Experiment HM-7: Electromyogram (EMG) Activity in Antagonistic Muscles and Range of Motion

Equipment Required

PC or Mac Computer

IXTA, USB cable, IXTA power supply

ROAM EMG

Disposable electrodes

GN-100 Single-axis Goniometer

Small weight

EMG Cable Setup

1. Locate the ROAM EMG and disconnect it from the dock.
2. 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.
3. Snap the leads onto the electrodes as shown and then place them on the arm.

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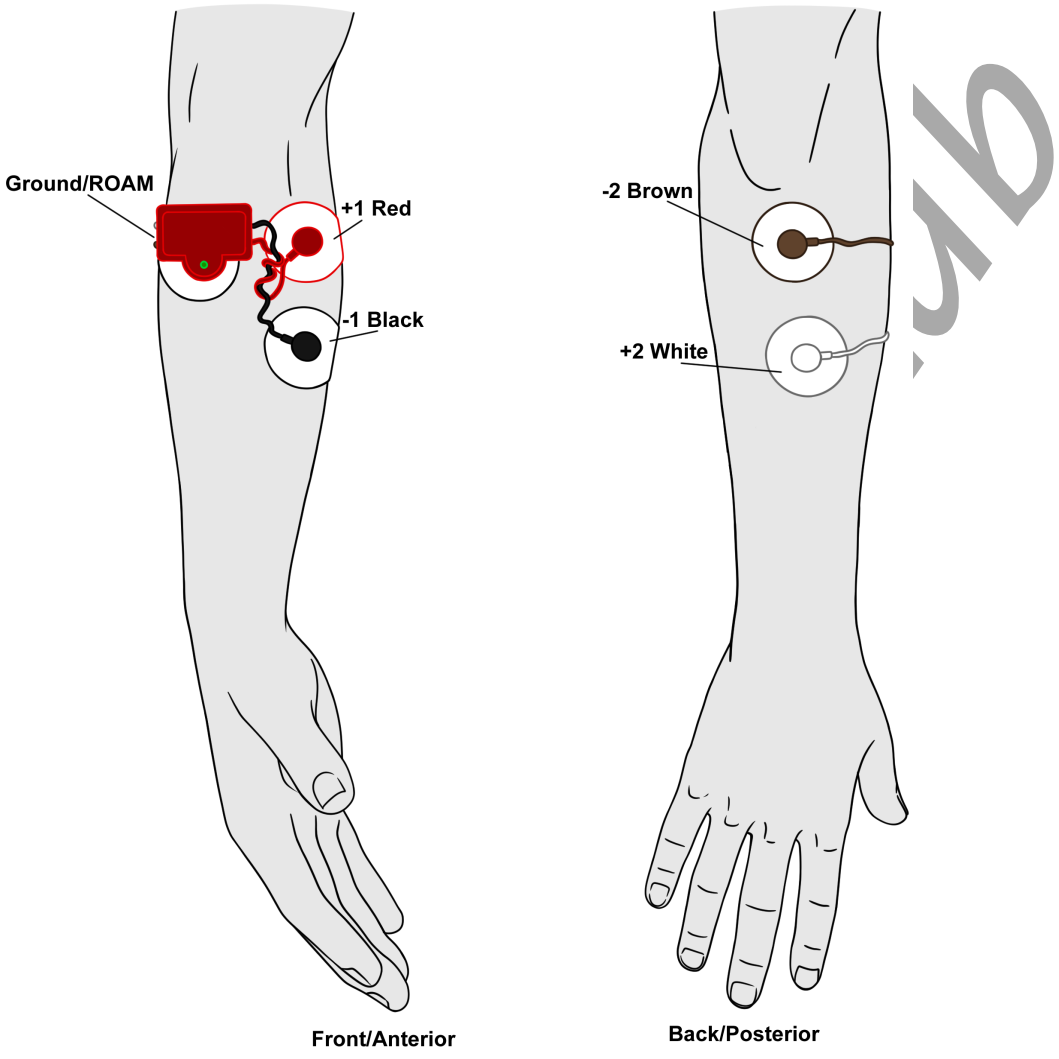

Figure HM-7-S1: Position of electrodes used to record EMG from muscles in the forearm during flexion and extension. Make sure the electrodes are on the flexors and extensors.

4. Locate the GN-100 Single-axis Goniometer.
5. Insert the DIN-8 connector on the GN-100 Goniometer into Channel A5 of the IXTA.

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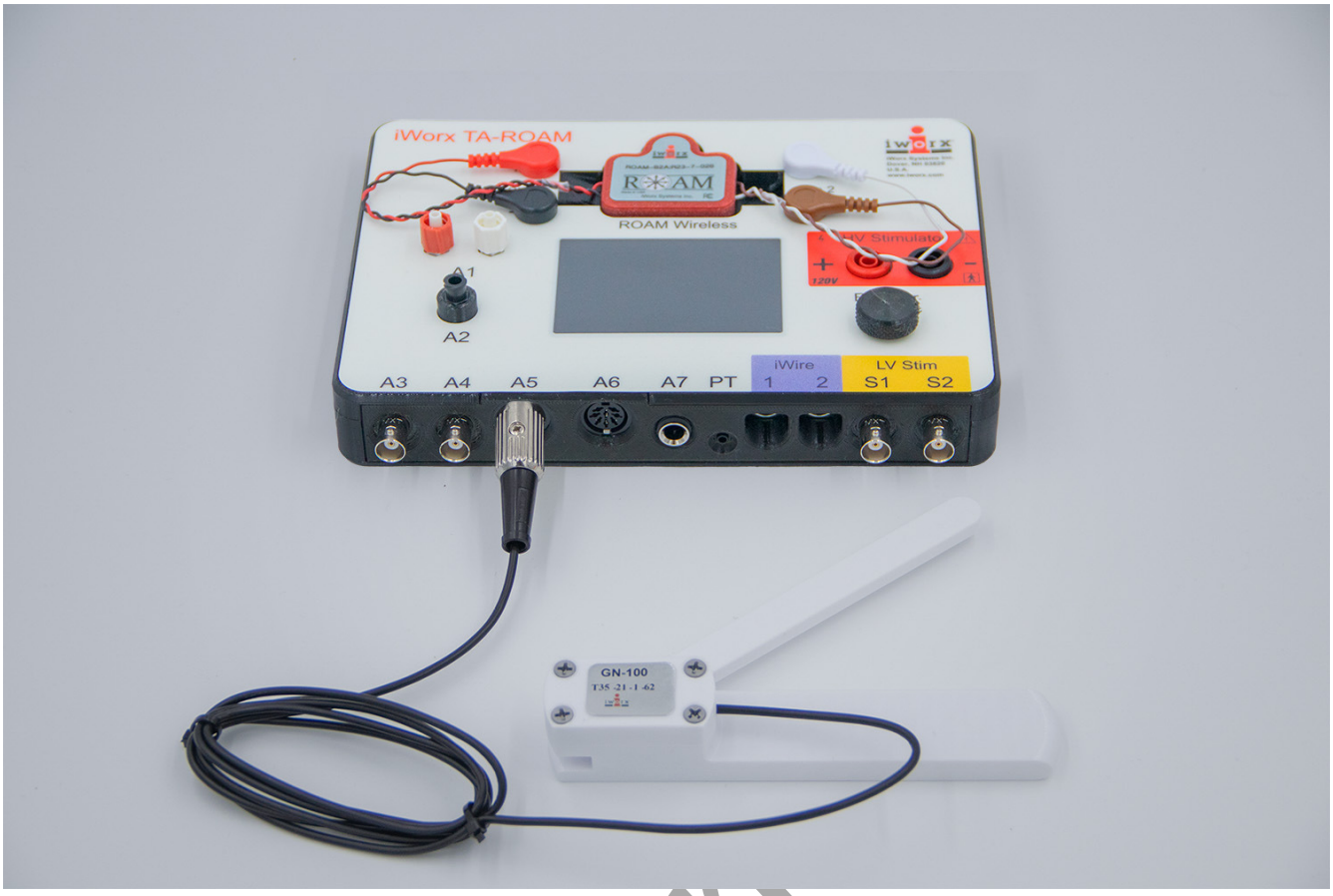

Figure HM-7-S2: The Singlie-axis Goniometer connected to an IXTA.

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GN-100 Single-axis Goniometer Calibration

1. 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.
2. Type **Closed and the angle (in degrees)** between the two arms in the Mark box.
3. Make sure the GN-100 goniometer arms are in the closed position. Click the Record button in the upper right corner of the LabScribe Main window.
4. Record with the GN-100 goniometer in the closed position for 5 seconds. Click on the Mark button to label the recording. Continue recording.
5. Open the arms of the GN-100 as far as possible. Use a protractor to measure the angle between each arm.
6. Type **Open and the angle (in degrees)** between the two arms in the Mark box. The open angle should be 180 degrees or greater.
7. Make sure the GN-100 goniometer arms are in the fully open position. Record for 5 seconds. Click the mark button to label the recording when the trace reaches a plateau.
8. Click the Stop button.
9. Select Save As in the File menu, type a name for the file. Click Save.

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.
3. Click the 2-Cursor icon on the LabScribe toolbar so that two cursors appear on the Main window.

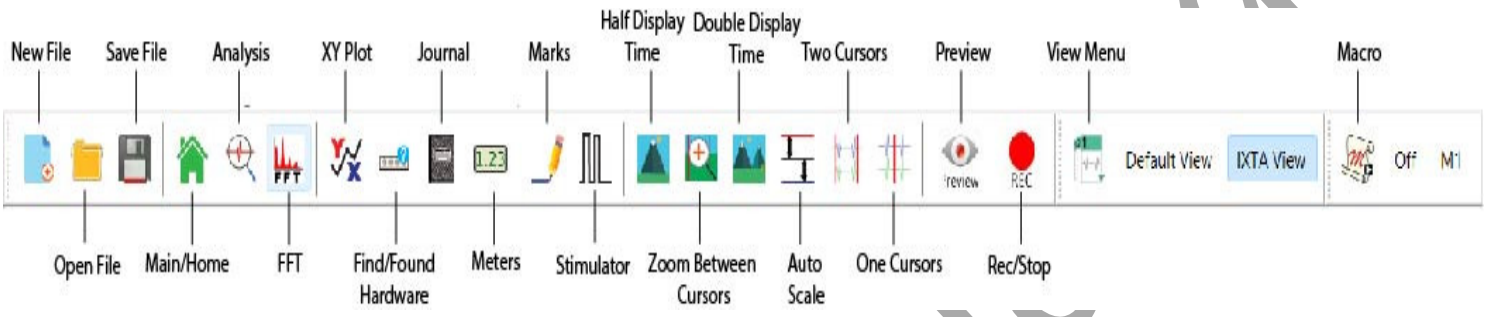

Figure HM-7-S4: The LabScribe Toolbar

4. 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.
5. Click V2-V1 on the right side of the Goniometer channel and click Simple to open the Simple Units Conversion dialogue window.

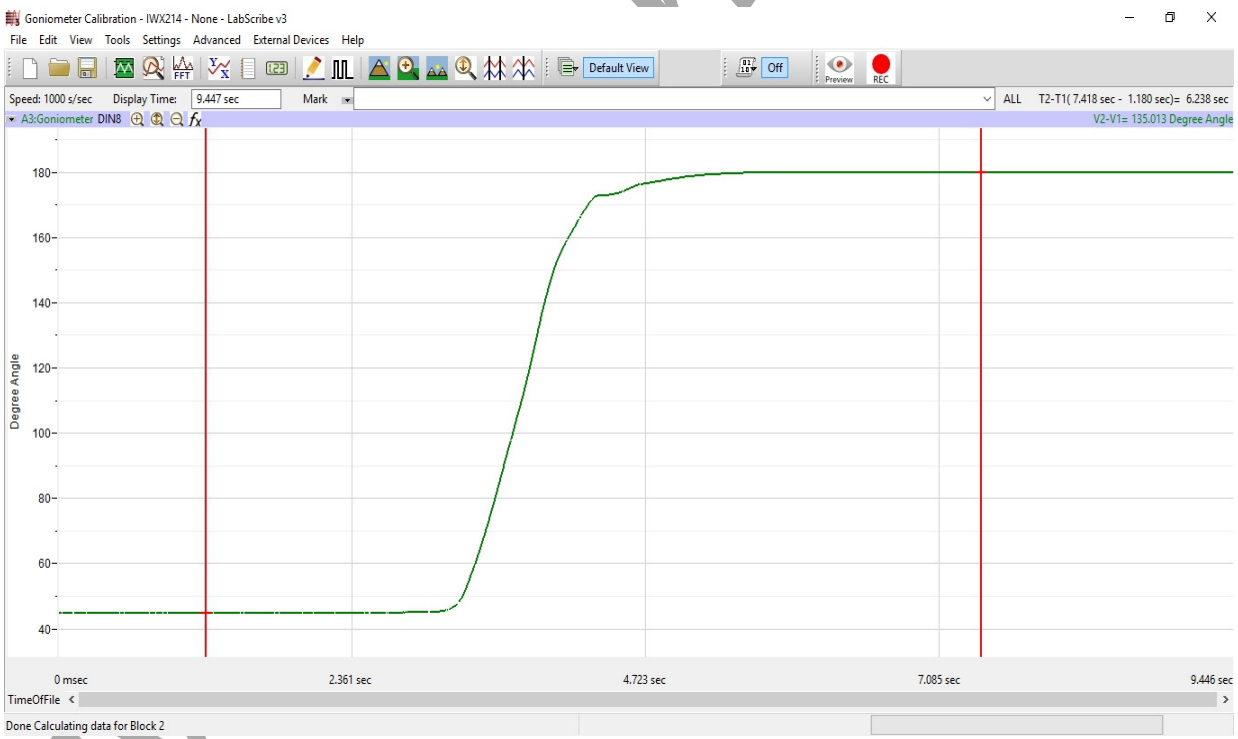

Figure HM-7-S5: Recording of the calibration of the GN-100 Goniometer showing the cursors in the correct position for calibration.

Template

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.

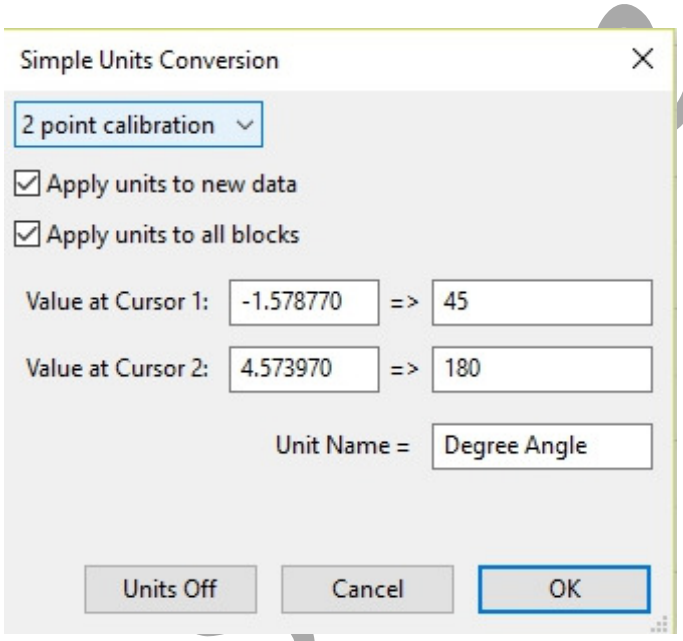

Figure HM-7-S6: The Simple Units Conversion dialogue window with the voltages at the cursors set to equal the closed and open angles of the GN-100 goniometer.

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

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Experiment HM-7: Electromyogram (EMG) Activity in Antagonistic Muscles and Range of Motion

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.

Approximate Time: 20 minutes

Procedure

1. Strap the GN-100 goniometer to the right wrist of the subject using the Velcro straps so that the goniometer axis is located at the joint of the carpals with the radius and ulna. The straps should hold the goniometer firmly to the wrist but not restrict any movement.

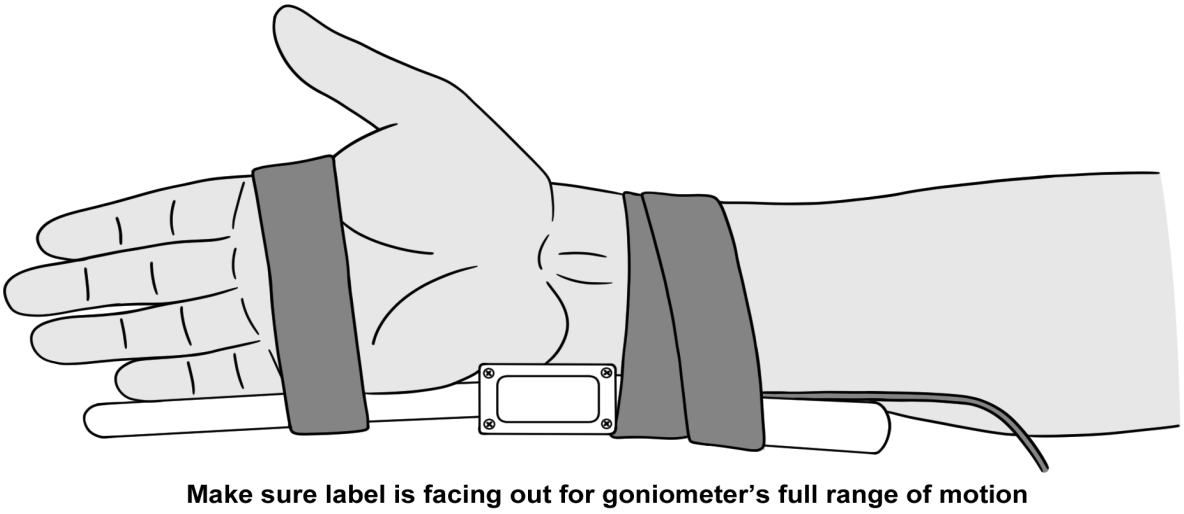

Figure HM-7-L1 Position of the GN-100 on the right wrist.

2. Instruct the subject that he or she will be doing the following during this exercise:
    - Before the recording begins, the subject extends their arm in front of their body with the palm facing upward. This position is defined as the neutral position.
    - Keep their hand open (fingers extended) during the recording.
    - Move their hand upward (palmar flexion) from the neutral position as far as possible and hold it in this position for five seconds.
    - Return the hand to the neutral position (extension) for five seconds.
    - Continue recording as the subject repeats the cycle of flexion and extension two more times.
4. Before starting the recording, type **Neutral-Open** in the Mark box to the right of the Mark button. Instruct the subject to place their hand in the neutral position.

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5. Click the Record button then click on the Mark button to label the recording.

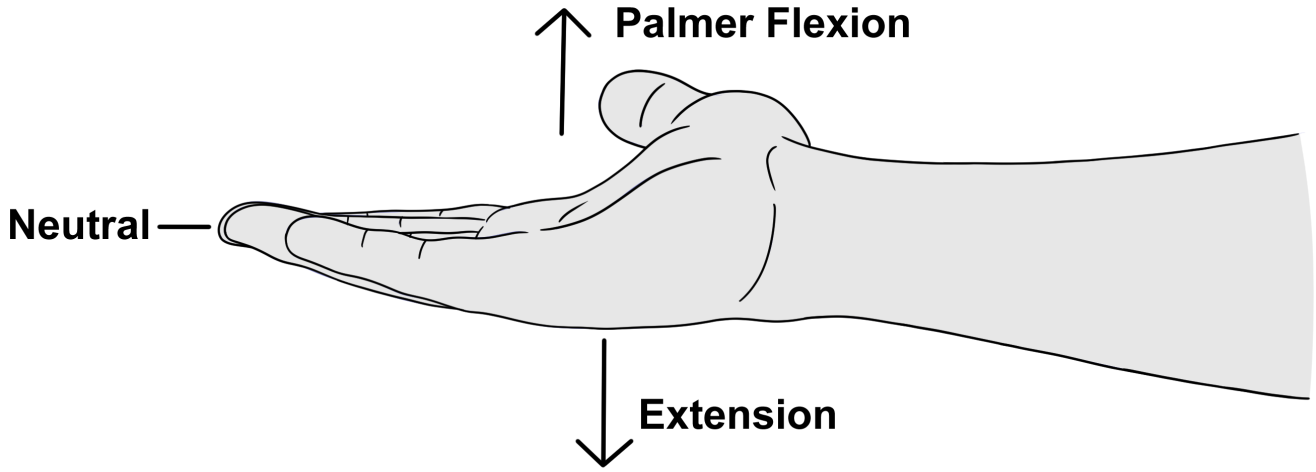

Figure HM-7-L2: Movements performed while recording palmar flexion and extension of the wrist.

6. While the subject's hand is in the neutral position, type **Palmar Flexion-Open** in the Mark box.
7. Instruct the subject to flex their hand. When the subject's hand reaches the flexed position, click on the Mark button to label the recording.
8. While the subject's hand is in the flexed position, type **Neutral** in the Mark box.
9. Instruct the subject to extend their hand to the neutral. When the subject's hand reaches the neutral position, click on the Mark button.
10. Repeat Steps 3 through 8 for two more cycles of palmar flexion and extension.
11. Instruct the subject to curl their fingers into a tight fist. Repeat Steps 3 through 8 three times while the subject the subject is forming a tight fist. Mark the recording with appropriate comments to indicate when the subject's fist underwent palmar flexion or extension to the neutral position.
12. When the last cycle is completed, click the Stop button.
13. Select Save As in the File menu, type a name for the file. Click on the Save button to save the data file.

Optional Exercise 1: Attach the goniometer to the inside of the subject's left wrist. On this wrist, the moveable arm of the GN-100 can go below the neutral position. Use the same techniques used in Steps 3 through 9 to measure the range of motion of the subject's left hand as it undergoes dorsiflexion.

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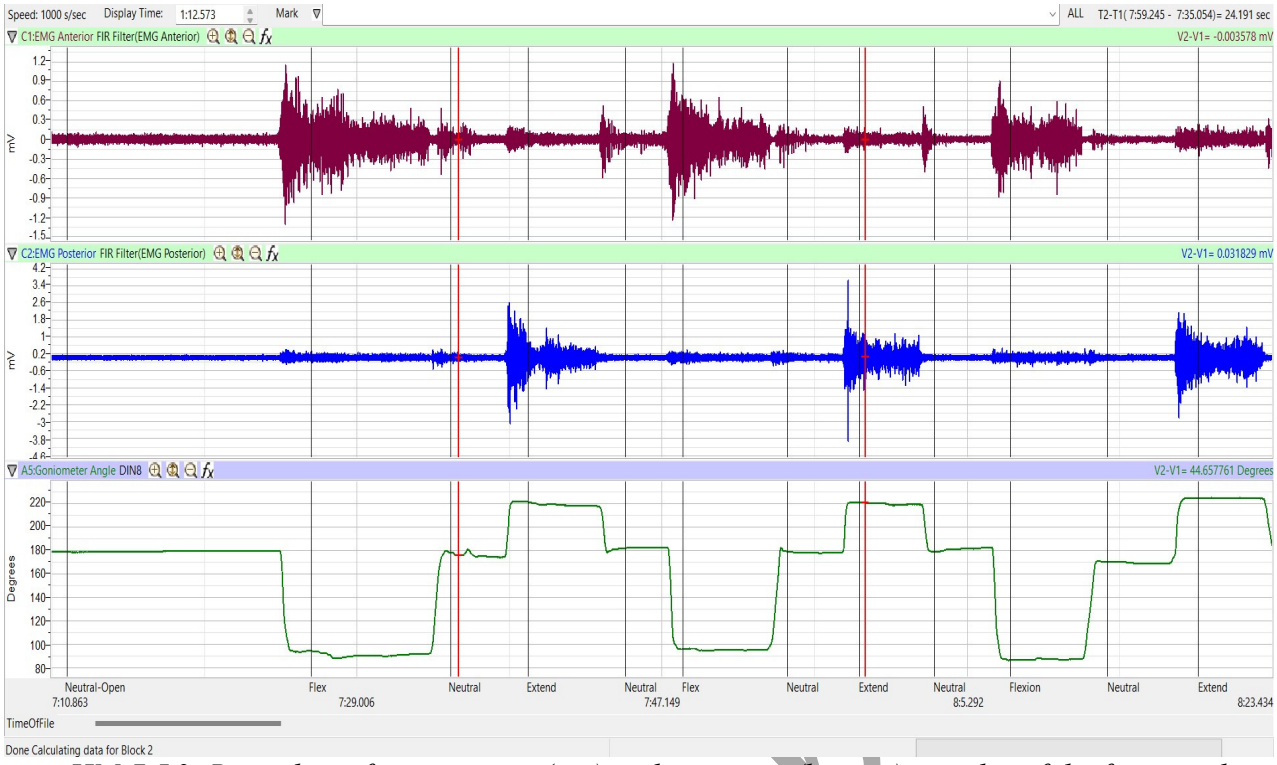

Figure HM-7-L3: Recordings from anterior (top) and posterior (bottom) muscles of the forearm during flexion and extension of the hand while the subject's fingers are extended.

Data Analysis

1. Scroll through the recording and find the section of data recorded while the subject was flexing and extending their right 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.
3. Click on the Analysis window icon in 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., Max-Min, T2-T1, and V1 should appear in this table. The values for Abs. Int., Max-Min, T2-T1, and V1 on each channel are seen in the table across the top margin of each channel.

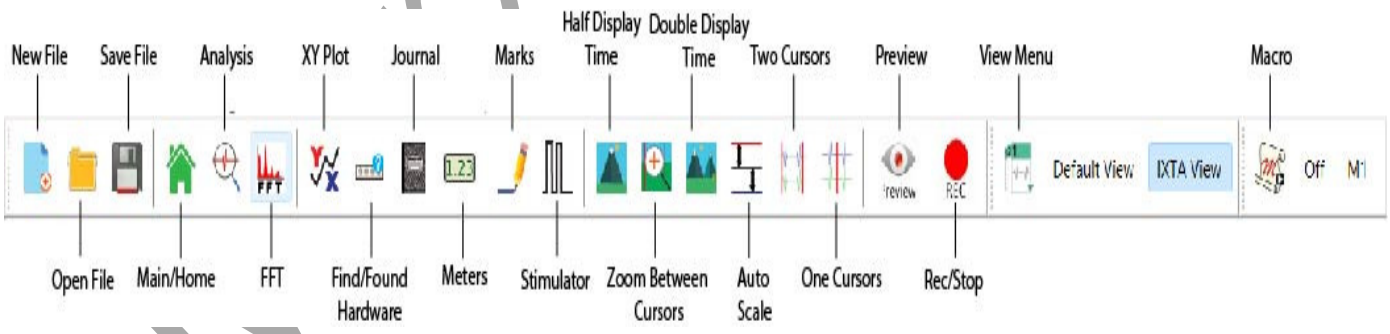

Figure HM-7-L4: The LabScribe toolbar.

IXTA Sample

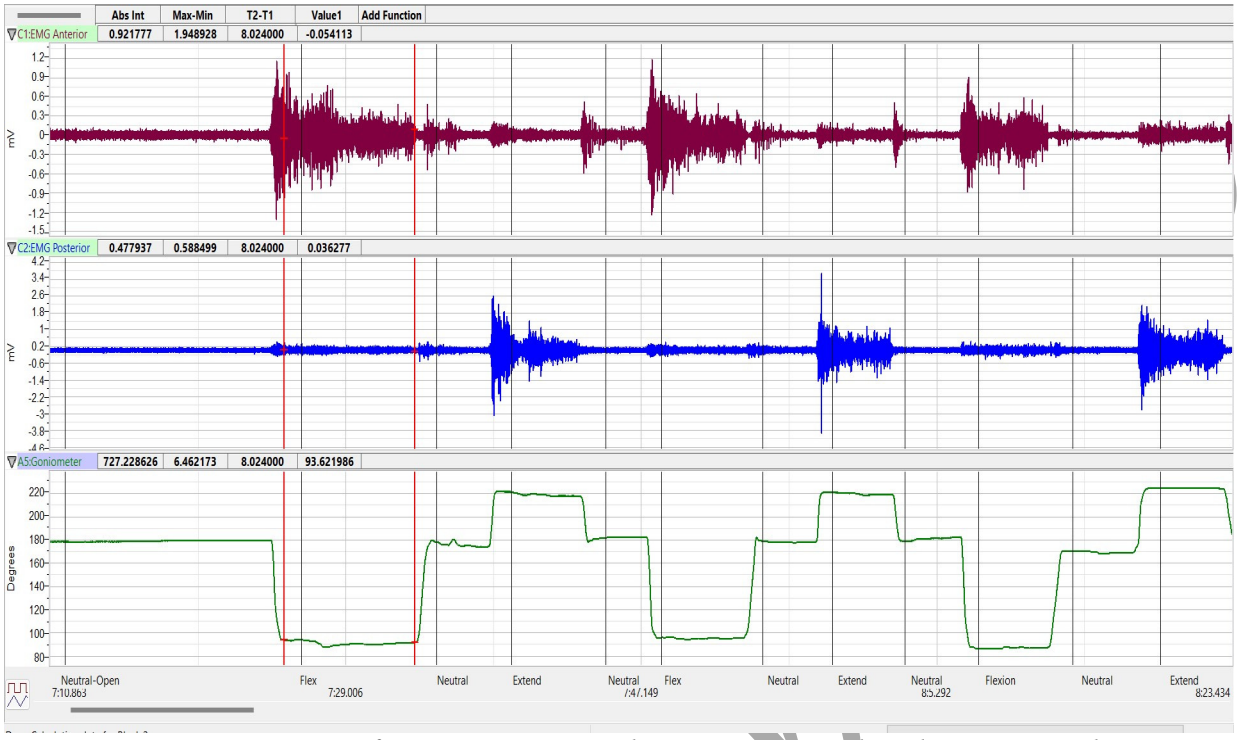

Figure HM-7-L5: EMG activity from opposing muscles. Cursors are placed to measure the EMG activity taking place simultaneously in flexors and extensors.

5. Use the mouse to click on and drag the cursors to the onset and offset of the EMG burst during the first flexion. The values for Abs. Int., 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 flexion as shown in Figure HM-7-L5. 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.
6. 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. 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 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 Anterior Channel pull-down menu.
    - Transfer the values for the absolute integrals to the Journal using the Add All Data to Journal function in the Anterior Channel pull-down menu.
7. Record the values from each muscle group during the first flexion in the Journal, or on a data table.

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8. 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. Int., Max-Min, and T2-T1 from both groups of muscles during this extension.
9. Measure the Abs. Int., Max-Min, and T2-T1 for the EMG bursts from the anterior and posterior muscles from the remaining flexions and extensions.
10. Average the values for each parameter taken from the anterior muscles during flexion and 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 1.
11. In the main window, click the Single cursor icon in the LabScribe toolbar. If in the Analysis window, the left-most cursor will be V1.
12. Use the mouse to click on and drag the cursor to the level area of the trace during the first flexion. The value for V1 on the Range of Motion channel is the angle of flexibility during flexion of the wrist.
13. Record the value of the angle of flexibility during the first flexion in the Journal, or on a data table.
14. Use the mouse to move the cursor to the level area of the trace during extension. Measure and record the value for V1 during this extension.
15. Measure the V1 Angle of Flexibility from the remaining flexions and extensions. Enter these values on Table 1.
16. Once the cursor is placed in the correct position for measuring the angles of flexion and extension, 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.
17. Average the values taken during flexion. Find the average during extension. Enter these values in the data table.
18. Select Save from the File menu.
19. Repeat data analysis for Optional Exercise 1 *if completed*.

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?
4. Does the angle of flexibility differ between flexion and extension of the wrist?
5. Does the positon of the fingers affect the flexibility of the wrist?
6. What do you think would happen to the range of motion of the wrist if the hand was turned at a 90 degree angle (perpendicular to the neutral plane of motion)?

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Exercise 2: Antagonistic Muscles Doing Work

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

Approximate Time: 20 minutes

Procedure

1. Use the same experimental setup used in Exercise 1. Instruct the subject to rest their forearm, with the electrodes, on a flat surface with the palm up. Place a weight (2-3kg) in the palm of the subject's hand.
2. Click Record. Record the EMG activity from the muscles of the forearm as the subject lifts the weight by flexion of the wrist. 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.
3. Click Stop to halt the recording.

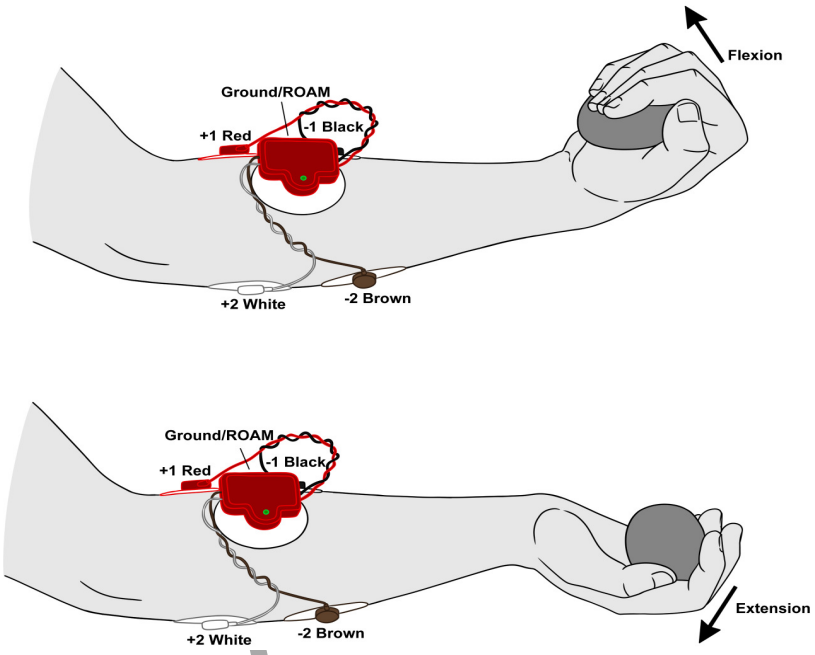

Figure HM-7-L6: Hand in the correct position for lifting the weight by flexion. The ROAM wireless connection is shown.

4. Instruct the subject to rest their forearm on a flat surface with the palm up.
5. Have the subject grip the same weight (2-3kg).
6. 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.
7. Click Stop to halt the recording.
8. Select Save in the File menu.

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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. Int., Max-Min, T2-T1, and V1 from each muscle group while the weight was lifted by flexion and by extension.

   Average the values for each parameter taken from the anterior muscles while weight was lifted by flexion and extension. Also, find the averages for the parameters from the posterior muscles while the weight was lifted by flexion and by extension. Enter the means on Table 1.
3. Select Save from the File menu.

Table HM-7-L1: Relative EMG Activity in the Muscles of the Forearm during Flexion and Extension.

	Averages: Anterior Muscles			ROM	Averages: Posterior Muscles			ROM
Forearm Action	Abs. Int.	V2-V1 (V)	T2-T1 (sec)	V1 (degrees)	Abs. Int.	V2-V1 (V)	T2-T1 (sec)	V1 (degrees)
Flexion, Hand Open								
Extension, Hand Open								
Flexion, Hand Closed								
Extension, Hand Closed								
Flexion, Lifting Weight								
Extension, Lifting Weight								
Dorsiflexion, Hand Open								
Dorsiflexion - Closed								
Dorsiflexion - Weight								

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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?
3. What is the effect of the weight on the ROM/angle of flexibility of the wrist joint? Is either flexion or extension affected more than the other?

Exercise 3: Antagonistic Muscles in Lower Leg

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

Approximate Time: 30 minutes

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. To locate the tibialis anterior, feel for the subject's tibia. Place your fingers 2 cm to the lateral side of the tibia and 8-12 cm below the kneecap. As the subject points their foot inward (supination) and upward (dorsiflexion), you should be able to see and feel the contraction of the anterior tibialis muscle. The first electrode will be placed about 10 centimeters below the knee on the midline of the muscle. The second electrode will be placed on the midline of the muscle, about 10 centimeters below the first.
    - 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. The second electrode 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. Use an alcohol swab to clean and scrub the areas where the electrodes will be placed. Let the areas dry before attaching the electrodes.
2. Remove the plastic disk from a disposable electrode.
3. 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.

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- the brown “-2” lead is attached to the electrode in the middle of the calf muscle.
- the green lead (the ground) is attached to the electrode above the ankle.

4. Strap the GN-100 Goniometer so that the axis is on the ankle joint between the lower leg and the tarsals. Make sure the arms of the goniometer move freely with the movement of the subject’s ankle and is not inhibited in any way.
5. Have the subject to try to keep the ankle in a neutral position of approximately 90 degrees.
6. While the subject is sitting, click Record. Have the subject alternate between plantar flexion and dorsiflexion of their foot. Click AutoScale on channels 1 and 2 to amplify signals. Use the techniques explained in Exercise 1 to mark the recording of the EMG activities.
7. 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.
8. Determine which muscle group, gastrocnemius or anterior tibialis muscles, contract when the subject rocks forward or rocks backward.

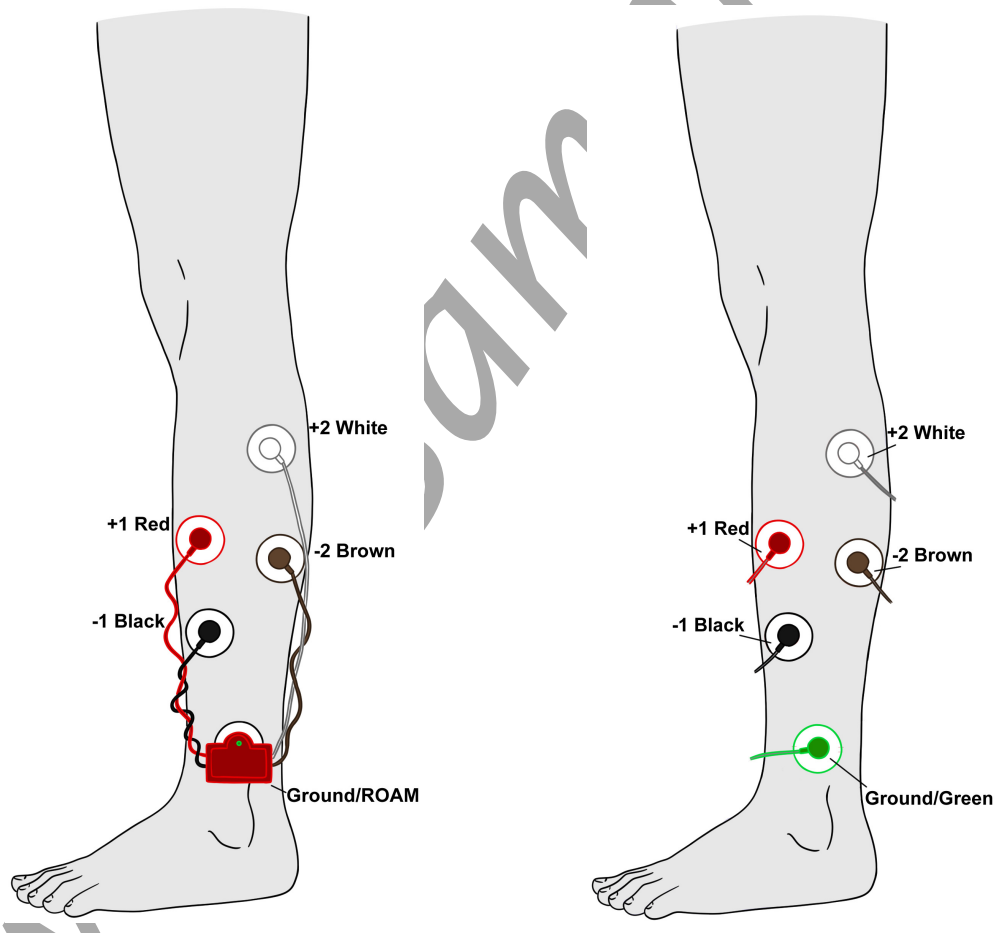

Figure HM-7-L7: Position of electrodes used to record EMG from muscles in the lower leg during plantar flexion and dorsiflexion.

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9. 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.
10. 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. There may be a slight change in the ROM of the ankle at this point to help stabilize the leg.
11. 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.

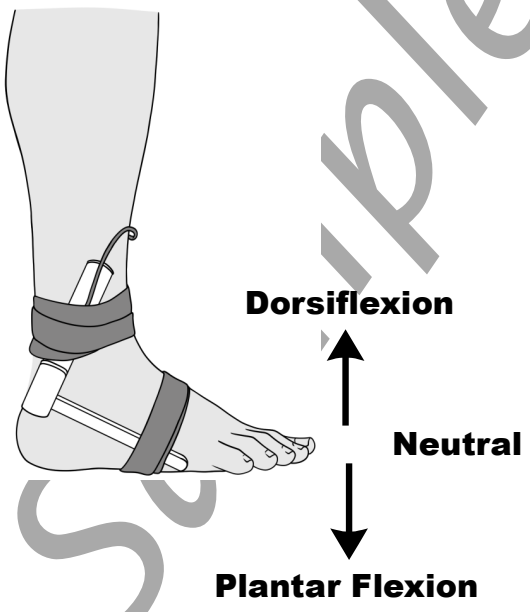

Figure HM-7-L8: Position of the GN-100 on the right ankle.

12. Ask the subject to sit comfortably .
13. As the subject is sitting, have them move the ankle as far as possible in both the plantar and dorsiflexion position.
    - Record plantar flexion of the ankle for five seconds. Mark the recording appropriately.
    - Record the ankle in neutral position for five seconds.
    - Record dorsiflexion for 5 seconds and mark the recording.
14. Click Stop to halt recording.
15. Select Save in the File menu.

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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 integral, difference in amplitudes, and durations of the EMG bursts from the anterior and posterior muscles of the lower leg while the subject moved their 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;
    - Sitting, plantar flexion;
    - Sitting, dorsiflexion
3. Enter the means for each parameter, from each muscle group during the various motions, on Table 2
4. Use the same procedures from Exercise 1 to measure the ROM of the ankle while subject moved their ankle in the different positions.
5. Record this data in the data table.

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?
4. How is the ROM of the ankle affected by the different movements?
5. Which movement, plantar flexion or dorsiflexion, has the wider ROM? Is there any anatomical reason for this?
6. Was the ROM of the ankle greatest while the subject was sitting? What is the reason for your answer?

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Table HM-7-L2:Relative EMG Activity in the Muscles of the Lower Leg during Changes in Posture.

	Averages from Anterior Tibialis			ROM	Averages from Posterior Gastrocnemius			ROM
Leg Activity	Abs. Int.	V2-V1 (V)	T2-T1 (sec)	V1 (degrees)	Abs. Int.	V2-V1 (V)	T2-T1 (sec)	V1 (degrees)
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								
Sitting, Plantar Flexion								
Sitting, Dorsiflexion								

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Table HM-7-L3: Average ROMs (Adapted from Luttgens & Hamilton, 1997 and the American Academy of Orthopaedic Surgeons, 1994)

Joint/Segment	Movement	Source 1*	Source 2*	Source 3*	Source 4*
Wrist	Flexion (Palmar Flexion)	60	90	80	60
	Extension (Dorsiflexion)	60	70	70	50
Ankle	Plantar flexion	40	45	45	50
	Dorsiflexion	30	15	20	20

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