Experiment HN-7: Median Nerve Conduction Velocity

This lab written by: Nathan Heller, Undergraduate research assistant; Kathryn Forti, Undergraduate research assistant; Keith K. Schillo, PhD, Associate Professor, Biology Department, SUNY Oneonta,Oneonta, NY

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Equipment Required

PC or Mac Computer

IXTA , USB cable, Power supply for IXTA

iWire-B3G cable and three EMG lead wires

Disposable snap electrodes

HV stimulator lead wires and round stimulating electrodes

Note – You must connect the iWire-B3G cable to the IXTA prior to turning it on.

The Equipment Setup

1. Attach the connector on the end of the iWire-B3G cable to the iWire 1 input of the front of the IXTA.
2. The subject should remove all jewelry from their right hand and wrist.
3. Obtain seven disposable electrodes (3 recording and 4 stimulating).
4. Locate and mark the sites listed as shown; place electrodes over these locations and attach the colored recording leads. *Note: It may be necessary to trim the adhesive of the electrode to prevent overlapping.*
5. The recording electrodes go on the thumb so that the red electrode is on the fleshy part and the base of the metacarpal joint and the black is just below it. The green electrode will be on the wrist. See Figure HN-7-S1.
6. Locate and mark the following sites, place electrodes over these locations and attach the colored stimulating leads which are attached to the red and black stimulator channels.
    - Short distance (80 mm):
        - At the center of the wrist crease 50 mm from the Recording '-' (Black) lead and then 30 mm superior to the center of the wrist crease along the midline of the forearm: Stimulating '-' (Black) lead.
        - On the midline of forearm, proximal to the Stimulating '-' (Black) lead: Stimulating '+' (Red) lead.
    - Long distance:
        - Just below the elbow crease: Stimulating '-' (Black) lead slightly to the radius side.
        - On the medial side of the of the Stimulating '-' (Black) lead: Stimulating '+' (Red) lead.

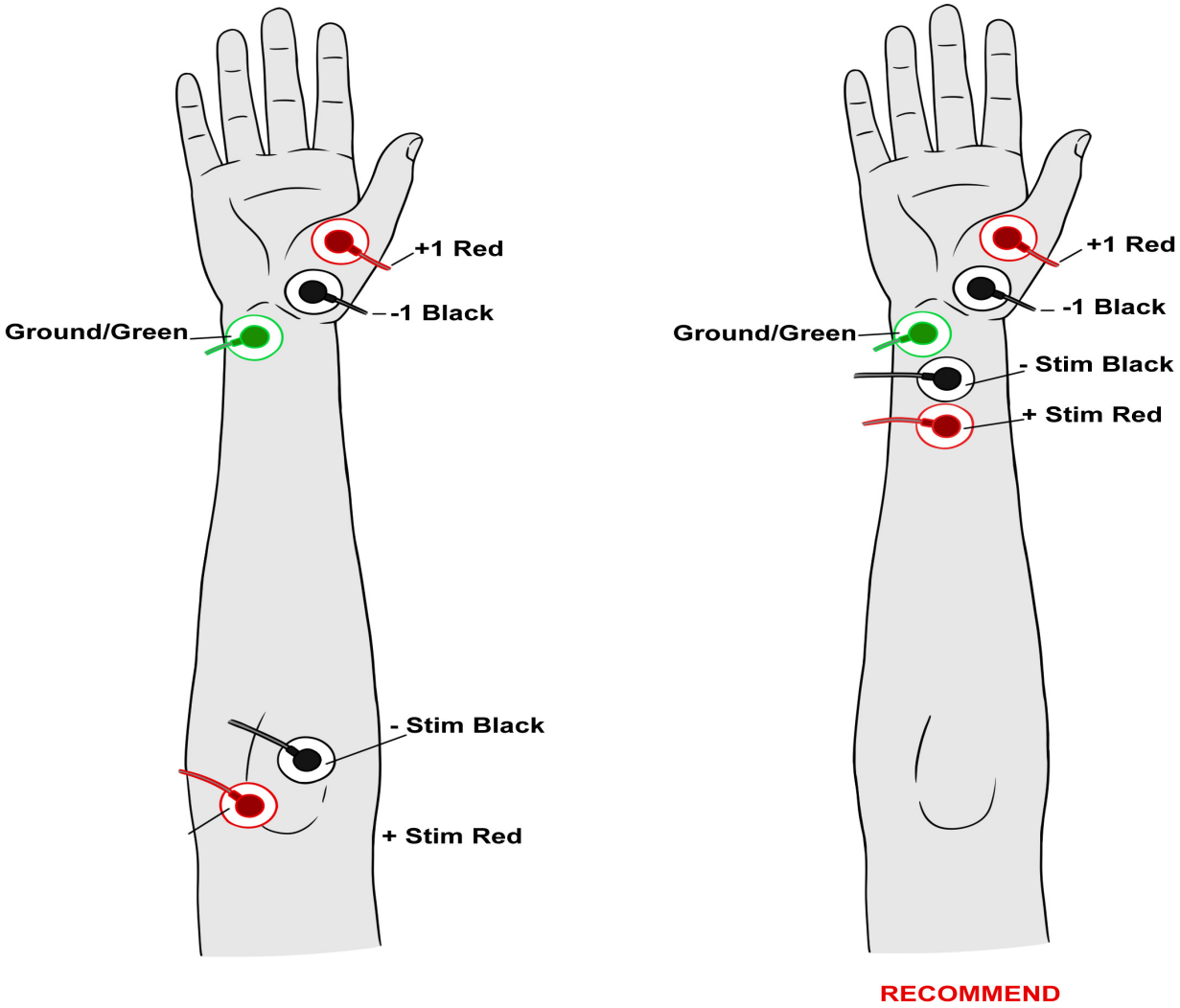

Figure HN-7-S1: The red and black recording leads are placed on the thumb, the green ground lead is placed on the wrist, and the red and black stimulating leads are placed just above the ground. The long distance placement is shown on the left.

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Table HN-7-S1. Summary of Electrode and Lead Placement

Electrode	Lead	Placement
Ground - From iWire-B3G	Green	Just above the wrist crease on the ulnar side.
Recording '+' From iWire-B3G	Red	Placed just distal to the first metacarpophalangeal (MCP) joint.
Recording '–' From iWire-B3G	Black	Placed along the pollicis brevis muscle, the midpoint between the first MCP joint and the wrist crease.
Short Stimulating '–' From iWorx TA box	Black	80mm from recording '–' electrode. Measure 50mm from the recording- electrode toward the center of the wrist crease. Then measure 30mm superior to this point along the midline of the arm.
Short Stimulating '+' From iWorx TA box	Red	Placed just superior to the short stimulating '–' electrode, along the same axis.
Long Stimulating '–' From iWorx TA box	Black	Placed at a point just below the elbow crease
Long Stimulating '+' From iWorx TA box	Red	Placed just superior to the long stimulating '–' electrode.

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IXTA Isolated Stimulator

The IXTA has a high voltage stimulus isolator designed to deliver constant current to the nerve or muscle being studied. In situations where the resistance (R) along the path of the current increases, the voltage (V) increases to maintain the current (I in V = IR, Ohm's Law). The ability of the IXTA to adjust the voltage to deliver the required current is known as voltage compliance. The upper limit of this compliance by the IXTA is set at 100 Volts.

Constant current devices differ from constant voltage devices when presented with an increase in resistance, like the dehydration of the conductive gel under the electrodes. As pointed out earlier, a constant current stimulator is voltage compliant. In constant voltage stimulators, the current delivered to the tissue decreases as the resistance increases because the power supply of the constant voltage device is not designed to deliver additional current.

Although the IXTA can generate up to 100 Volts, the current delivered by the unit is limited to a maximum of 20 milliamperes, for a maximum duration of 10 milliseconds per pulse, and a maximum frequency of 50 pulses per second (Hz). At these levels, the maximum amount of power delivered by the IXTA will not cause injury or tissue damage.

The current is selected using the Stimulator Control Panel. The HV Stimulator can deliver a maximum output of twenty milliamperes

The duration, frequency, and number of stimulus pulses generated by the stimulator are also controlled by making changes to the values in the Stimulator Control Panel. The initial values of the pulses generated by the IXTA are programmed by the same settings file that configured the recording software. For example, if a pulse from the IXTA is programmed for a duration of 1 millisecond and a frequency of 1 Hz, the stimulator will generate a stimulus pulse with the same duration and frequency.

IXTA Stimulator Setup

1. Place the IXTA on the bench near the subject.

Warning: Before connecting the IXTA stimulting electrodes to the subject, check the Stimulator Control Panel to make sure the amplitude value is set to zero (0).

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

2. Instruct the subject to remove all jewelry before beginning the experiment.

Figure HN-7-S2: The IXTA stimulating electrodes.

Figure HN-7-S3: The front panel of the IXTA with the stimulating electrodes connected correctly.

Warning: Make sure the Amplitude is set to zero.

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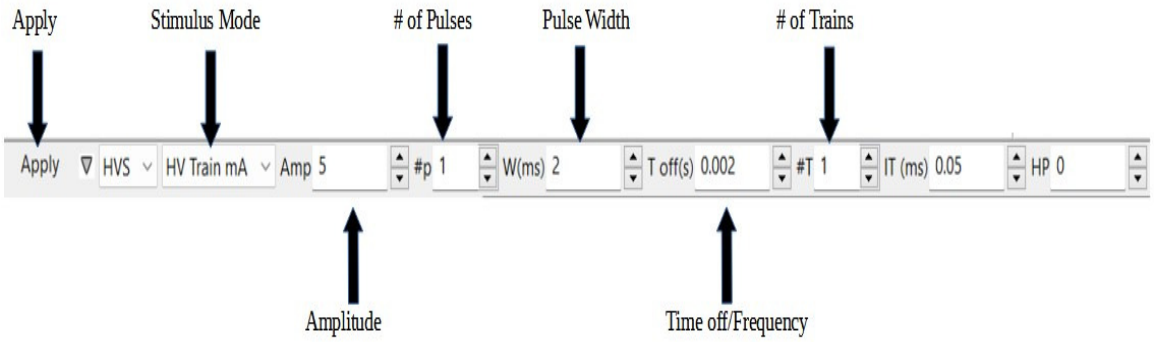
3. Connect the color-coded stimulator lead wires to the High Voltage Current Stimulator. Make sure you push the safety connector of each lead wire into the appropriate socket as far as possible.
4. Connect the 2 stimulating electrodes as stated above.
5. Start with the stimulator programmed in this manner:
    - On the Stimulator Control Panel that appears 2 lines above the upper recording panel.
        - Amps will be the only variable changed (between 3-20 amps). Begin with 3 amps and increase until a consistent response is achieved (7 amps has yielded consistent results).
        - Make sure to hit ***APPLY*** after choosing the settings.



Stimulator Control Panel

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WARNING - The Stimulator should only be used for the method of application for which the Stimulator is intended as shown in the directions below. If the subject feels a painful stimuli, then the electrodes are in the wrong place.

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 as shown in the Setup. Click "APPLY" to make any changes.

Exercise 1: Stimulus Strength and Muscle Response.

Aim: To determine the effect of stimulus strength on the response of the innervated muscle.

Approximate Time: 30 minutes

Procedure

1. Ask the subject to place their right hand on the bench with the palm up. Tell the subject to relax.

Note: *The subject should make sure to relax his/her forearm and hand completely. Any tensing of the muscles would interfere with the recording.*

2. Set the Amplitude to zero or in the Stimulator Control Panel for the IXTA (click "Apply" to make the change).
3. Click Record button on the LabScribe Main window. LabScribe will record a single sweep with a display time of 50 milliseconds. Since the output amplitude is set to zero, there should be no response from the abductor muscle.
4. Increase the output amplitude to 0.5 and click Apply. Click the Record button again and record another single sweep. Click the AutoScale button for the Muscle channel to improve the display of the muscle's response.
5. Continue to increase the output amplitude by 0.5 in the Stimulator Control Panel for the IXTA (click "Apply").
    - Click the Record button to record a single sweep after each increase in the stimulus amplitude.
    - Continue to increase the output amplitude and record the response until the muscle impulse is shown clearly on the graph.
6. Perform the following steps for both the short and long stimulation sites:
    - To administer the stimulus, press 'Record' in the upper right hand corner of the computer screen.

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- Repeat this procedure until a response is generated for each distance and measure the amount of time between the start of the stimulus and the peak voltage of the CAP.

7. Select Save As in the File menu, type a name for the file. Click the Save button to save the file (as an *.iwd file).

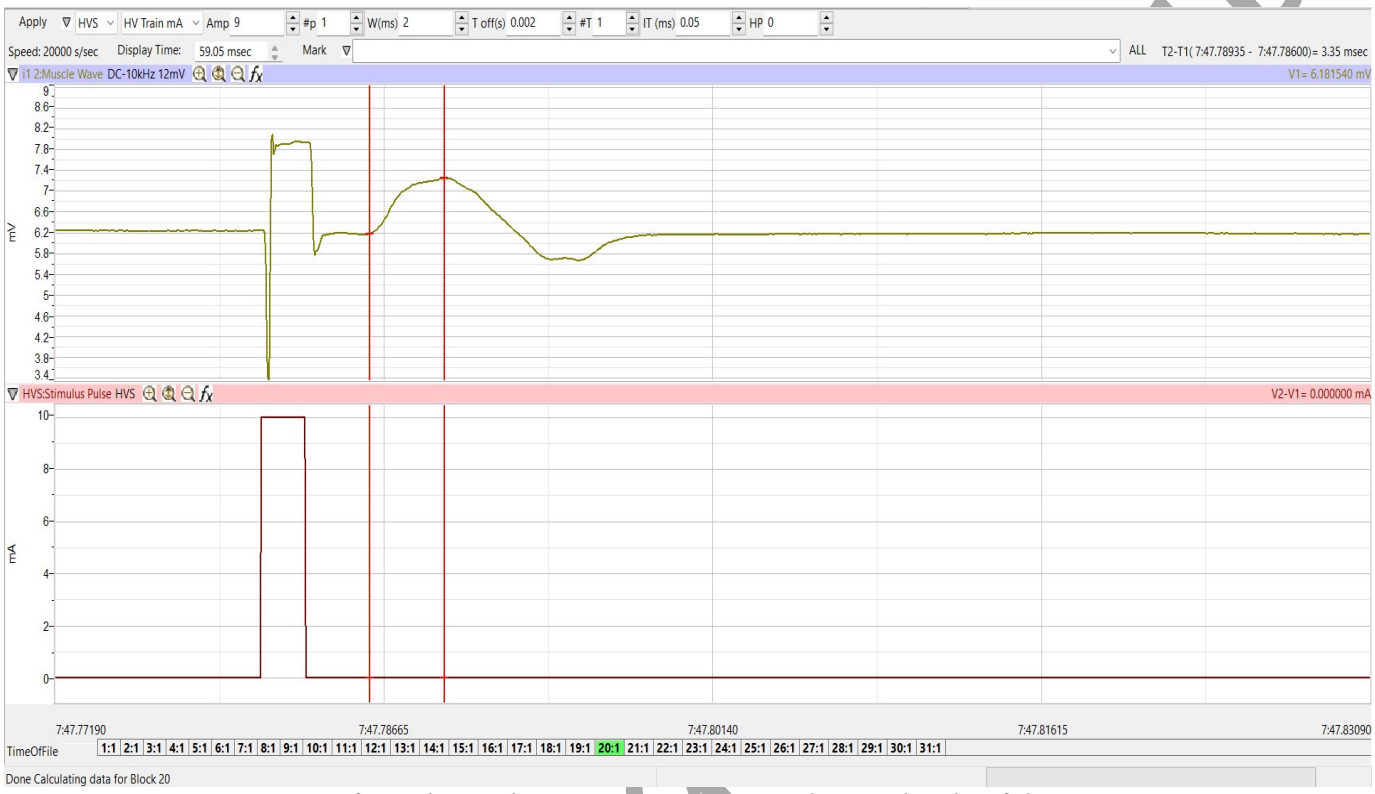

Figure HN-7-L1: A CAP from the median nerve; measuring the amplitude of the response.

Data Analysis

1. Click the Analysis icon in the LabScribe toolbar to view all the recorded sweeps.
2. Use the Windows control-click function to select the sweeps of interest from the Sweeps list on the bottom of the Analysis window. For comparison, superimpose the selected sweeps on each other by clicking the sweeps of interest. See the image below.
3. Select V2-V1 and T2-T1 from the Add Functions list if they are not already listed. Data analysis can also be performed on the main window.

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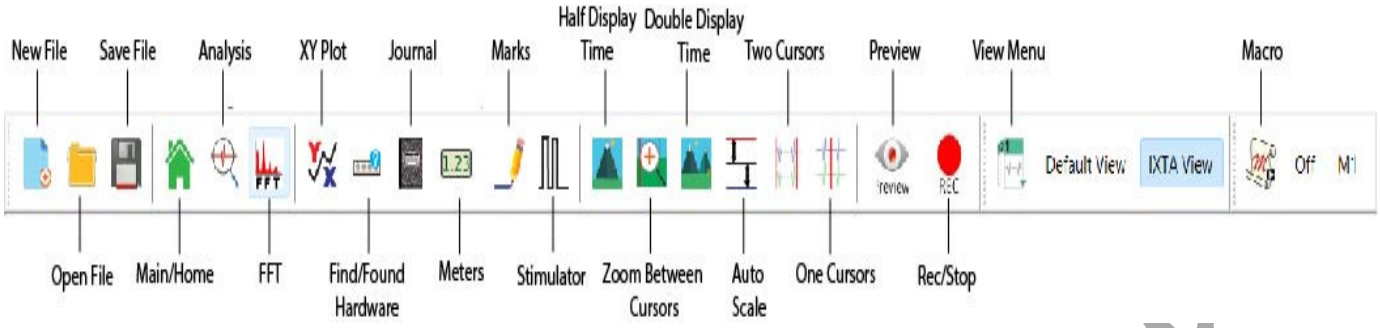

Figure HN-7-L2: The LabScribe toolbar.

4. Go to the Sweep List at the top of the Analysis Window and select the sweep that has one of the largest muscle responses for the short distance. Selecting a sweep from this menu will display the measured values of that sweep in the table at the top of the Analysis window.
5. Click the 2-Cursor icon in the LabScribe toolbar. Drag one cursor to the left of the stimulus artifact and the second cursor to the peak of the muscle response. The value for V2-V1 in the table at the top of the Analysis window is the amplitude of the muscle response.

Figure HN-7-L3: Comparison of muscle responses to different stimulus amplitudes. Sweeps are superimposed in the Analysis window. Values for sweep #21 are shown.

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 muscle response.
    - Transfer the names of the mathematical functions used to determine the muscle response to the Journal using the Add Title to Journal function in the Muscle Channel pull-down menu.
    - Transfer the values for the change in muscle response to the Journal using the Add Ch. Data to Journal function in the muscle channel pull-down menu.
7. Record the stimulus amplitude used to generate the nerve response along with the other data for the sweep in the Journal.
8. Find the amplitudes (V2-V1) for the other selected sweeps in the same manner. Record these values and the values of the stimulus amplitudes used to generate these responses in the Journal.
9. Graph the amplitude of the muscle response as a function of the stimulus amplitude.
10. Place one cursor on the start on the stimulus and one cursor on the peak of the response and perform these calculations:
    - Calculate the average amplitude of the three responses for each distance.
    - Calculate the difference between the long (B) and short (A) distances on the arm (mm) = $\mathbf{D_B - D_A = \Delta D}$
    - Calculate the difference in the average conduction times between the two distances (ms)
    $$\mathbf{T_B - T_A = \Delta T}$$
    - Calculate the Nerve Conduction Velocity (mm/ms or m/s)
    $$\mathbf{\Delta D / \Delta T}$$
11. Repeat the procedure three times and calculate the nerve conduction velocity for each of these replicates. Calculate the average of these three measurements.
12. Table 1 shows nerve conduction velocities in the median nerves of eight subjects who underwent the procedure outlined in this laboratory protocol.
13. According to values reported in the scientific literature conduction velocity of the median nerve ranges between 40 and 78 $m \cdot s^{-1}$. All but two of the test subjects had velocities that fell within this range.
    - It is noteworthy that the three lowest conduction velocities were from the three oldest subjects, one of whom was previously diagnosed with a mild case of Carpal Tunnel Syndrome. According to previous studies the mean conduction velocity of the median nerve is 57 $m \cdot s^{-1}$. The mean conduction velocity measured with this protocol is 51.4225 $m \cdot s^{-1}$.

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Questions

1. Does the amplitude of the action potential in each fiber in the median nerve increase or do the numbers of nerve fibers in the nerve that respond increase with increased stimulus strength?
2. Does the amplitude of the muscle response increase because the response of each muscle fiber increases or the number of muscle fibers responding increases?
3. Which stimulus amplitudes are subthreshold? Which ones are suprathreshold or submaximal? Which ones are supramaximal?
4. How do conduction velocities differ by:
    - age?
    - gender?
    - Handedness?

Table HN-7-L1. Median Nerve Conduction Velocity in Eight Subjects.

Subject	Gender	Age	Conduction Velocity ($m \cdot s^{-1}$)
1	F	20	67.72
2	M	44	37.59
3	F	21	62.34
4	F	19	51.19
5	F	19	52.8
6	F	63	44.9
7	M	21	58.76
8	M	61	36.08
Mean			51.42
Standard deviation			11.40

Experimental Design

Refer students to the following References and ask them to design their own hypothesis relating to nerve and muscle responses.

This can include:

- Increasing stimulus amplitude
- Reversing polarity of the stimulus
- Looking at other muscle/nerve combinations

Have them perform their experiment and compare results with other groups.

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References

Buschbacher RM and Prahlow ND. 2006. Manual of Nerve Conduction Studies. 2nd ed. New York: Demos Medical Publishing; 2006. p. 10-17.

Palmieri, R. M., Ingersoll, C. D., & Hoffman, M. A. 2004. The Hoffmann Reflex: Methodologic Considerations and Applications for use in Sports MEdicine and Athletic Training Research. Journal of Athletic Training, 39(3), 268-277.

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