

Experiment HC-4: Pulse Contour Analysis

Exercise 1: Arterial Stiffness

Aim: To determine the Student Stiffness Index (SSI) of the subject's major arteries.

Procedure

1. Make sure the subject's hands and arms are warm to promote good peripheral circulation. The subject should be resting in the supine position for at least one minute before a recording is made. He or she should also remain motionless throughout the recording.
2. Click on the Record button, located on the upper right side of the LabScribe Main window ([Figure HC-4-L1](#)). 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.

3. Click on the AutoScale buttons at the upper margin of the Pulse and Pulse Integral channels. Your recording should look like the figure below.
 - If the signal on the Pulse channel is upside down when compared to the 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.

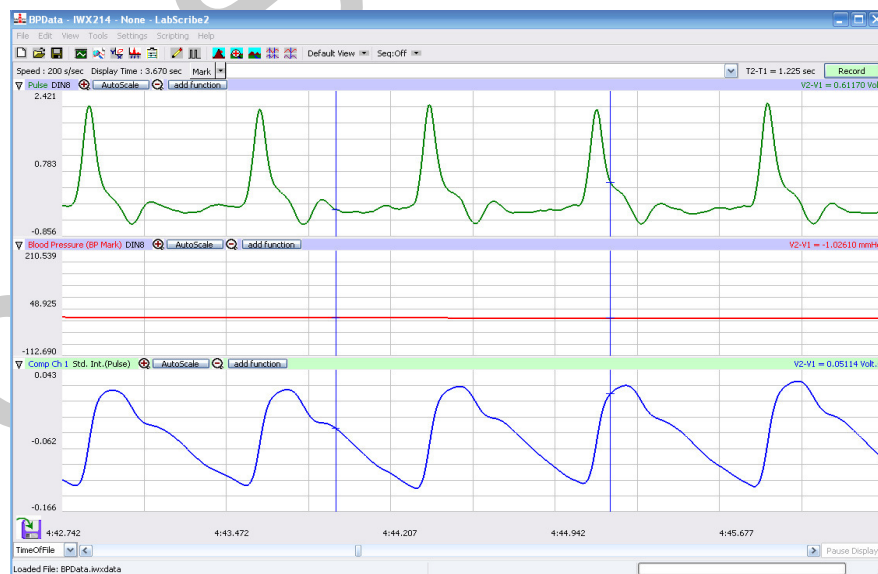


Figure HC-4-L10: The pulse and pulse integral of a resting subject displayed in the Main window.

4. When you have a suitable trace, type <Subject's Name> Resting Pulse in the Mark box to the right of the Mark button. Press the Enter key on the keyboard to attach the comment to the data. Record for a minute.
5. Click Stop to halt recording.
6. Select Save in the File menu.

Data Analysis

1. Scroll through the recording and find a section of data with five or six exemplary pulse/pulse integral cycles in succession.
2. Use the Display Time icons to adjust the Display Time of the Main window to show at least four complete pulse/pulse integral cycles on the Main window. Four adjacent pulse/pulse integral cycles can also be selected by:
 - Placing the cursors on either side of a group of four complete pulse/pulse integral cycles.
 - Clicking the Zoom between Cursors button on the LabScribe toolbar to expand the segment with the four selected pulse cycles to the width of the Main window.
3. Click on the Analysis window icon in the toolbar or select Analysis from the Windows menu to transfer the data displayed in the Main window to the Analysis window ([Figure HC-4-L2](#)).
4. Look at the Function Table that is above the uppermost channel displayed in the Analysis window. The names of the mathematical functions used for analyzing data in this experiment, V2-V1, T2-T1, Value1, and Value2 appear in this table. The values for these parameters from each channel are seen in the table across the top margin of each channel. In this exercise, you will only need to record the values for T2-T1.
5. Once the cursors are placed in the correct positions for determining the reflection time from each pulse integral cycle, the values for the reflection times can be recorded in the on-line notebook of LabScribe by typing the 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 reflection time of the pulse integral cycle.
 - Transfer the name of the mathematical function used to determine the reflection time to the Journal using the Add Title to Journal function in the ECG Channel pull-down menu.
 - Transfer the value for the reflection time to the Journal using the Add Ch. Data to Journal function in the ECG Channel pull-down menu.
7. Use the mouse to click on and drag the cursors to specific points on the pulse integral cycle to measure the reflection time of the pulse wave. Place one cursor on the systolic peak of the first pulse integral and the second cursor on the inclination point or peak of the diastolic component of the pulse integral. The value for T2-T1 on the Pulse Integral channel is the reflection time. Record the value in the Journal using the one of the techniques described in Steps 5 or 6.
8. Measure the reflection time for two additional pulse integral cycles. Record these values in the

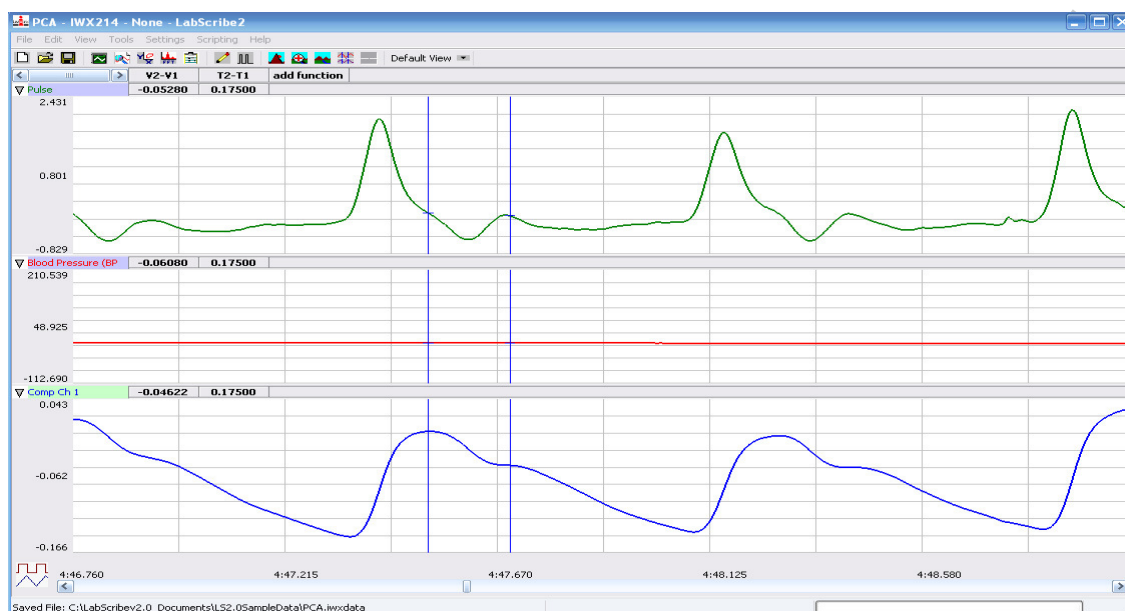


Figure HC-4-L2: The pulse and the pulse integral from a hypertensive subject displayed in the Analysis window. The cursors are at positions on the Pulse Integral channel to measure the reflection time (T2-T1).

9. Determine the mean reflection time for the three pulse integral cycles that were measured. Enter this mean in the Journal.
10. Use a meter stick to measure the height of the subject in meters (m). Enter this value in the Journal.
11. Select Save in the File menu to save the entries to the Journal.
12. Calculate the Student Stiffness Index (SSI) by dividing the the height of the subject by mean reflection time:

$$\text{SSI (m/sec)} = \text{Height (m)} / \text{Mean Reflection Time (sec)}$$

13. Enter the Student Stiffness Index (SSI) for each subject in the Journal and [Table HC-4-L1](#).

Exercise 2: Vascular Tone

Aim: To determine the Student Reflection Index (SRI), the indicator of vascular tone in the subject's large vessels.

Procedure

Use the same data recorded in Exercise 1 to complete Exercise 2 and determine the Student Reflection Index.

Analysis

1. Use the same section of data that was used to determine the Student Stiffness Index (SSI) in Exercise 1.
2. Display the selected data from the Pulse Integral channel in the Analysis window as it was done in Exercise 1.
3. Once the cursors are placed in the correct positions to measure the amplitudes of the systolic and diastolic waves on the Pulse Integral channel, record the values in the Journal using the one of the techniques described in Exercise 1.

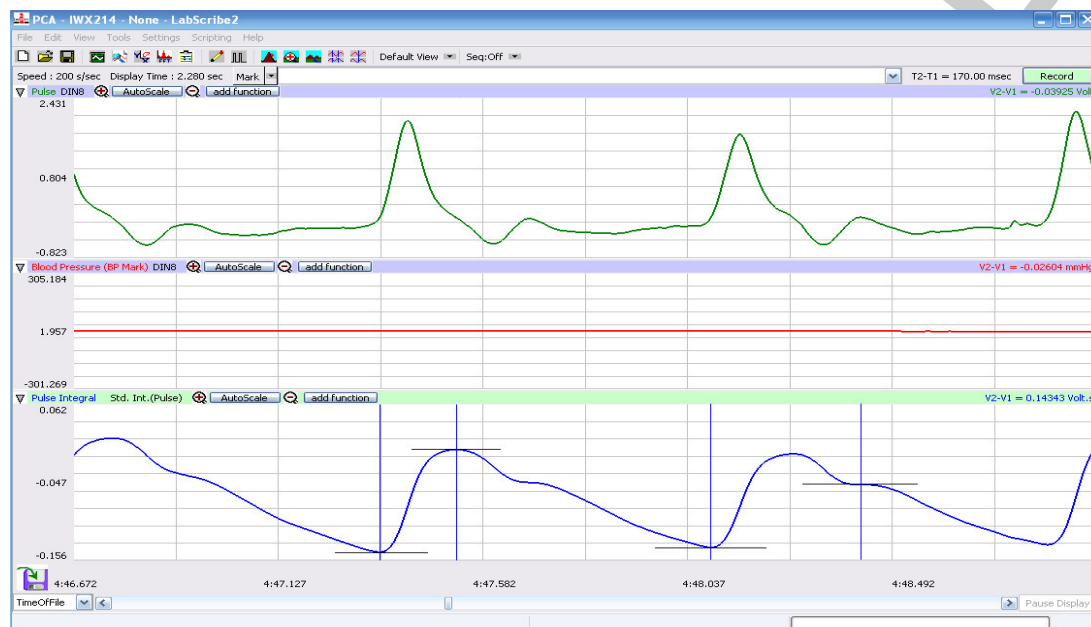


Figure HC-4-L3: The pulse and the pulse integral from a hypertensive subject displayed in the Analysis window. The wave on the left shows the positions of the cursors used to measure the relative systolic amplitude; the wave on the right shows the positions of the cursors used to measure the relative diastolic amplitude.

4. Use the mouse to click on and drag the cursors to specific points on the Pulse Integral channel to measure:
 - Relative amplitude of the systolic wave. Place one cursor at the minimum value before the first pulse integral wave and the second cursor on the peak of the systolic component on the same pulse integral wave ([Figure HC-4-L3](#)). The value for V2-V1 on the Pulse Integral channel is the relative amplitude of the systolic component.
 - Relative amplitude of the diastolic wave. On the same pulse integral wave, move the second cursor from the peak of the systolic component to the peak or inclination point of the diastolic component. Now, the value for V2-V1 on the Pulse Integral channel is the relative amplitude of the diastolic component.
5. Enter the values for the relative amplitudes of the systolic and diastolic waves into the Journal.

6. Repeat Steps 3, 4, and 5 for two additional pulse integral waves that are displayed on the Analysis window.
7. Select Save in the File menu to save the entries to the Journal.
8. Calculate the mean relative amplitudes of the diastolic and systolic waves of the three pulse integral waves. Enter these means in the Journal.
9. Calculate the Student Reflection Index (SRI) by dividing the mean relative amplitude of the diastolic peak by the mean relative amplitude of the systolic peak:

$$\text{SRI(\%)} = \frac{\text{Mean Diastolic Amplitude} \times 100}{\text{Mean Systolic Amplitude}}$$

10. Enter the Student Reflection Index (SRI) for each subject in the Journal and [Table HC-4-L1](#)

Exercise 3: Blood Pressures

Aim: To determine if the subject is hypotensive, normotensive, prehypertensive, or hypertensive.

Procedure

1. Place the blood pressure cuff of the BP-600 around the upper portion of the left arm, just above the elbow. Place the PT-104 pulse plethysmograph on the volar surface (where the fingerprints are located) of the distal segment of the left middle finger. Wrap the Velcro strap around the end of the finger to attach the unit firmly in place.
2. The subject should be resting in the supine position for at least five minutes before taking his or her blood pressure.
3. At the end of the rest period, click on the Record button to begin recording the subject's pulse, pulse integral, and the blood pressure.
4. Inflate the blood pressure cuff until the finger pulse wave on the Pulse channel disappears ([Figure HC-4-L4](#)).
5. Once the pulse wave disappears, release the cuff pressure at the rate of ~10 mmHg/second. Continue to release the pressure in the cuff until the aneuroid gauge reads 20 mmHg.
6. Click the Stop button. Remove the blood pressure cuff and the pulse plethysmograph from the subject. The subject should flex and extend their fingers to encourage blood circulation.
7. Select Save in the File menu.

Analysis

1. Scroll through the recording and find the section of data recorded while the pressure in the cuff was occluding the pulse.
2. Use the Display Time icons to adjust the Display Time of the Main window to show the pulse, pulse integral and the pressure in the cuff of the BP-600 from the occlusion of the artery to the pressure in the cuff being 20 mmHg. This section of data can also be selected by:

- Placing the cursors on either side of the section of data needed.
 - Clicking the Zoom between Cursors button on the LabScribe toolbar to expand the segment of data to the width of the Main window.
3. Click on the Analysis window icon in the toolbar or select Analysis from the Windows menu to transfer the data displayed in the Main window to the Analysis window ([Figure HC-4-L4](#)).

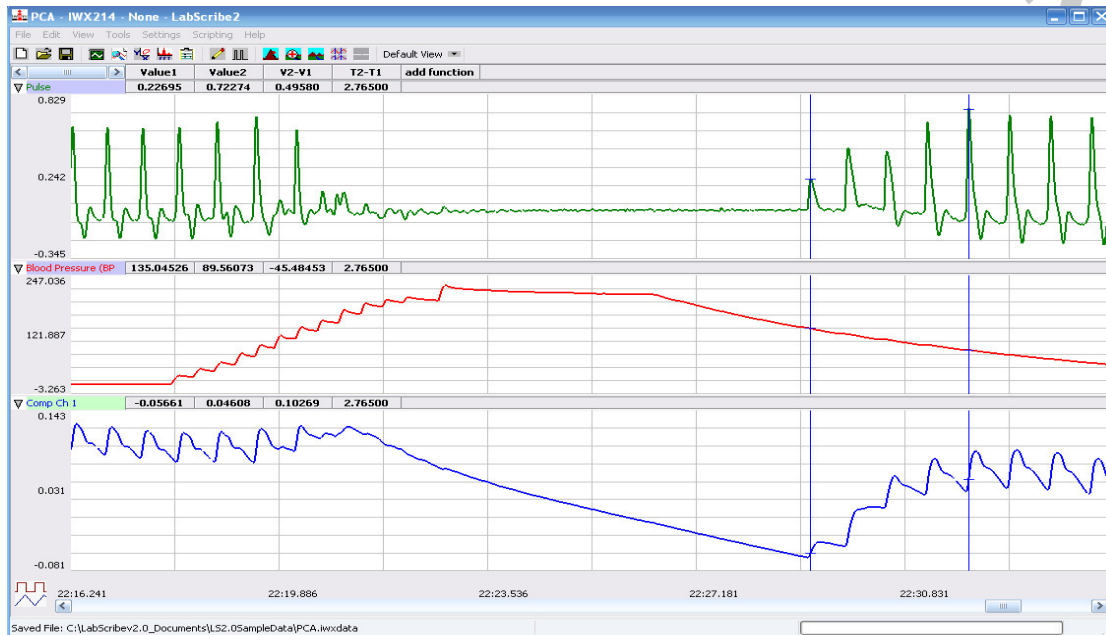


Figure HC-4-L4: The pulse wave, the pressure in the cuff of the BP-600, and the pulse integral recorded before, during, and after the occlusion of the brachial artery. Pulses disappeared as the pressure in the cuff exceeded the pressure in the artery. As the pressure in the cuff is released, the pulse wave first reappears, as marked by the left cursor, when the pressure in the cuff is equal to the systolic pressure. As the pressure in the cuff continues to be released, the pulse wave reaches a maximum amplitude, as marked by the right cursor, when the pressure in the cuff is equal to the diastolic pressure.

4. Look at the Function Table that is above the uppermost channel displayed in the Analysis window. The mathematical functions that are listed should include V2-V1, T2-T1, Value1, and Value2. The values for these parameters from 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 systolic, diastolic, and pulse pressures, record the values for these pressures in the Journal using the one of the techniques described in Exercise 1.
6. Use the mouse to click on and drag the cursors to specific points on the pulse and blood pressure recording to measure the following:
 - Systolic blood pressure. To determine the subject's systolic blood pressure, place a cursor on the first of the smallest pulse waves that reappear after the pressure from the cuff of the BP-600 is released. Value1 on the Blood Pressure channel is the subject's systolic blood pressure. Enter this pressure in [Table HC-4-L1](#).

- Diastolic blood pressure. To determine the subject's diastolic blood pressure, place the other cursor on the first of the largest pulse waves that reappear after the pressure from the cuff of the BP-600 is released. Value2 on the Blood Pressure channel is the subject's diastolic blood pressure. Enter this pressure in the data table.
 - Pulse pressure, which is the difference between the systolic and diastolic pressures. To measure the pulse pressure, leave the cursors on the pulses that occur at the systolic and diastolic pressures. The value for V2-V1 on the Blood Pressure channel is the subject's pulse pressure. Enter this pressure and the subject's age in the data table.
7. Enter the values for the pressures into the Journal.
 8. Divide the subject's diastolic blood pressure by his or her systolic blood pressure. Enter this ratio into the Journal and in the data table.
 9. Determine the subject's blood pressure class from [Table HC-4-L2](#). List it in [Table HC-4-L1](#).

Questions

1. Does the Student Reflection Index (SRI) of the subject correlate to his or her blood pressure?
2. Does the Student Stiffness Index (SSI) of the subject correlate to his or her age?
3. Is there a correlation between the Student Reflection Index (SRI) and the Student Stiffness Index (SSI)?
4. To which parameter in the table does the pulse pressure correlate?
5. To which parameter in the table does the diastolic/systolic ratio correlate?
6. Divide the subjects into groups based on age (11-19, 20-29, 30-39, and so on). Compare the average Student Stiffness Index (SSI) of each age group to the other groups. What is the trend?
7. Compare the average Student Reflection Index (SRI) of each age group to the other groups. What is the trend?

Table HC-4-L1: Resting Blood Pressures

Subject	Age	Student Stiffness Index (SSI)	Student Reflection Index (SRI)	Systolic Pressure (mmHg)	Diastolic Pressure (mmHg)	Pulse Pressure (mmHg)	Diastolic/Systolic	Blood Pressure Class

Table HC-4-L2: Classification of Blood Pressure Levels According to JNC VI (The Sixth Report of the Joint National Committee on High Blood Pressure).

Class	Systolic Pressure (mmHg)	Diastolic Pressure (mmHg)
Hypotensive	Below 90	Below 60
Optimal	Below 120	Below 80
Normal	Below 130	Below 85
Prehypertensive	130-139	85-89
Hypertensive Stage 1	140-159	90-99
Hypertensive Stage 2	160-179	100-110
Hypertensive Stage 3	180 and above	110 and above