Electromyogram and Stretch Reflex Experiments

PreLab –answer the following questions:

1. What is the origin of the muscle electrical activity recorded here and its relationship to the force generated? Why must the EMG activity recorded here be processed to quantify muscle activity?
2. Fatigue can be divided into psychological and physical forms. In psychological fatigue, discomfort discourages us from sending out the same intensity of signals to the muscle. In physical fatigue, however, the signals are sent out to the muscle at the same rate, but force falls off in spite of that. What happens to EMG activity during physical muscle fatigue and why (look at figure 4)? Relate this to force output.
3. What is a stretch receptor and what information does it generate?
4. What is the pathway that the signal travels in the stretch reflex? Describe all parts.
5. What is the utility of the stretch reflex for human function in a normal environment?
6. Describe the patterns of activation of antagonist muscles and why it is important that they be controlled in this way.

Part I: Grip Strength and Electromyogram (EMG) Activity

Background

A **motor unit** is composed of a motorneuron and all the muscle fibers that are innervated by that motorneuron. In a persistent muscle contraction, like a clench, 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 and to the frequency of their activation. 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 mean 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 (pressure bulb)** 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 (force) as a function of the mean of 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.

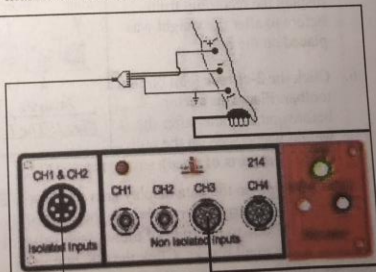

Fig 1: Experimental Setup for recording EMGs.

Equipment Required

- PC Computer and iWorx unit with USB cable
- AAMI cable and five EMG leads
- Alcohol and tissues
- Hand Dynamometer (bulb pressure transducer)
- 4kg weight

Equipment Setup

1. Attach the **big connector** on one end of the cable to the **isolated Channel 1 and 2 inputs on the iWorx** unit.
2. Connect the **hand dynamometer (bulb)** to the input of **Channel 3** on the iWorx unit.
3. The subject should remove all jewelry from their wrists, and use **alcohol and tissue** to clean and scrub three regions on the subject's dominant forearm where the electrodes will be placed (see Figure 1 above). One area is **near the wrist**, the second is in the **middle of the forearm**, and the third area is **about 1 inch from the elbow**. Let the areas dry before attaching the electrodes.
4. Apply the **disposable electrodes** to the scrubbed areas.
5. **Attach three color-coded electrode cables** to the disposable electrodes, so that:
   a. the **red "+1" lead** is attached to the electrode **near the elbow.**
   b. the **black "-1" lead** is attached to the electrode in the **middle of the forearm.**
   c. the **green "C" lead** (the ground) is attached to the electrode **on the wrist.**

Start the Software

1. Click open the Human Phys folder, and start **LabScribe2.**
2. Select **Load Group** from the **Settings** menu, and select **IPLMV4.iwxgrp.**
3. Click on the **Settings** menu again and select the **Human Muscle/EMG-GripStrength** settings file.

Calibrating the Hand Dynamometer

1. Disconnect the big EMG connector for this part, and replace after the calibration is done.
2. Lay the hand dynamometer down on the bench top. Click the **Start** button (upper right) and **record a baseline for 10 seconds.**
3. Balance the 4kg weight on the bulb of the hand dynamometer, get a stable recording for ~10 sec, and then click **Stop**.
4. Save file to desktop/Lab data **(as an *.iwxdata file)**, giving it your name. (If it crashes, you can restart it with the calibration intact).
5. Click **Auto Scale for the force channel.** Use the **Display Time icons (Half time, 2X time, see below)** and scroll buttons at bottom to display the recording from before to after the weight was placed on the bulb.
6. Click the **2-cursor icon** on the toolbar. Place one cursor before and the other after the weight was placed on the bulb (on the flat parts of trace).

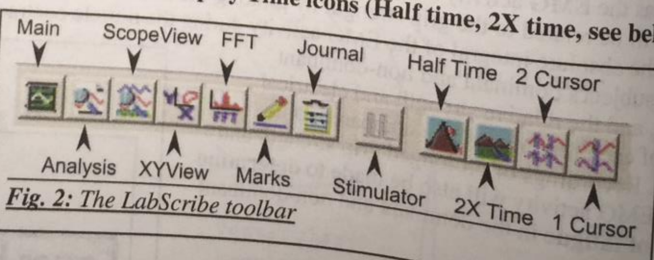

Fig. 2: The LabScribe toolbar

7. **Right-click** on the data display area of **Muscle Force** panel. Select **Units/Simple** from the right-click menu. Type zero (0) in the box to the right of the voltage value of the first cursor; type the weight (in kg) in the box to the right of the voltage value of the second cursor. Type the unit" kg" in the Name box and apply to all blocks. Click the OK button.
8. **Set the blue cursors to the far left and right. Right click on the data display area of the EMG (top). From the right click menu, click Units/zero. This will zero the EMG trace. Now reconnect the EMG cable to the box.**

WARNING. **The EMG electrodes will pick up spurious signals due to movements of the arm or wires. Start the trace going and play with this so that you can avoid it in your EMG recordings.**

Exercise 1: EMG Intensity and Force

Aim: To determine the relationship between the EMG intensity and force of contraction.

Procedure—do this several times until you get good data (as in Figure 3 below).

1. **Overview--**The subject should sit quietly with his/her dominant forearm resting on the table top. The subject will **clench his/her fist around the hand dynamometer six times, each clench is two seconds** long followed by **two seconds of relaxation. The first clench should be the strongest to set the scale. Then go back and make a *very weak* clench and** then **stronger and stronger ones to cover the range of force. THE SUBJECT MUST SEE THE SCREEN and get visual feedback to produce good data.**
2. Click the **Start** button to begin recording. **Type "Increasing Clenches"** in the **comment line** to the right of the **Marks** button. Press the **Enter** key on the keyboard. Before doing the increasing series, give one very hard clench. Then click autoscale on each channel and leave at that magnification for the full set of increasing clenches. After the last relaxation, click **Stop**. **AutoScale** each channel.
3. **Save the File.** The recording should be similar to that in Figure 3 below.

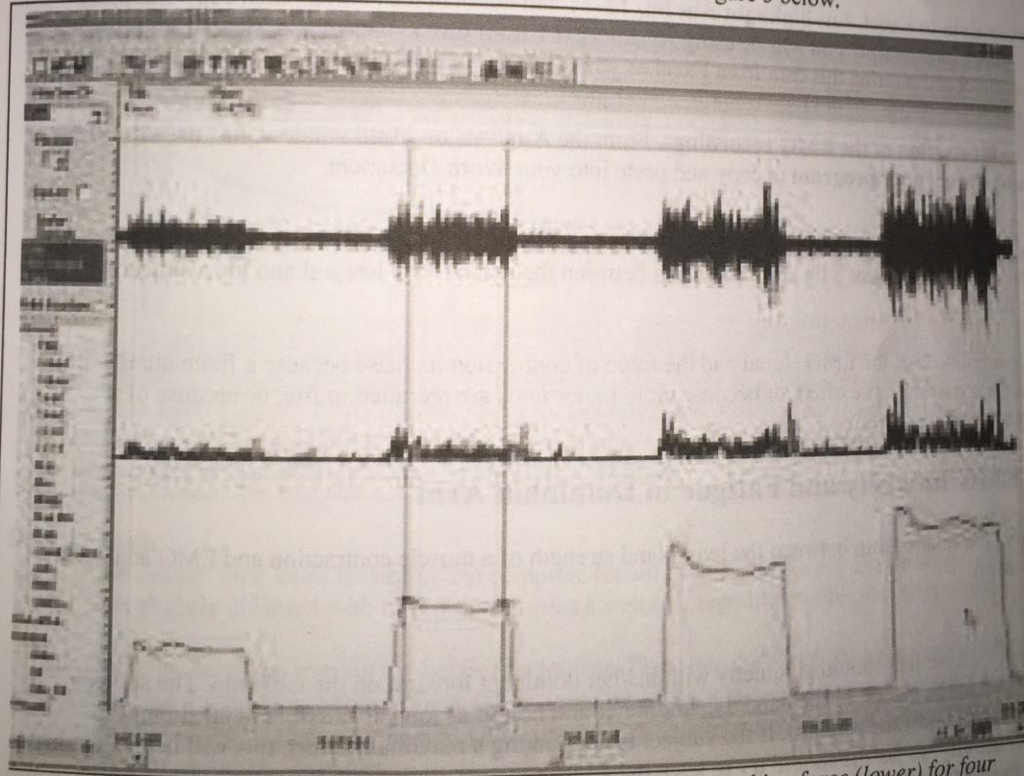

Fig. 3: *The EMG (upper), EMG absolute integral (middle), and clenching force (lower) for four progressively stronger clenches displayed in the Main window.*

Data Analysis

1. Adjust the time displayed on **the Main window** to display the subject's five clenches on the screen (see above) Use the **Display Time** icons on the LabScribe toolbar (see Fig 2) to set the proper screen width.

2. Click the **2-cursor icon** on the toolbar. Place cursors on either side of the five clench cycles displayed in the Main window. Click the **Analysis icon** on the toolbar to send the data to the **Analysis window**.

3. Above the EMG panel, click **add function**, and select **Integral(Area)/Absolute Integral**. **The units of this number are mV*msec, so we need to divide by T2-T1 to control for the length of time selected.** So **add function** again for **T2-T1**. Repeat to add **General/Mean.**

4. Place the cursors on the **force trace** just after the onset and just before the offset of the smallest muscle clinch—choose only the flat part at the top—see arrows in Figure 3. The program will average the EMG **Integral** values between these two points and show the value above the EMG trace. Divide this number by T2-T1. The mean force will also be shown above the force channel—these are the only two numbers that we use. Record the **Title** and **Mean** in the **Journal**. Data can be entered into the Journal by either typing the titles and values directly or by using the **right-click menu** while in the Analysis window (select **Add Title to Journal** first, then repeat the right click selecting **Add All Data to Journal** from the menu to add the measurements to the Journal). **Repeat the procedure for each of the remaining muscle clinches. Reset after each cycle.** Use the **Journal** button to go and see that your data is being entered correctly—displayed in window at right.

5. **Save your data to Excel**. Just **highlight** Abs Int, T2-T1 and Mean in the Journal, then **copy** and **paste** into an Excel spreadsheet. You will be using AbsInt/T2-T1 from EMG channel and Mean from Muscle Force channel and plotting this data from Excel as you did in the MetaNeuron Experiments. (Muscle Force vs EMG Integral/(T2-T1)—linear XY scatter plot).

6. **Save the illustration of the EMG recordings.** From the **Analysis or Main** window, just **use alt-Print Screen or the cropper program** to copy and paste into your Word Document.

Questions

1. In your plot of average muscle force as a function of the mean EMG integral (using the points from the 5 muscle clinches), is there a linear relationship between the mean EMG integral and the averaged muscle force?

2. Does the amplitude of the EMG signal and the force of contraction increase because a finite number of motor units are firing more often, or because more motor units are recruited to fire, or because of 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. **Overview--**The subject should sit quietly with his/her dominant forearm on the table top. The subject will do a maximum clench of the hand dynamometer and hold it as long as possible in an attempt to fatigue the muscles of the forearm. If the subject is not making a maximum effort, this will be evident in less EMG activity, so he/she should try to keep the EMG constant all through the clench. **Do it over again if the EMG decreases during the clench, because that means that the subject's effort has decreased (psychological fatigue), which is quite different from physical fatigue.** This way we study only study actual physical fatigue. When the subject's clench force falls well below 50% of the maximum clench force, the recording can be halted.
2. Click the **Start** button in the **Main** window to begin recording. **Record a baseline** with no force for a few seconds, **then begin the maximum clench**. Click the **AutoScale** buttons on all three recording channels. Continue to record the fatigue of the subject's forearm **until the force of the muscle contraction drops below 50% of the maximum**; then click **Stop**.

3. Use a **tailor's tape measure** to determine the **circumference** of the widest part of the subject's dominant forearm. Record this measurement.

4. **Save the .xls and .iwxdata files. Save an image of the fatigue traces to Word.**

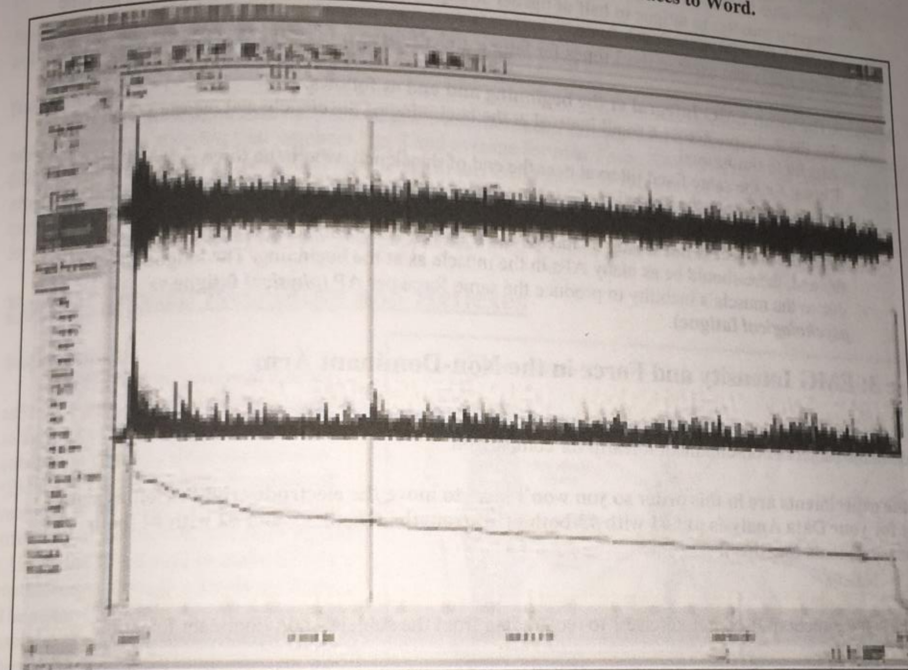

Fig. 4: *The EMG (upper), EMG absolute integral (middle), and clench force (lower) during a prolonged muscle contraction as displayed in the Analysis window. The cursors are placed to measure the time needed to lose 50% of his maximum clench strength.*

Data Analysis

1. Use display time icons to display the complete record of this experiment on one screen (Fig 4—will look slightly different with new program—no absolute integral in middle, functions at top).

2. Click the **2-cursor icon** on the LabScribe toolbar. Place one cursor on the relaxation period that precedes the fatigue exercise. Place the second cursor to the right of the point when the subject released the bulb of the hand dynamometer. Click the **Analysis** icon on the toolbar to send the data to the **Analysis** window.

3. In the Analysis window (top), you will see **V2-V1**, and **T2-T1**. Place one cursor on the relaxation period before the maximum contraction, and the second cursor on the peak of the muscle contraction. The difference in amplitude (**V2- V1**) is the **maximum clench force** of the subject, which should be recorded in the **Journal**. (Data can be entered into the Journal by either typing the titles and values directly or by using the right-click menu.).

4. **Determine the time it takes the subject's forearm to fatigue to half its strength** as follows.
   a. Divide the maximum clench force by 2. This is the half-maximum clench force.

b. Put one cursor on the maximum value of the muscle contraction (**Force**).
c. Move the other cursor to the right of the peak until the value for **V2-V1** at the top of the Force window is equal to the half-maximum clench force.
d. The value for **T2-T1** when the cursors are in these two positions is the time it takes the subject's forearm muscles to fatigue to half of his/her strength. Enter this value in the Journal as the time to the half-maximum clench force.
e. Repeat 2X, and average the 3 times for fatigue to half force.

5. **Measure the mean EMG Integral at the beginning and end** as follows.
   a. Set the 2 cursors across a small interval at the beginning of the clench, and measure the EMG Abs Int to the Journal.
   b. Repeat for the same fixed interval near the end of the clench, where the force is about half, and record its mean to the journal.
   c. **Is the EMG Integral/(T2-T1) still the same when the force is down to half? If this activity falls, the subject is not trying as hard!! Do it again.** If the subject was really trying as hard at the end, there should be as many APs in the muscle as at the beginning. The fatigue will then be due to the muscle's inability to produce the same force per AP (***physical*** **fatigue vs** ***psychological*** **fatigue**).

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 for comparison.

Note—the experiments are in this order so you won't have to move the electrodes right to left as many times, but for your Data Analysis put #1 with #3(both grip strengths together), and #2 with #4 (both fatigue measurements together).

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

Data Analysis
Analyze the data from the subject's non-dominant forearm as it was done in Exercise 1. Make a table for each arm of Force and the associated EMG Integral, as well as arm diameter. Furnish this information to your TA, and get the values from the other groups from your TA for inclusion in your Data Analysis. Use the information from Exercises 1 and 3 to answer the following questions.

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 maximum grip force to the mean 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.
3. Is there a difference between the circumference of the dominant and non-dominant forearms? Calculate the percent difference between the circumferences.
4. Is there a relationship between the circumference of the forearm and the maximum force developed? If there is, what is it?
5. 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.

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 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. Make a table for each arm showing trial numbers 1 to 3 and average for Max Force, EMG Integral, Half Max Force, EMG Integral, and Time to half Max Force. Furnish this information to you TA nad get the data from the other groups for inclusion in your Data Analysis. Use the information from Exercises 2 and 4 to answer the following question: How does the time to fatigue to half-strength in the dominant forearm compare to the same parameter for the non-dominant forearm both for your subject and for the whole lab?

Part II: Stretch Receptors and Reflexes

Background
Studying the vertebrate stretch reflex is a good way to introduce students to the topics of stretch receptors, nerve conduction velocity, electromyograms (EMG), and motor control. Specialized receptors in the muscle respond to stretching of the muscle, and send signals (APs) to the spinal cord to make EPSPs in motorneurons through a single synapse. The motorneurons fire an AP down their axons to the muscle fibers, which depolarize and twitch in response to the incoming impulse from the motorneuron.

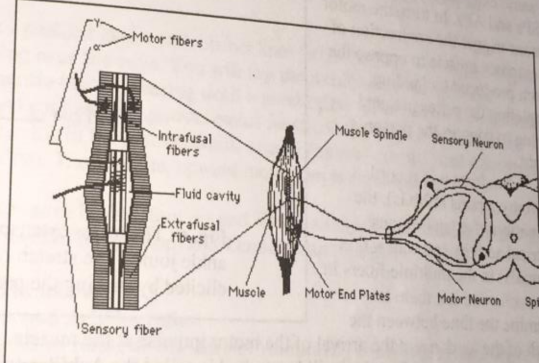

Fig. 5: A monosynaptic stretch reflex arc.

The Stretch Receptor. The majority of a muscle consists of extrafusal fibers, which are innervated by alpha motor neurons and are responsible for developing muscle tension. But skeletal muscles also have specialized receptors, inside the intrafusal fibers, which convey information about muscle length to the central nervous system. The sensory receptors responsible for providing information about the length, or the rate of change of the length, of a muscle are called muscle spindles. Arranged in parallel with extrafusal muscle fibers (see figure above), the spindles are stretched when the muscle is stretched by an external force. Therefore, these receptors play a significant role in developing antigravity reflexes and maintaining muscle tone. Intrafusal muscle fibers do not contribute much to the overall tension of the muscle, but regulate the excitability of the afferent spindle nerves by mechanically deforming the receptors. These fibers are innervated by gamma motor neurons.

The Stretch Reflex. When a muscle is stretched, excitation of its muscle spindles causes a reflex contraction of the muscle. This reflex response is known as a stretch (myotatic) reflex. The minimal delay between the muscle stretching and the reflex contraction is due to its monosynaptic pathway. The sensory afferent nerves from the spindles synapse directly with motor neurons; there are no interneurons. This pathway constitutes the shortest possible reflex arc (see figure above).

As an example of the adaptive value of the stretch reflex, consider the reflex response that occurs when a person jumps from a low stool to the floor. The extensor muscles of the legs (see figure above) are stretched on landing, lengthening all their muscle spindles. The discharge of the muscle spindles is conveyed to the central nervous system through the fast-conducting Ia afferent axons. These sensory axons enter the spinal cord through the dorsal root and synapse with the motor neurons of the same extensor muscle, causing EPSPs and APs. In turn, the motor neurons trigger the contraction of the extensor muscle to oppose the stretch produced by landing, completing the reflex arc, and helping to support the person's weight.

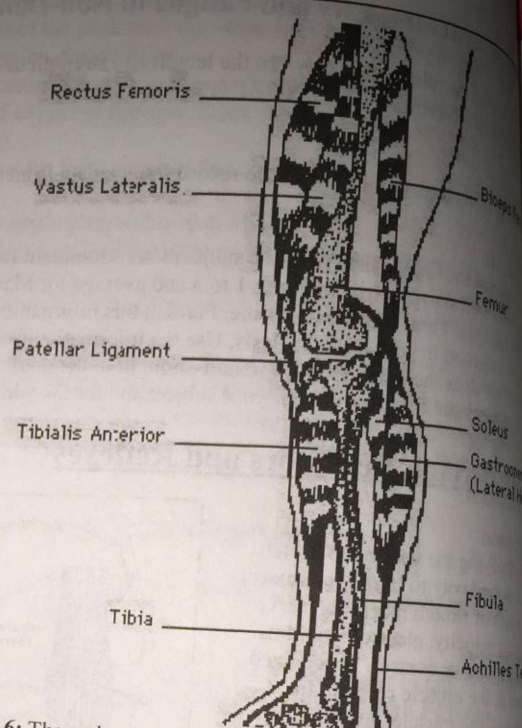

Fig. 6: The major extensors and flexors of the human knee and ankle joints. The stretch reflexes used in this exercise are elicited by striking the patellar tendon or the Achilles tendon.

Students will record electromyograms (EMGs), the summation of asynchronous electrical activity (muscle action potentials) in the multiple fibers in the muscle, and use them to determine the time between the stretch of the tendon and the arrival of the motor impulse at the muscle.

The human reflex that will be studied is called the **Achilles tendon reflex. Conduction times** and **nerve velocities** for the reflex arc will be determined. The effect of pre-existing tension in the effector muscle, or motor activity in other muscle groups, upon reflex responses will be measured. The coordination of motor activity in antagonistic muscles will also be studied.

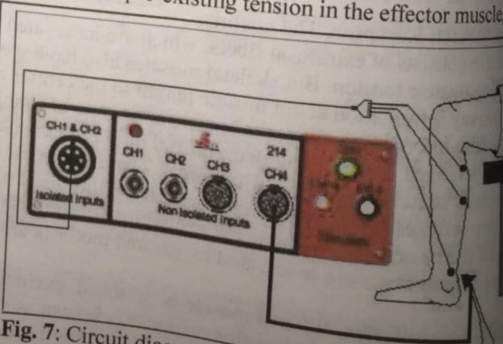

Fig. 7: Circuit diagram for recording electromyograms from the calf muscles

Equipment Required

PC Computer with iWorx unit and USB cable
AAMI cable and five EMG leads,
Alcohol and tissues,
PT-104 Pulse plethysmograph
Percussion Reflex Hammer—(here we use a metal rod)

Equipment Setup

1. Use the **alcohol and tissue** to clean and abrade three regions on the calf of the left leg for electrode attachment (see Fig 7). One area is **near the ankle**, the second is in the **middle of the calf muscle**, and the third area is **about 2 inches below the back of the knee**. Let the areas dry.

2. Apply **disposable electrodes** to the abraded areas. Attach the **AAMI connector** on one end of the cable to the isolated Channel 1 and 2 inputs on the iWorx unit. Attach **three color-coded electrode leads** to the ground and Channel 1 inputs on the lead pedestal and snap the other ends onto the disposable electrodes, so that:
   a. the **red "+1"** lead is attached to the electrode near the back of the knee.
   b. the **black "-1"** lead is attached to the electrode in the middle of the calf muscle.
   c. the **green "C"** lead (the ground) is attached to the electrode on the ankle.

3. Plug the **plethysmograph cable into Channel 3** (Tap). Attach the plethysmograph to the side of the aluminum rod with its velcro strap. As the rod strikes the tendon, the plethysmograph will emit a signal recorded on Channel 4, which will mark the time when the tendon is struck.

Start the Software

Click on the **Settings** menu and select the **Human Nerve/AchillesStretchReflex** settings file.

Exercise 1: EMG Recording and Reflex Timing

Aim: To determine conduction time from stimulus to response in the Achilles tendon reflex arc.

Procedure

1. **Overview:** the **subject kneels on a padded chair**, with his/her knee joints forming a 90 degree angle and his/her **ankles and feet hanging over the edge. You will tap the Achilles tendon with the aluminum rod (start with very gentle taps increasing until a good reflex is obtained).** The Achilles tendon is located above the heel and connects the gastrocnemius muscle to the heel bone. Take a few trials to produce a consistent contraction of the gastrocnemius muscle (back of the calf) and a downward movement of the foot (plantar flexion). The opposite, upward movement is dorsiflexion.

2. Click **Start**. First ask the **subject to move his/her foot up and down**, alternating **plantar flexion** with **dorsiflexion.** Click **AutoScale** on the **EMG Calf** (top) and **Tendon Tap** (bottom) channels.

3. **Record 3 different blocks of data as follows**:
   a. Record **10 trials for the normal Achilles reflex.**
   b. Record **10 trials for the Achilles reflex as the subject voluntarily contracts his/her lower leg strongly, but keeps the foot angle at 90 degrees as before.**
   c. Record **10 trials for the Achilles reflex as the subject performs the Jendrassik Maneuver.** To begin this maneuver, subject should curl his/her fingers toward the palm of each hand to form a hook, and interlock his/her hands so the fingers of one hand fit in the hook of the other. Then, as the subject holds his/her arms in front of his/her chest with elbows pointed out, the subject attempts to pull his/her hands apart. This **isometric contraction** develops motor activity in another part of the body (the arm and shoulder muscles). **Record the Achilles reflex during this motor activity.**

4. **Save** your File under your name in Desktop/Lab Data folder.

Data Analysis

1. **Scroll** the data on the **Main** window until the **first twitch of the series** is positioned in the center of the screen.

2. Drag the blue lines to the left and right of the tap and the twitch and open the **Analysis** window. The window displays **EMG Calf and Tendon Tap with T2-T1 shown above each.**

3. **Drag one cursor to the beginning of the spike** on the Tendon Tap channel and the **second cursor to the peak of the EMG spike** on EMG Calf channel. The time interval (**T2-T1**) is the **reflex time in seconds** of the subject's stretch reflex. Move the decimal point 3 places to the right to get the time in milliseconds (msec).

4. Scroll through your data and **repeat the measurements for all 10 trials**. Copy and paste the data to the Journal to Excel. Drop the longest and shortest times, and **average the remaining eight values** to determine the mean reflex time.

5. **Using the tape measure, measure the distance between the belly of the subject's calf muscle and the site of the sensory-motor synapse in the spinal cord.** For the purpose of this exercise, assume the sensory-motor synapse is at spinal segments **L5 and S1,** which are **just above the top of the hip bone. Multiply this measurement by 2** to determine the total length of the nerve path.

6. Even though this stretch reflex is known as a **monosynaptic reflex,** the pathway includes the neuromuscular synapse (NMJ) as well as the synapse in the Sp.Cord. If synaptic transmission takes about 0.5 msec each, calculate the mean conduction velocity in the nerves composing this reflex pathway by the equation:

$$\textbf{Conduction Velocity (m/sec)} = \frac{\textbf{total path length (mm)}}{\textbf{Mean reflex time (msec)} - \textbf{1.0msec}}$$

7. Repeat the measurements above for both the contracted case and the case with the Jendrassik maneuver. Transfer this data to your Excel worksheet. Organize your data by category of experiment and plot bar graphs showing average reflex time and standard error for each group.
8. To get Excel to put error bars on the bargraph, right click the bar to get the format dialog box. Click Y error bars and enter the standard error. These can be calculated using the STDEV function in Excel. Standard error is the stdev divided by the square root of n (# samples).

Questions

1. Which muscles are involved in plantar flexion and dorsiflexion of the ankle?
2. Is the Achilles reflex inhibited or enhanced by voluntary muscle activity in the gastrocnemius? Note that a contracting muscle resists stretch, so the stretch receptors will send fewer APs to the CNS.
3. Is the Achilles reflex facilitated during the Jendrassik's Maneuver (voluntary muscle activity an another part of the body)? Speculate on the mechanism of enhancement or inhibition. Since AP Conduction Velocity is roughly constant, could it be a change in the time that it takes either to initiate an AP at the muscle spindle in one case or the time for transmission in the Sp. Cord in the other?
4. Do isometric contractions in other muscle groups facilitate the Achilles reflex response? Speculate on the mechanism of enhancement or inhibition that these muscles employ.
5. Besides excitatory inputs from stretch receptors, what synaptic inputs might influence the activity of spinal motorneurons.

Exercise 2: Antagonistic Muscles in Achilles Stretch Reflex

Aim: To study muscles working in opposition to each other that flex and extend extremities,

Software Change

Click on the Settings menu again and select the **Human Muscle/Antagonistic Muscle** settings file.

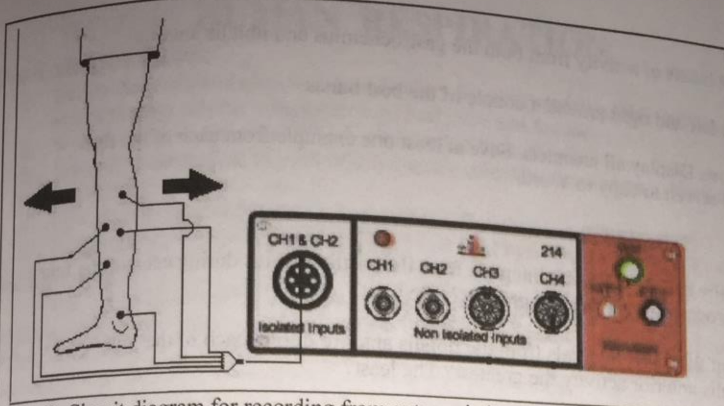

Fig. 8: Circuit diagram for recording from antagonistic muscles of the lower leg.

Procedure

1. **Disconnect the percussion rod/plethysmograph unit from the Channel 4 input.**

2. Keep the two recording electrodes on the belly of the **gastrocnemius (calf muscle)** and the ground electrode on the ankle. The leads used in Exercise 1 remain connected to their electrodes.

3. Place another pair of electrodes over the belly of the **tibialis anterior on the same leg**, so that:
   a. the **white "+2"** lead is placed on the upper portion of the tibialis anterior (below knee).
   b. the **brown "-2"** lead is placed on the middle portion of the tibialis anterior.

4. This **muscle is located just lateral to the tibia (shinbone) in the upper part of the calf** (see figure below). Locate the tibialis anterior: feel for the tibia, and place your fingers 1inch to the side of the tibia and 4-5in below the kneecap. Ask the subject to dorsiflex his/her foot. You should be able to feel and see the contraction of the anterior tibialis muscle beneath the skin.

5. **Make Four Recordings--** Start and stop to isolate each one, and label with Mark text.
   a. While the subject is sitting on the counter with the leg hanging free, record while the subject alternates between plantar flexion and dorsiflexion of his/her foot. Click **AutoScale** on all channels to amplify signals.
   b. Have the subject stand erect and rock on his/her feet from heels to toes and back to heels, 6 or 7 times. Notice the alternating contractions of the gastrocnemius and anterior tibialis muscles when the subject rocks back and forth. Make sure that the subject is **putting most weight on the leg with the electrodes.** Even though one muscle may dominate the record, the other muscle is also somewhat active.
   c. **Have the subject stand on the foot being recorded 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 helps to maintain balance. **Joint stabilization** is particularly important to leg and postural muscles involved in bipedal locomotion.
   d. Within the limits of artifacts induced by leg movement and cable lengths, explore the activity of the ankle flexors. Have the **subject alternately squat and stretch upward** on his/her toes.

6. **Save** the **File** under your name in the Desktop/Lab Data folder..

Data Analysis

1. Scroll the data to the first bursts of activity from both the gastrocnemius and tibialis anterior.
2. Drag the blue lines to the left and right around a couple of the best bursts.
3. Open the **Analysis** window. Display all channels. Save at least one example from each of the five recordings using alt-print screen to copy to Word.

Questions

1. Compare the amplitudes (by eye) of the EMG integrals from the gastrocnemius during each of the four activities. When was gastrocnemius activity the greatest? The least?
2. Compare the amplitudes of the EMG integrals from the tibialis anterior during each of the four activities. When was tibialis anterior activity the greatest? The least?
3. How does EMG activity in the gastrocnemius correlate to EMG activity in the tibialis anterior?
4. Name some other locomotive activities that require coordination of antagonists.
5. What roles would stretch reflexes play in these locomotive activities?

Data Analysis:

1. Illustration of raw traces of EMG and Forces for hand grip—5 clinch cycles in dominant arm.
2. Plot of force generated vs EMG integral for above 5 clinches.
3. Both of above for non-dominant arm and comparison of forces and circumferences.
4. Fatigue of dominant arm's grip—traces showing EMGs and force output, calculation of fatigue half time, and avg EMG integral early and late in the fatigue trace.
5. Same for non-dominant arm.
6. Typical trace showing measurement of reflex time between Achilles tendon tap and gastrocnemius EMG onset. Show your calculations of nerve conduction velocity, average values and individual measurement data. Construct a bar graph with different experimental conditions.
7. Traces showing Tibialis anterior and gastrocnemius EMGs during each of four activities recorded.