# **Experiment HM-4: Stimulus Response, Work, Summation, and Tetanus in Human** Muscle

**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: If 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: Properties of a Finger Twitch**

Aim: To become familiar with SI-200 and SMT-100 and to record a finger twitch with and without a weight attached to the finger.

# Procedure

- 1. Instruct the subject to relax and place the hand that is used for the experiment on the bench, with its palm up.
- 2. Click the Stimulator Preferences icon on the LabScribe toolbar (<u>Figure HM-4-L1</u>) to open the stimulator control panel (<u>Figure HM-4-L2</u>) on the Main window.



Figure HM-4-L1: The LabScribe toolbar.



Figure HM-4-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, the pulse width (W) to 5 ms, the frequency (F) to 1 Hz; and, the number of pulses (#pulses) to 15. 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.

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- 4. Use the Amplitude knob of the SI-200 or change the amplitude in the software to set the stimulus current to the level determined in the Setup section of this lab.
- 5. Type the < Subject's Name> in the Mark box that is to the right of the Mark button. Click the Record button on the LabScribe Main window. Press the Enter key on the keyboard to mark the recording. Continue to record for 15 to 20 seconds. Click the Stop button.
- 6. 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.
- 7. Leave all the stimulus parameters at the same settings.

# Data Analysis

- 1. Scroll through the recording of the finger twitches (Figure HM-4-L3). Notice each finger twitch has two phases, a quick contraction phase followed by a slow relaxation phase. Since the duration of the stimulus pulses are short and their frequency is low, the muscles of the finger have the opportunity to relax between twitches as indicated by the return of the twitch amplitude to the same baseline between twitches.
- 2. Use the Display Time icons to adjust the Display Time of the Main window to show at least three complete twitches on the Main window. Three adjacent twitches can also be selected by:
  - Placing the cursors on either side of a group of three complete twitches; and
  - Clicking the Zoom between Cursors button on the LabScribe toolbar to expand the three twitches to the width of the Main window.
- 3. Click on the Analysis window icon in the LabScribe toolbar (<u>Figure HM-4-L1</u>) or select Analysis from the Windows menu to transfer the data displayed in the Main window to the Analysis window.



Figure HM-4-L3: Finger twitches recorded with a SMT-100, without a weight attached to the finger, seen on the upper channel. The signal of the IWX/214 used to trigger the SI-200 high voltage stimulus isolator is seen on the lower channel at a frequency of 1Hz.

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- 4. Look at the Function Table that is above the uppermost channel displayed in the Analysis window. The mathematical functions, V2-V1 and T2-T1 should appear in this table. Values for V2-V1 and T2-T1 on each channel are seen in the table across the top margin of each channel.
- 5. Once the cursors are placed in the correct positions for determining the amplitude and times of each finger twitch, the values of the parameters in the Function Table can be recorded in the online notebook of LabScribe by typing their names and values directly into the Journal, or on a separate 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 from the recording to the Journal. To use these functions:
  - Place the cursors at the locations used to measure the amplitude and times of each finger twitch.
  - Transfer the names of the mathematical functions used to determine the amplitude and times to the Journal using the Add Title to Journal function in the Finger Twitch Channel pull-down menu.
- 7. Transfer the values for the amplitude and period to the Journal using the Add Ch. Data to Journal function in the Finger Twitch Channel pull-down menu.
- 8. On the Finger Twitch channel, use the mouse to click on and drag the cursors to specific points on the recording to measure the following parameters:
  - Twitch Amplitude. To measure the amplitude of the twitch, place one cursor on the baseline at the point just before the twitch starts to develop, and the second cursor on the peak of the twitch. On the Finger Twitch channel, the value for V2-V1 is the amplitude of that twitch (Figure HM-4-L4).



Figure HM-4-L4: Finger twitches stimulated by maximal current at a frequency of 1 Hz.

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- Contraction Time, which is the time it takes the amplitude of the twitch to rise to its peak. To measure the contraction time of the twitch, keep the cursors in the same positions used to measure the twitch amplitude. On the Finger Twitch channel, the value for T2-T1 is the contraction time of that twitch.
- Relaxation Time, which is the time it takes the amplitude of the twitch to return to baseline. To measure the relaxation time of the twitch, place one cursor on the peak of the twitch, and the second cursor at the point where the amplitude returns to the baseline. On the Finger Twitch channel, the value for T2-T1 is the relaxation time of that twitch.

#### Question

How does the contraction time of a typical finger twitch compare to the relaxation time?

# **Exercise 2: The Effect of Weight on Finger Twitches**

Aim: To determine the amount of work performed by the finger with different weights, or loads, attached to the finger.

# Procedure

- 1. Check the stimulus parameters set in the Stimulator control panel on the LabScribe Main window. These settings should be the same as the ones used in Exercise 1.
- 2. Use the Amplitude knob of the SI-200 to set the stimulus current to the maximal level as used in Exercise 1.
- 3. Attach a thread to the last joint of the finger being used in the experiment. The thread should be long enough to go across the ring, middle, and index fingers of the same hand, and also allow the weight to hang over the edge of the table. Attach a weight to the other end of the thread. The weight could be a pen, a pencil, or washers.
- 4. Have the subject move his or her hand to the edge of the table, so the palm is up and the thread with the weight is hanging along the side of the table.
- 5. Type the weight of the object, that is on the thread, in the Mark box that is to the right of the Mark button. Click the Record button on the LabScribe Main window. Press the Enter key on the keyboard to mark the recording. Continue to record for 15 seconds. Click the Stop button.
- 6. Add another 10 gram weight to end of the thread and repeat Step 5.
- 7. Continue to add weight to the thread in 10 gram increments. Repeat Step 5 each time you add weight to the thread until the amplitude of the finger twitch is undetectable.
- 8. Select Save in the File menu on the LabScribe window.
- 9. Remove the weights and thread from the subject's finger.

# Data Analysis

1. Scroll to the beginning of the recording for this exercise. Locate the section of data in which finger twitches appeared when the stimulus threshold was reached. Click AutoScale to maximize the size of the twitch on the window.

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- 2. Use the Display Time icons to adjust the Display Time of the Main window to show a segment with four or five twitches on the Main window. The twitches can also be selected by:
  - Placing the cursors on either side of the selected twitches; and
  - Clicking the Zoom between Cursors button on the LabScribe toolbar to expand the segment of twitches to the width of the Main window.
- 3. Click on the Analysis window icon in the LabScribe toolbar (<u>Figure HM-4-L1</u>) or select Analysis from the Windows menu to transfer the data displayed in the Main window to the Analysis window.
- 4. Use the same techniques used in Exercise 1 to measure and record the amplitudes (V2-V1) of three twitches recorded at each weight.
- 5. For each weight, determine the average amplitude of three finger twitches.
- 6. Use the average twitch amplitude at each weight to calculate the work performed on that weight. For this exercise, use the following equation:

Work = Weight (g) x Average Amplitude of Twitch (mv) with that Weight

7. On a piece of graph paper or in a graphing program, plot the work performed at each weight as a function of the weight attached to the finger (Figure HM-4-L5).



*Figure HM-4-L5: The relationship between work performed at each weight and the weight moved by a finger twitch* 

# Questions

- 1. How do the amplitudes of the finger twitches with different weights compare to each other?
- 2. Why did the amount of work decrease when heavier weights were used?

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3. Is there any correlation between the weight moved and the contraction or relaxation times of the twitches?

#### **Exercise 3: Stimulus-Response**

Aim: To examine the effect of stimulus current on the amplitude of finger movement.

#### Procedure

- 1. Remind the subject to relax and place the hand that is used for the experiment on the bench, with its palm up.
- 2. Check the stimulus parameters set in the stimulator control panel on the LabScribe Main window. The duration of the stimulus pulses should be 5 milliseconds (ms), their frequency should be 1 Hz, and the number of pulses should be 0 (zero). Setting the number of pulses to zero makes the SI-200 stimulus isolator fire continuously. If the values of these parameters were changed, click the Apply button on the Stimulator control panel to effect the change
- 3. Make sure the Amplitude knob on the front of the SI-200 is set to zero. Type Zero in the Mark box that is to the right of the Mark button. Click the Record button on the LabScribe Main window. Press the Enter key on the keyboard to mark the recording.
- 4. While recording, type 0.5 mA in the Mark box that is to the right of the Mark button. Increase the current output of the SI-200 by 0.5mA by rotating the Amplitude knob half a turn. Press the Enter key on the keyboard to mark the recording. Record at this stimulus current for ten to fifteen seconds.
- 5. Repeat Step 4, in increments of 0.5 mA, until the stimulus current reaches the maximal level. Click the Stop button.
- 6. Open the File menu and select Save to save the data file.

# Data Analysis

- 1. Scroll to the beginning of the data for this exercise. Locate the segment of the finger twitches that occurred at threshold stimulus current. Click AutoScale to maximize the size of the twitch on the window. For any stimulus currents that did not cause finger movement, report the amplitude of the finger twitch as zero (0).
- 2. Use the Display Time icons to adjust the Display Time of the Main window to show a segment with four or five twitches on the Main window. The twitches can also be selected by:
  - Placing the cursors on either side of the selected twitches; and
  - Clicking the Zoom between Cursors button on the LabScribe toolbar to expand the segment of twitches to the width of the Main window.
- 3. Click on the Analysis window icon in the LabScribe toolbar or select Analysis from the Windows menu to transfer the data displayed in the Main window to the Analysis window.
- 4. Use the same techniques used in Exercise 1 to measure and record the amplitudes (V2-V1) of three twitches recorded for each stimulus current that causes a response.

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- 5. For each stimulus current, determine the average amplitude of three finger twitches.
- 6. On a piece of graph paper or in a graphing program, plot the average amplitude of the finger twitch at each stimulus current as a function of the stimulus current (Figure HM-4-L6).



Figure HM-4-L6: Average finger twitch amplitude as a function of the stimulus current

#### Questions

- 1. At which stimulus current did the finger first show a twitch? Why didn't a finger twitch occur at a lower stimulus current?
- 2. How does the finger twitch amplitude increase when the stimulus current is increased?
- 3. Is there a stimulus current at which the amplitude of the finger twitch is maximized?
- 4. Above a certain stimulus current, the amplitude of the finger twitch no longer increases. Why does this happen?

#### **Exercise 4: Summation and Tetanus**

Aim: To monitor the contraction and relaxation of the finger twitch in relation to the stimulus frequency.

#### Procedure

- 1. Remind the subject to relax and place the hand that is used for the experiment on the bench, with its palm up.
- 2. Check the stimulus parameters set in the stimulator control panel on the LabScribe Main window and the current output on the amplitude knob of the SI-200. The duration of the

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stimulus pulses should be 5 milliseconds (ms), their frequency should be 1 Hz, and the number of pulses should be set to 15.

- 3. During the course of this exercise, the stimulus frequency and the number of stimulus pulses will be changed to demonstrate summation and tetanus. After any stimulus parameter is changed, click the Apply button on the Stimulator control panel to effect the change.
- 4. Use the Amplitude knob of the SI-200 to set the stimulus current to the maximal level as used in Exercise 1.
- 5. Type 1 Hz in the Mark box to the right of the Mark button. Click the Record button on the LabScribe Main window. Press the Enter key on the keyboard. Click Stop when the stimulus pulse stop firing. There should be fifteen twitches on the recording.
- 6. Change the stimulus frequency to 2 Hz. Go to the Stimulator control panel on the LabScribe Main window, and change the value in the stimulus frequency box, labeled F(Hz), from 1 to 2. Click the up arrow in the box to increase the frequency. The frequency can also be changed by typing the new value into box. Click the Apply button to put any frequency change into effect.
- 7. Repeat Step 5 with the stimulus frequency set to 2. Type 2 in the Mark box that is to the right of the Mark button.
- 8. Repeat Step 5 for stimulus frequencies of 3, 4, 5, 10, 15, and 20 Hz. At higher frequencies, you will also need to increase the number of pulses sent to the subject's finger to see the effects of summation and tetanus. For example, it may take a few seconds to see the complete effect of tetanus at 20 Hz. So, the total number of pulses may need to be set to 40 or higher to see the complete effect (Figure HM-4-L7). Remember to click the Apply button to effect changes.
- 9. When performing the experiment at the highest frequency keep recording after complete tetanus is reached. Remove the cable from the stimulator of the IWX214 to stop the SI-200 stimulus isolator from firing. Continue to record as the tension in the muscles of the finger begins to relax.
- 10. When the muscles in the finger are relaxed, click Stop to halt the recording.
- 11. Select Save in the File menu.

# Data Analysis

- 1. Scroll to the beginning of the data for this exercise. Locate the segment of the finger twitches that occurred at a frequency of 1 Hz. Click AutoScale to maximize the size of the twitches on the window.
- 2. Use the Display Time icons to adjust the Display Time of the Main window to show the first four or five twitches at that frequency on the Main window. The twitches can also be selected by:
  - Placing the cursors on either side of the selected twitches; and
    - Clicking the Zoom between Cursors button on the LabScribe toolbar to expand the segment of twitches to the width of the Main window.

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*Figure HM-4-L7: Amplitudes of finger twitches at 10, 15, and 20 Hz from left to right. Recordings from 10 and 15 Hz show incomplete tetanus. Complete tetanus occurs at 20 Hz.* 

- 3. Click on the Analysis window icon in the LabScribe toolbar or select Analysis from the Windows menu to transfer the data displayed in the Main window to the Analysis window.
- 4. Use the same techniques used in Exercise 1 to measure and record the amplitudes (V2-V1) of two adjacent twitches recorded at a stimulus frequency of 1 Hz.
- 5. Move to the segment of data recorded at the next stimulus frequency. If the twitches at this frequency are all about the same amplitude, measure and record the amplitudes of two adjacent twitches.
- 6. Repeat Step 5, until the recording of the finger twitches show summation. Summation occurs when the time between twitches is not long enough to allow the muscle to completely relax to its baseline level of tension. Another twitch or contraction, following in quick succession to the first, will add on the first twitch at the current level of tension for the first twitch. The third twitch will add on to the current tension of the second twitch, and so on. Since the twitches were maximal, this summation is a form known as mechanical summation, which can be seen in Figure HM-4-L8.

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*Figure HM-4-L8: Summation of finger twitches occurring at a stimulus frequency of 5Hz. Cursors are place on the first twitch and the tallest twitch.* 

- 7. At stimulus frequencies where summation occurred, measure and record the amplitude of the first twitch in the series and the amplitude of the tallest twitch in the series (Figure HM-4-L8).
- If a level of relatively constant tension occurs during contractions at high frequency, the phenomenon is called tetanus. If small relaxations are still detectable along the level of constant tension, a state of incomplete tetanus exists (5 Hz in Figure HM-4-L8, 10 and 15 Hz in Figure HM-4-L7). If there are no detectable relaxations along the region of constant tension, a state of complete tetanus exists (20 Hz in Figure HM-4-L7).

# Questions

- 1. At which frequency did summation first appear? At which frequencies does incomplete tetanus occur? At which frequency did complete tetanus first occur?
- 2. How much greater than the amplitude of a single twitch is the amplitude of the tallest twitch during summation or incomplete tetanus?
- 3. How much greater than the amplitude of a single twitch is the amplitude of complete tetanus?
- 4. After the stimulator is turned off, the relaxation time after tetanus is much longer than relaxation time after a single twitch. Why?
- 5. What is the name for the decrease in the level of constant tension that occurs during tetanus?

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