch the ground when it is pointed downward.
2. Click the Stimulator Preferences icon on the LabScribe toolbar to open the stimulator control panel if it does not open anutomatically.

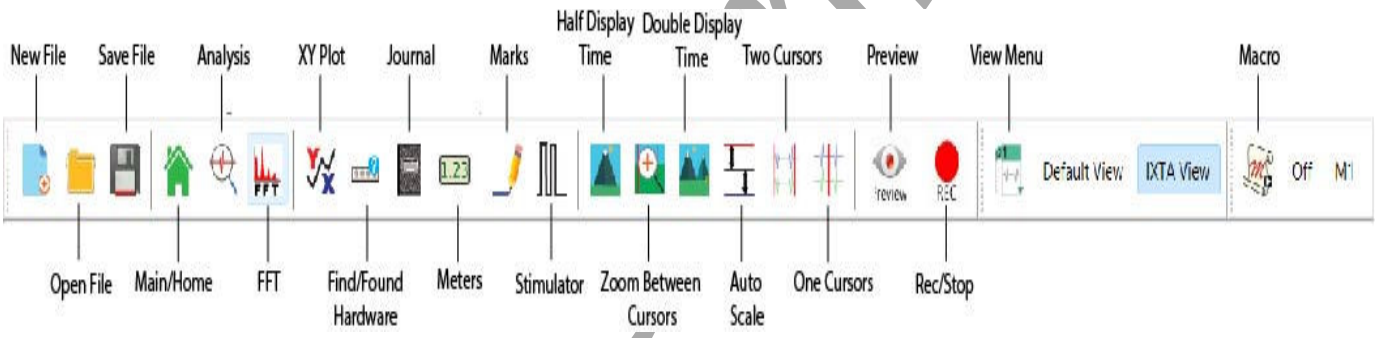

Figure HM-6-L1: The LabScribe toolbar.

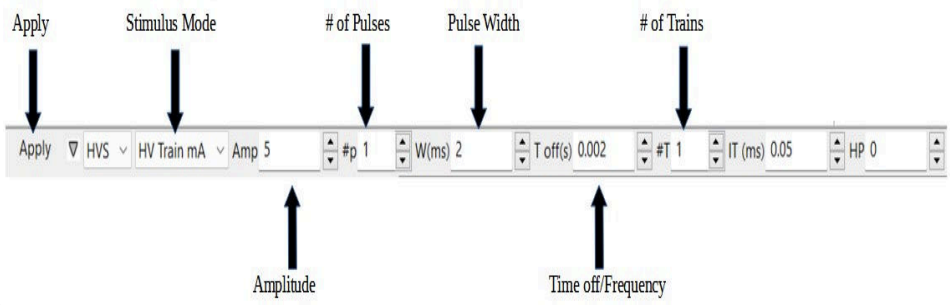

Figure HM-6-L2: The stimulator control panel.

3. Check the values for the stimulus parameters that are listed in the stimulator control panel on the Main window:
    - the pulse amplitude (Amp) should be set to 5.0V or mA for the IXTA;
    - the pulse width (W) to 2ms;
    - the frequency (F) to 1 Hz;
    - the number of pulses (#pulses) to 0, which will program the stimulator to pulse continuously.
4. The value for a stimulus parameter can be changed by either of two methods:
    - click on the arrow buttons to the right of the window that displays the value of the parameter to increase or decrease the value; or,
    - type the value of the parameter in the window next to the label of the parameter.
    - Click the Apply button to finalize the change in any stimulus parameter.

Warning: Make sure the Amplitude in the Stimulator Control Panel for the IXTA is set to zero.

5. Type the **Tibialis Response** in the Mark box.
6. Click on the Record button on the LabScribe Main window to generate stimulus pulses. For the IXTA, any changes to amplitude will be made through the Simulator Control Panel.
7. Click on the Mark button to label the recording. There should be no response from the subject's muscle since the current output is zero. Continue to record.
8. Change the Pulse Amplitude to 2 mA. Ask the subject to indicate when he or she first feels a tingling sensation under the stimulating electrodes.
9. If no foot movement is detected, the pulse amplitude is below the current level needed to create a muscle contraction. The pulse amplitude that first causes a muscle contraction is known as the Threshold Amplitude.

Note: *The pulse amplitude required to cause a foot flexion will differ between subjects. Some subjects require as low as 6 milliamperes of current to create a maximum response, while other subjects may require 10 or more milliamperes to create the strongest response.*

10. If a foot flexion does not occur at 2 mA after 4 or 5 pulses, change the Pulse Amplitude by 1 mA to 3. Stimulate for another 4 or 5 pulses. Ask the subject to indicate if tingling and foot movement is detected.
11. Increase the current output in increments of 1 mA, and record 4 or 5 pulses, until the subject's foot flexes with the largest range of motion.

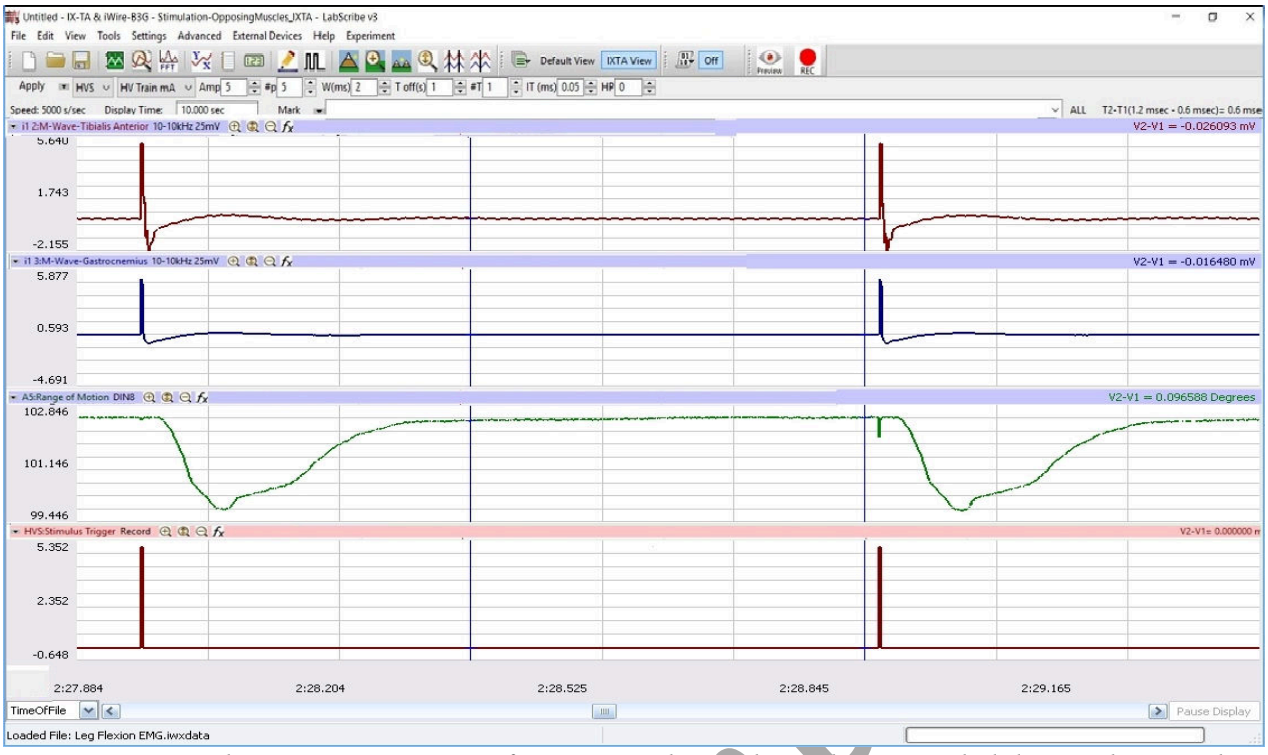

Figure HM-6-L3: The M-waves, ranges of motion, and stimulus pulses recorded during the stimulation of the tibialis anterior muscle with maximal stimulus pulses. The movement of the foot, which is a dorsiflexion, is recorded on the Range of Motion channel as a negative change in angle of the foot.

Note: *The lowest stimulus that causes the largest possible response is called the maximal stimulus. Any stimulus that is above the maximal level is known as supra-maximal. Currents above threshold and below maximal are called sub-maximal.*

12. Click on the Stop button on the LabScribe2 Main window.
13. Select Save As in the File menu, type a name for the file. Click on the Save button to save the data file.

Exercise 2: Dorsiflexion and Summation

Aims: To measure the angle of deflection of the foot during dorsiflexion at different frequencies of stimulation.

Approximate Time: 20 minutes

Procedure

1. Except for the number of pulses (#pulses), use the same stimulus parameters that were found in Exercise 1 to create the maximum response of the tibialis anterior muscle.

2. On the stimulator control panel, change the number of pulses (#pulses) to 10, which will program the stimulator to pulse ten times. Click the Apply button to finalize the change in any stimulus parameter.
3. Type the **Dorsiflexion-1Hz** in the Mark box.
4. Click on the Record button on the LabScribe Main window to stimulate and record the response of the tibialis anterior muscle. Click on the Mark button.
5. Click on the Stop button after the last contraction of the tibialis anterior muscle. The results should be similar to the recording below.

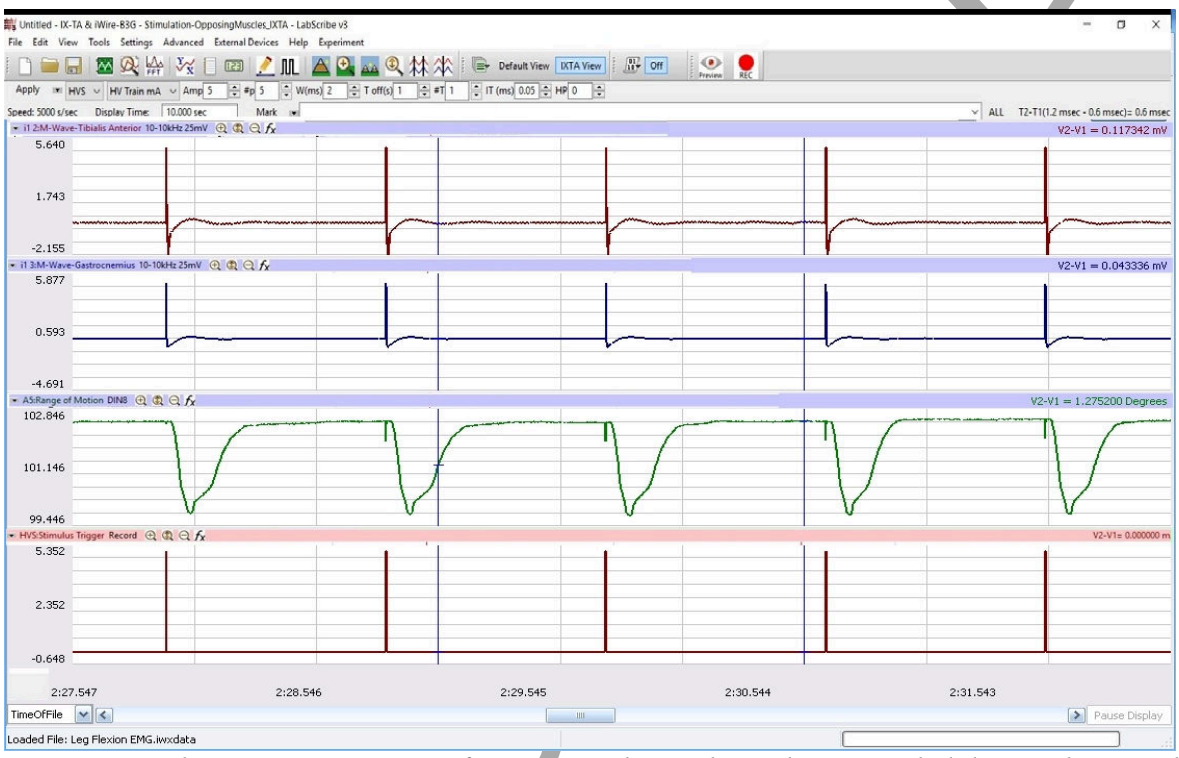

Figure HM-6-L4: The M-waves, ranges of motion, and stimulus pulses recorded during the stimulation of the tibialis anterior muscle with maximal stimulus pulses at 1Hz. The average range of motion for these dorsiflexions is -2.666 degrees.

6. On the stimulator control panel, change the frequency (F) to 2 Hz, which will program the stimulator to stimulate the muscle twice every second. Click the Apply button to finalize this change to the stimulus parameters.
7. Type the **Dorsiflexion-2Hz** in the Mark box that is to the right of the Mark button.
8. Click on the Record button on the LabScribe Main window to stimulate and record the response of the tibialis anterior muscle. Click on the Mark button to label the recording.
9. Click on the Stop button to halt the recording after the last contraction of the tibialis anterior muscle.

10. Repeat Steps 7 through 10 for 3, 4, 5, and 8 Hz.
11. If stimulating the tibialis anterior muscle at 8Hz does not cause summation of the muscle response as indicated by an increase in the range of motion of the foot, increase the stimulus frequency until summation occurs.
12. Click Save in the File menu.

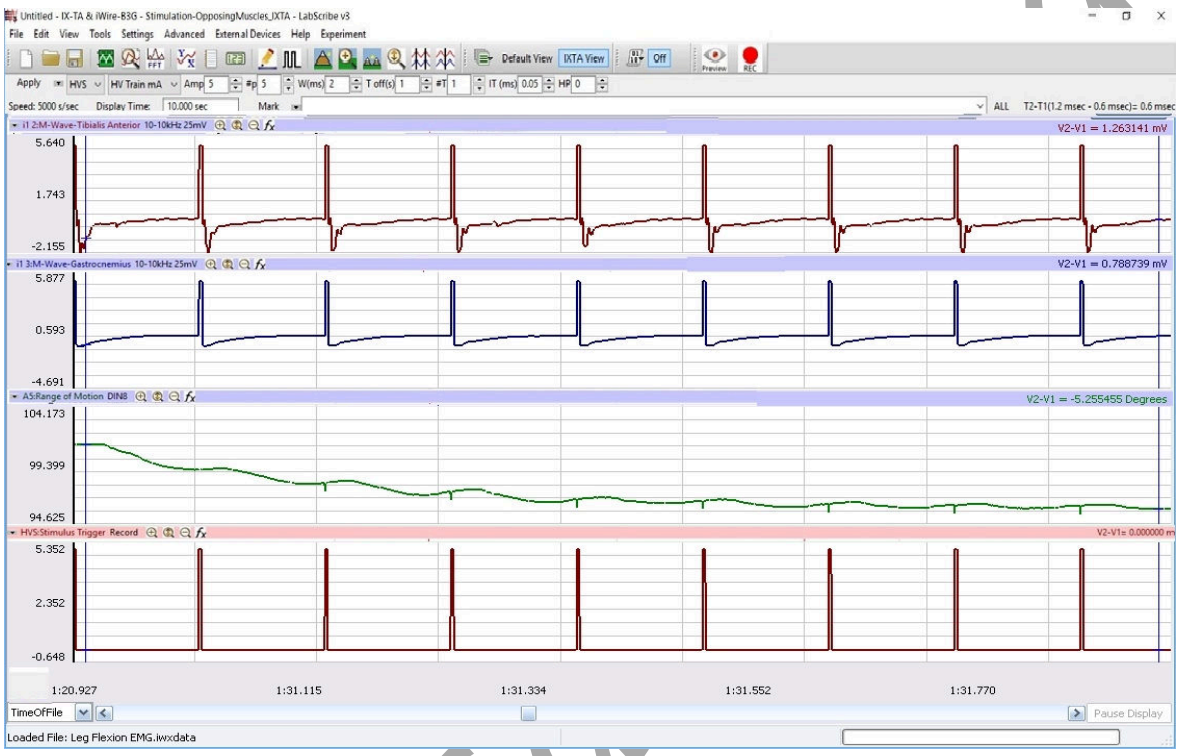

Figure HM-6-L5: The M-waves, ranges of motion, and stimulus pulses recorded during the stimulation of the tibialis anterior muscle with maximal stimulus pulses at 8Hz. The range of motion for the summation of the flexions is -5.288 degrees.

Data Analysis

1. Scroll through the recording and find the section of data recorded while the subject's tibialis anterior muscle was contracting at 1 Hz.
2. Use the Display Time icons to adjust the Display Time of the Main window so that three adjacent flexions of the same approximate amplitude are displayed on the Main window. The three flexions can also be selected by:
    - Placing the cursors on either side of the three adjacent flexions; and
    - Clicking the Zoom between Cursors button on the LabScribe toolbar to expand the segment with the three flexions to the width of the Main window.
3. Click on the Analysis window icon in the LabScribe toolbar.

4. Look at the Function Table that is above the channel displayed in the Analysis window. The mathematical functions, T2-T1 and V2-V1, should appear in this table. The values for T2-T1 and V2-V1 are seen in the table across the top margin of the channel.
5. Once the cursors are placed in the correct positions for measuring the latency, contraction time, range of motion, and relaxation time, the values for the times and angle can be recorded in the on-line notebook of LabScribe by typing the names and values directly into the Journal.

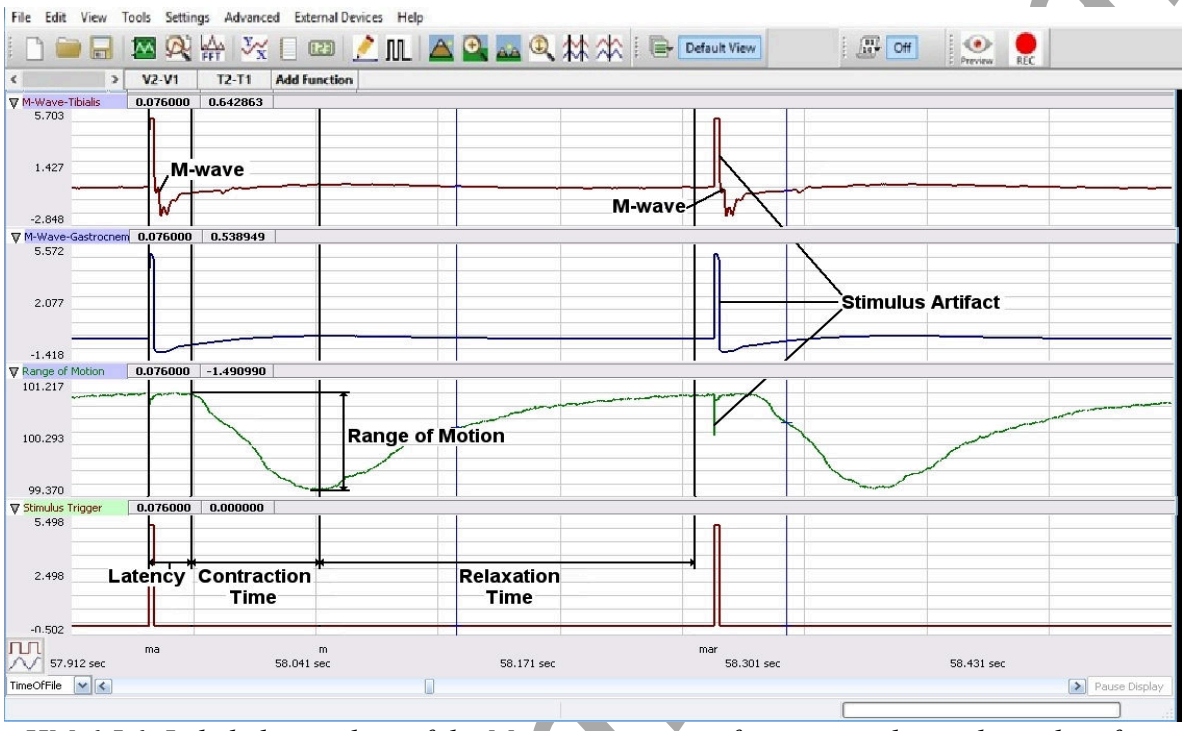

Figure HM-6-L6: Labeled recording of the M-waves, ranges of motion, and stimulus pulses from two dorsiflexions displayed in the Analysis window. The cursors are positioned to measure the range of motion (-1.491 degrees) and the contraction time (76.000 msec) on the Range of Motion channel.

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 times and angle in the Journal. To use these functions:
    - Place the cursors at the locations used to measure the times and angle.
    - Transfer the names of the mathematical functions used to determine the times and angles to the Journal using the Add Title to Journal function in the Range of Motion channel pull-down menu.
    - Transfer the values for the times and angles to the Journal using the Add All Data to Journal function in the Range of Motion channel pull-down menu.

Note: *Dorsiflexion is the upward movement of the foot, but the range of motion for dorsiflexion is recorded as a negative angle. The range of motion during plantar flexion is recorded as a positive angle.*

7. On the Goniometer and Stimulus Trigger channels, use the mouse to click on and drag the cursors to specific points on the recording to measure the following parameters:
    - Latency, which is the time between the onset of the stimulus pulse and the initial response of the goniometer during dorsiflexion of the foot. To measure the latency, place one cursor at the beginning of the stimulus pulse displayed on the Stimulus Trigger channel, and the second cursor on the beginning of the goniometer's response displayed on the Range of Motion channel. The value for the T2-T1 function on any channel is the latency. Record this value in the Journal and on Table 1.
    - Contraction Time, which is the time it takes the foot to move from the relaxed position to dorsiflexed position. To measure the contraction time, move the cursor that is on the beginning of the stimulus pulse to the peak of the goniometer's response. Keep the other cursor on the beginning of the goniometer's response. The value for the T2-T1 function on any channel is the contraction time. Record this value in the Journal and on the data table.
    - Range of Motion, which is the change in angle of the foot between the relaxed position and the dorsiflexed position. Keep the cursors in the same positions used to measure contraction time. The value for the V2-V1 function on the Range of Motion channel is range of motion for dorsiflexion of the foot. Record this value in the Journal and on Table 1.
    - Relaxation Time, which is the time it takes the foot to move from the dorsiflexed position back to the relaxed position. To measure the relaxation time, move the cursor that is on the beginning of the goniometer's response to the end of the goniometer's response to dorsiflexion. Keep the other cursor on the peak of the goniometer's response. The value for the T2-T1 function on any channel is the relaxation time. Record this value in the Journal and on the data table.
8. Repeat Step 7 for the other two dorsiflexions recorded at 1 Hz.
9. Repeat Step 7 for each of three dorsiflexions recorded at 2, 3, 4, and 5 Hz.
10. Measure the total range of motion of the foot during summation of the dorsiflexions at a stimulus frequency of 8Hz or greater. On the Range of Motion channel:
    - Place one cursor on the section of the recording when the foot was in the relaxed position;
    - Place the other cursor on the section of the recording when the foot reached maximum flexion.
    - The value for the V2-V1 function on the Range of Motion channel is total range of motion during summation.
    - Record this value in the Journal and on data table.
11. Select Save in the File menu.

Questions

1. Is the latency of the muscle's response the same for each stimulus frequency?
2. Are the contraction and relaxation times the same for each stimulus frequency?
3. Is the range of motion of the subject's foot the same for each stimulus frequency?

Exercise 3: Recruitment and the Maximum Response of the Gastrocnemius Muscle

Aims: To determine the minimum stimulus amplitude needed to cause the maximum response of the gastrocnemius muscle.

Approximate Time: 20 minutes

Procedure

1. Move the stimulator lead wires to the stimulating electrodes for the gastrocnemius muscle (refer to the set up document), so that:
    - the black (-) lead is on the electrode on the back of the knee.
    - the red (+) lead is on the electrode just above the ground electrode over the gastrocnemius muscle.

Warning: Make sure the Amplitude in the Stimulator Control Panel for the IXTA is set to zero. Do not click Record until the setting is 0.

2. Use the stimulator control panel on the Main window to set the stimulus parameters to the following values before beginning the recording:
    - the pulse amplitude (Amp) should be set to 5.0V;
    - the pulse width (W) to 2ms;
    - the frequency (F) to 1 Hz;
    - the number of pulses (#pulses) to 0, which will program the stimulator to pulse continuously.
    - Click the Apply button to finalize the change in any stimulus parameter.
3. Use the same procedures employed in Exercise 1 to determine the minimum stimulus amplitude that generates the maximum response of the gastrocnemius muscle.

Warning: If the negative (-) stimulating electrode has been placed over a nerve, the muscles on both sides of the lower leg will contract simultaneously and cause the foot to move outward rather than downward. If this occurs move the negative (-) stimulating electrode closer to the middle of the back of the knee.

4. Label the recording to indicate that the responses came from the subject's gastrocnemius muscle. Save the data when finished with this part of the lab.

Table HM-6-L1: Contraction & Relaxation Times, Latency and Range of Motion during Dorsiflexion at Different Frequencies.

Parameter	Dorsiflexion at 1Hz			
	1st	2nd	3rd	Average
Latency (ms)				
Contraction Time (ms)				
Range of Motion (^{o})				
Relaxation Time (ms)				
Parameter	Dorsiflexion at 2Hz			
	1st	2nd	3rd	Average
Flexion Latency (ms)				
Contraction Time (ms)				
Range of Motion (^{o})				
Relaxation Time (ms)				
Parameter	Dorsiflexion at 3Hz			
	1st	2nd	3rd	Average
Flexion Latency (ms)				
Contraction Time (ms)				
Range of Motion (^{o})				
Relaxation Time (ms)				
Parameter	Dorsiflexion at 4Hz			
	1st	2nd	3rd	Average
Flexion Latency (ms)				
Contraction Time (ms)				
Range of Motion (^{o})				
Relaxation Time (ms)				

Parameter	Dorsiflexion at 5Hz			
	1st	2nd	3rd	Average
Flexion Latency (ms)				
Contraction Time (ms)				
Range of Motion (^{o})				
Relaxation Time (ms)				
Parameter	Dorsiflexion at 8Hz			
				Total
Range of Motion (^{o})				

Exercise 4: Plantar Flexion and Summation

Aims: To measure the angle of deflection of the foot during plantar flexion at different frequencies of stimulation.

Approximate Time: 20 minutes

Procedure

1. Except for the number of pulses (#pulses), use the same stimulus parameters that were found in Exercise 3 to create the maximum response of the gastrocnemius muscle.
2. On the stimulator control panel, change the number of pulses (#pulses) to 10, which will program the stimulator to pulse ten times. Click the Apply button to finalize the change in any stimulus parameter.
3. Use the same procedures employed in Exercise 2 to determine the response of the gastrocnemius muscle to stimulus pulses of different frequencies. Recording should be similar to the recording below.
4. Label the recording to indicate the stimulus frequency used for each group of plantar flexions recorded.
5. Make sure the data file is saved at the end of the exercise.

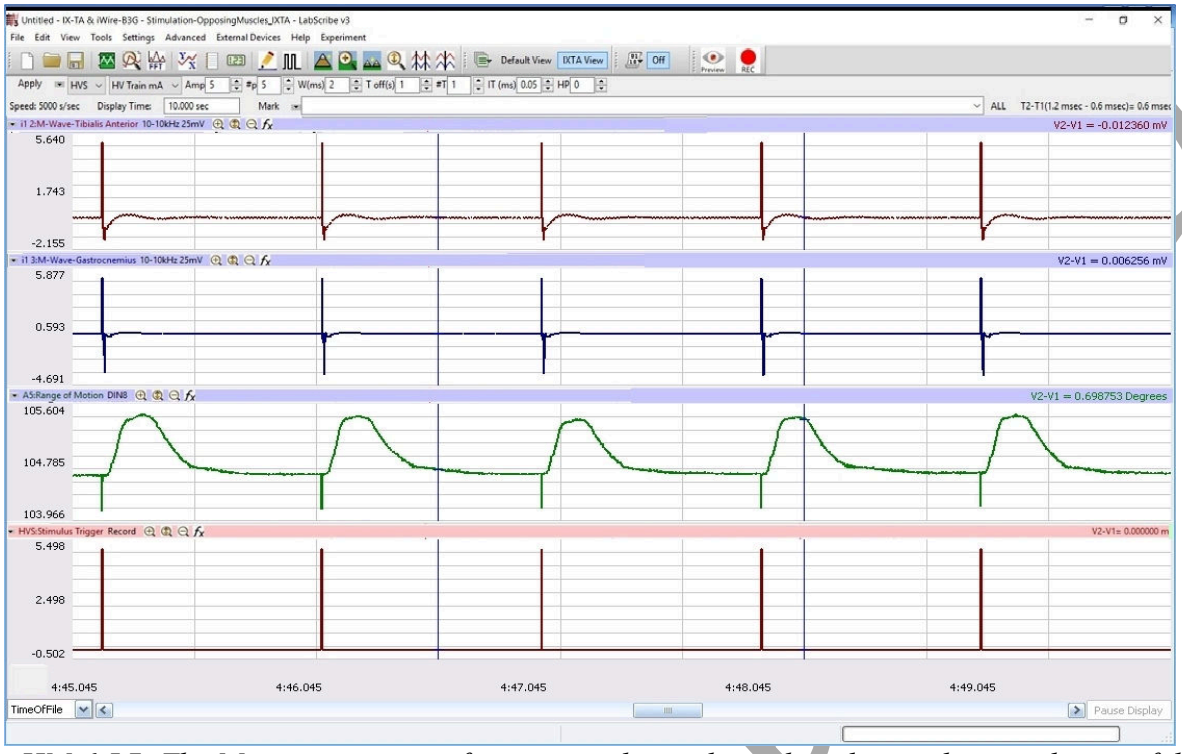

Figure HM-6-L7: The M-waves, ranges of motion, and stimulus pulses during the stimulation of the gastrocnemius muscle with maximal stimulus pulses at 1Hz. Plantar flexion is recorded as a positive change in angle of the foot.

Data Analysis

1. Use the same techniques employed in Exercise 2 to analyze the response of the gastrocnemius muscle to stimulus pulses of different frequencies.
2. Record the measurements in the Journal and on Table 2.

Questions

1. Is the latency of the muscle's response the same for each stimulus frequency?
2. Are the contraction and relaxation times the same for each stimulus frequency?
3. Is the range of motion of the subject's foot the same for each stimulus frequency?
4. For each stimulus frequency, compare the ranges of motion for dorsiflexion and plantar flexion. How do the ranges of motion during dorsiflexion compare to the ranges of motion during plantar flexion?

Table HM-6-L2: Contraction & Relaxation Times, Latency and Range of Motion during Plantar Flexion at Different Frequencies.

Parameter	Plantar Flexion at 1Hz			
	1st	2nd	3rd	Average
Latency (ms)				
Contraction Time (ms)				
Range of Motion (^{o})				
Relaxation Time (ms)				
Parameter	Plantar Flexion at 2Hz			
	1st	2nd	3rd	Average
Flexion Latency (ms)				
Contraction Time (ms)				
Range of Motion (^{o})				
Relaxation Time (ms)				
Parameter	Plantar Flexion at 3Hz			
	1st	2nd	3rd	Average
Flexion Latency (ms)				
Contraction Time (ms)				
Range of Motion (^{o})				
Relaxation Time (ms)				
Parameter	Plantar Flexion at 4Hz			
	1st	2nd	3rd	Average
Flexion Latency (ms)				
Contraction Time (ms)				
Range of Motion (^{o})				
Relaxation Time (ms)				

Parameter	Plantar Flexion at 5Hz			
	1st	2nd	3rd	Average
Flexion Latency (ms)				
Contraction Time (ms)				
Range of Motion (^{o})				
Relaxation Time (ms)				
Parameter	Plantar Flexion at 8Hz			
				Total
Range of Motion (^{o})				