

Experiment HC-3: Pulse Wave Velocity

Equipment Required

PC or Mac Computer

IXTA, USB cable, IXTA power supply

ROAM ECG electrodes

PPG-320 Pulse plethysmograph

Alcohol swabs

Disposable ECG electrodes

Surgical tape

FT-220 Hand dynamometer

ECG Cable and Pulse Transducer Setup

1. Locate the ROAM and the PPG-320 pulse plethysmograph. Plug the connector to the PPG-320 into the PT port.
2. Turn on the ROAM. The LCD screen will prompt you when the ROAM is recognized and ready to use.
3. Place the ROAM ECG electrodes as shown in the image below.



Figure HC-3-S1: The PPG-320 pulse sensor and the TA with the ROAM in the dock.

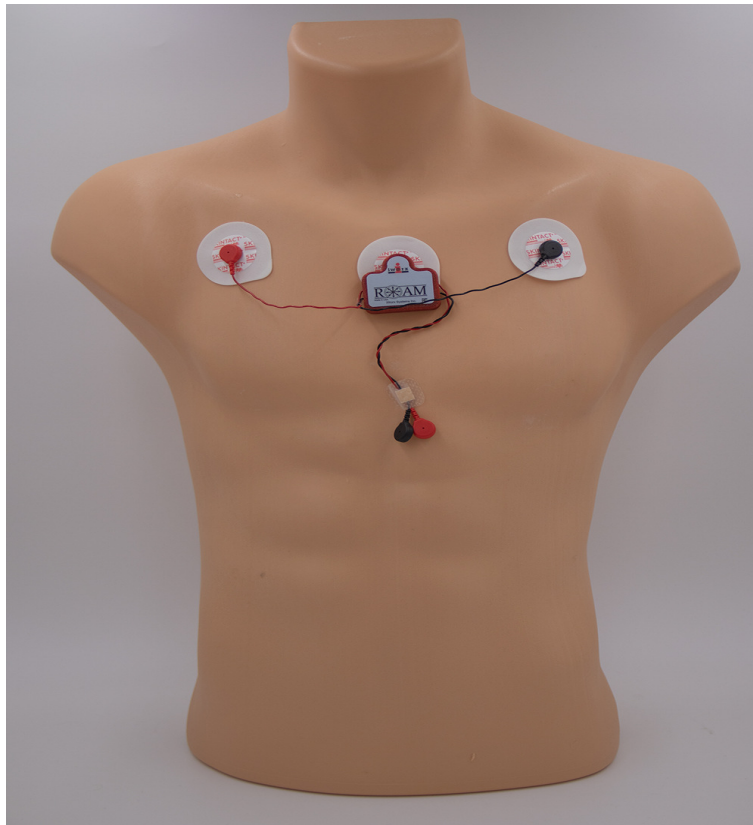


Figure HC-3-S2: Placement of the ROAM ECG electrodes.

10. Palpate the inside of the left elbow to locate the point where the brachial artery gives the strongest pulse. Place the plethysmograph on this point and hold it firmly in place with a long Velcro strap or a piece of surgical tape.
11. Instruct the subject to sit quietly with their hands in their lap.

Experiment HC-3: Pulse Wave Velocity

Exercise 1: The Pulse Wave Velocity at Rest

Aim: To measure the pulse wave velocity in a resting individual.

Approximate Time:

Procedure

1. Click on the Record button. The signal should begin scrolling across the screen.

***Note:** If the user clicks the Record button and there is no communication between the iWorx unit and computer, an error window will appear in the center of the Main window. Make sure the iWorx unit is turned on and connected to the USB port of the computer. Click OK and select the Find Hardware function from the LabScribe Tools menu.*

2. Click on the AutoScale button at the upper margin of the ECG and Pulse channels. Your recording should look like the figure shown.
 - If the signal on either the ECG or the Pulse channel is upside down when compared to trace, click on the downward arrow to the left of the channel title and select the Invert function. The trace should now look similar to the one in the figure
 - If the pulse signal is small or noisy, adjust the tension on the strap holding the pulse plethysmograph to the finger or try the thumb.
3. When you have a suitable trace, type **Resting/Pulse at Elbow** in the Mark box. Click the mark button to attach the comment to the data. Record for a minute or two.
4. Click Stop to halt recording.
5. Remove the pulse plethysmograph from the elbow and place it on the volar surface (where the fingerprints are located) of the distal segment of the left middle finger or thumb. Wrap the Velcro strap around the end of the finger to attach the unit firmly in place. Measure the distance between the position of the pulse plethysmograph on the elbow and its position on the finger in millimeters.
6. Click on the Record button and begin recording the subject's ECG and the pulse wave from the middle finger.
7. When you have a suitable trace, type **Pulse at Finger** in the Mark box. Click the mark button to attach the comment to the data. Record for a minute or two.
8. Click Stop to halt recording. Then, select Save As in the File menu, type a name for the file. Click on the Save button to save the data file.



Figure HC-3-L1: An ECG and pulse recording displayed on the Main window.

Data Analysis

1. Scroll through the recording and find the data recorded when the pulse plethysmograph was on the brachial artery. Select a section of data with ten exemplary ECG/pulse cycles in succession.
2. Use the Display Time icons to adjust the Display Time of the Main window to show at least five to ten complete ECG/Pulse cycles on the Main window.
3. Data can be collected from the Main window or the Analysis window. If you choose to use the Analysis window, click on the Analysis window icon in the toolbar.
4. The mathematical function, $T2-T1$, should appear on screen. Value for $T2-T1$ will show on the top right of the screen.

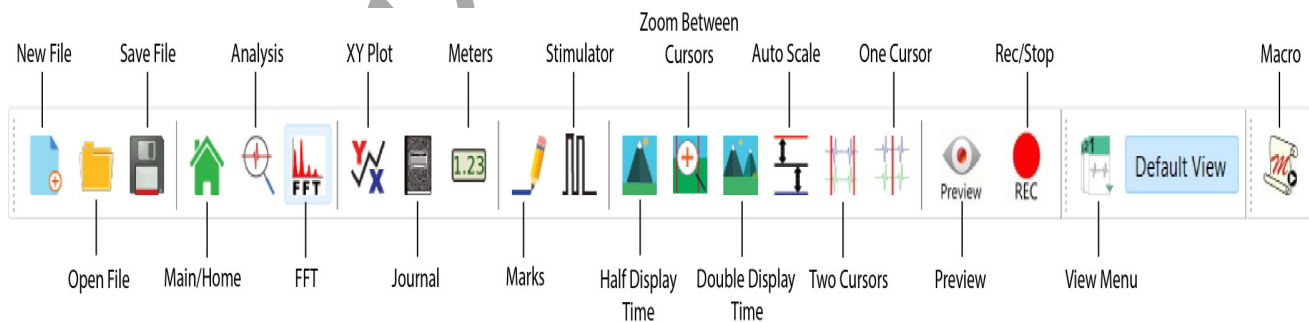


Figure HC-3-L2: The LabScribe toolbar.

5. Once the cursors are placed in the correct positions for determining the time intervals on each ECG/Pulse cycle, the values of the time intervals can be recorded in the on-line notebook of LabScribe by typing their names and values directly into the Journal.
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 period of the ECG/Pulse cycle.
 - Transfer the names of the mathematical functions used to determine the time interval to the Journal using the Add Title to Journal function in the ECG Channel pull-down menu.
 - Transfer the value to the Journal using the Add Ch. Data to Journal function in the ECG Channel pull-down menu.

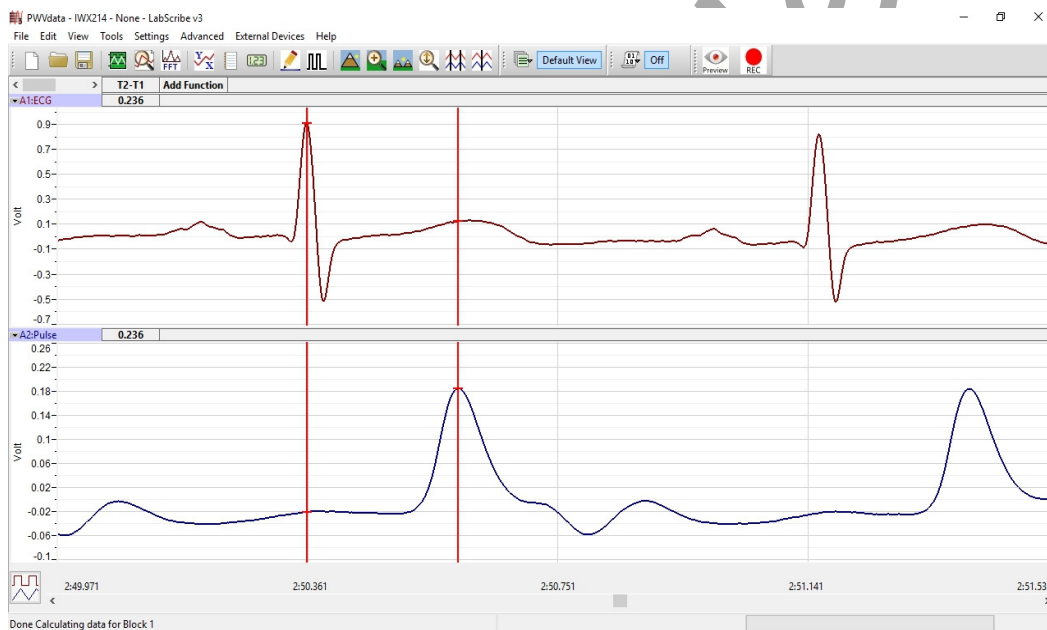


Figure HC-3-L3: An ECG and pulse wave recording shown in the Analysis window. The pulse plethysmograph was placed on the tip of the left middle finger. The time difference (T_2-T_1) between the peaks of the R and pulse waves is 230 msec.

7. Measure the R-Pulse interval, which is the time interval between the peak of the R wave and the peak of the pulse wave that follows the R wave. Use the mouse to click on and drag a cursor on the peak of an R wave, and the other cursor to the peak of the pulse wave to its right. The value for T_2-T_1 is the R-Pulse interval. Record this value in the Journal.
8. Measure this interval for two additional ECG/Pulse cycles. Record these values in the Journal.
9. Calculate the mean R-Pulse interval when the pulse transducer was over the brachial artery. Type the mean into the Journal.

10. Go to the section of the recording made while the pulse transducer was on the distal segment of the middle finger of the left hand. Repeat Steps 2 through 9 for the data collected when the pulse transducer was on the subject's middle finger.

Calculation of Pulse Wave Velocity

1. Subtract the mean R-Pulse wave interval found at the elbow from the mean R-Pulse wave interval found at the elbow. This is the time it takes the pulse wave to move from the position of pulse transducer at the elbow to the position of pulse transducer on the tip of the middle finger. Express this time in milliseconds.
2. Divide the distance between the two positions of pulse transducer (as measured in millimeters in the Procedures section of this exercise) by the difference in the mean R-Pulse wave intervals determined in Step 1. The quotient is the pulse wave velocity of the artery between the elbow and the tip of the middle finger. Express the velocity in meters/second.
3. Record the subject's resting pulse wave velocity in the Journal and Table 1. Before putting the data for your subject on the table, list the names of all the subjects on the table in order of ascending age (youngest to oldest).

Exercise 2: Pulse Wave Velocity After Hand Exercise

Aim: To determine pulse wave velocity in the artery to the hand after exercise.

Procedure

1. Attach the pulse plethysmograph to the same location on the subject's left elbow used in Exercise 1.
2. The subject should grasp the FT-325 hand dynamometer in the palm of his or her left hand.

Note: *The hand dynamometer is not plugged into the recording unit; It is just being used to provide resistance against which the hand muscles can do work.*

3. Rhythmically squeeze the dynamometer bulb every two or three seconds for two minutes or until the muscles of the subject's forearm start to fatigue. While the subject is exercising the muscles of the forearm, type **Post-Exercise at Elbow** in the Mark box.
4. When the subject stops exercising, he or she should sit quietly. Click on the Record button and then click the mark button. As soon as a clean set of ECG/Pulse cycles are recorded, click Stop to halt the recording.
5. Quickly move the pulse transducer from the elbow to the left middle finger tip as it was done in Exercise 1. Type **Post-Exercise at Finger** in the Mark box.
6. Click on the Record button and then click the mark button to mark the recording. As soon as a clean set of ECG/Pulse cycles are recorded, click Stop.
7. Select Save in the File menu.

8. Measure the distance between the positions of the pulse plethysmograph on the left elbow and left middle finger.

Data Analysis and Calculation of Pulse Wave Velocity

1. Use the same techniques used in Exercise 1 to determine the subject's post-exercise pulse wave velocity.
2. Record the subject's post-exercise pulse wave velocity in the Journal and Table 1.

Exercise 3: Resting and Post-Exercise Pulse Wave Velocities in Other Subjects

Aim: To measure the pulse wave velocity in the artery from the elbow to the finger for different subjects.

Procedure

Repeat Exercises 1 and 2 on other subjects of different age groups (11-19, 20-29, 30-39, and so on), gender, or physical fitness levels.

Data Analysis and Calculation of Pulse Wave Velocity

1. Use the same techniques used in Exercises 1 and 2 to determine the resting and post-exercise pulse wave velocities from other subjects.
2. Enter the data from the other subjects into the data table.
3. On a piece of graph paper or in a graphing program, plot the mean resting PWV of each age group as a function of the age group. Include the standard error for the mean of each age group

Questions

1. Does the PWV of the subject's brachial artery increase or decrease with exercise?
2. Does vasodilation cause the PWV in an artery to increase or decrease? Conversely, does vasoconstriction cause the PWV of an artery to increase or decrease?
3. Does the mean resting PWV differ between genders?
4. Does the mean resting PWV depend on the level of fitness of the subjects?
5. Does the mean resting PWV increase or decrease with age?
6. Which age group has the smallest standard error of the means? Which age group has the largest standard error of the means?
7. How can large standard errors for each mean be avoided?

Optional Exercise

While measuring the effects of temperature on the peripheral pulse volume in the The Electrocardiogram and Peripheral Circulation experiment in this manual, use the techniques employed in this experiment to measure the PWV of arteries in arms exposed to cold and hot temperatures.

Table HC-3-L1: Pulse Wave Velocity, Gender, and Fitness Data from Different Subjects.

Subject	Age	Resting PWV	PostEx PWV	Gender	Fitness Level