# Experiment HC-1: Blood Pressure, Peripheral Circulation, and Body Position

## Equipment Required

PC or Mac Computer

IXTA, USB cable, IXTA power supply

PT-104 Pulse plethysmograph

Stethoscope

BP-220 Non-invasive blood pressure transducer

BT-220 Black tygon tubing with Luer connectors

## Blood Pressure and Pulse Transducers Setup

1. Locate the BP-220 non-invasive blood pressure (NIBP) transducer and PT-104 pulse plethysmograph in the iWorx kit.

*Figure HC-1-S1: The BP-220 non-invasive blood pressure transducer.*

2. Plug the DIN8 connector of the PT-104 into Channel A5.
3. Plug the tubing connector of the BP-220 into the channel labeled A2 on the front of the IXTA.
4. Calibrate the BP-220 and then put it aside until it is needed in Exercise 1.

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*Figure HC-1-S2: The PT-104 pulse plethysmograph.*

*Figure HC-1-S3: The PT-104 pulse transducer and the BP-220 non-invasive blood pressure transducer connected to an IXTA.*

**Calibration of the Non-Invasive Blood Pressure Transducer**

***Procedure***

1. Lay the cuff of the BP-220 on the lab table.
2. 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.. 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 Tools menu.*

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3. Click on the AutoScale button at the upper margin of the Pulse and Blood Pressure channels.
    - If the signal on the Pulse channel is upside down, 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.
4. On the Blood Pressure channel, move one cursor to the left side of the screen and the other to the right, spanning about 6-8 seconds of data.
5. Click V2-V1 on the right side of the Blood Pressure channel and click Set Offset.
6. When the Set Offset window opens, set the values and radio buttons as in the image below.
    - Put a check mark in the box next to Apply the calculated offset for this block to all blocks. Set the Mean Value between Cursors to: "0" in the box at the top. Click on the OK button in the lower right corner.
7. Click OK. Click Save As in the File menu and save your data file.

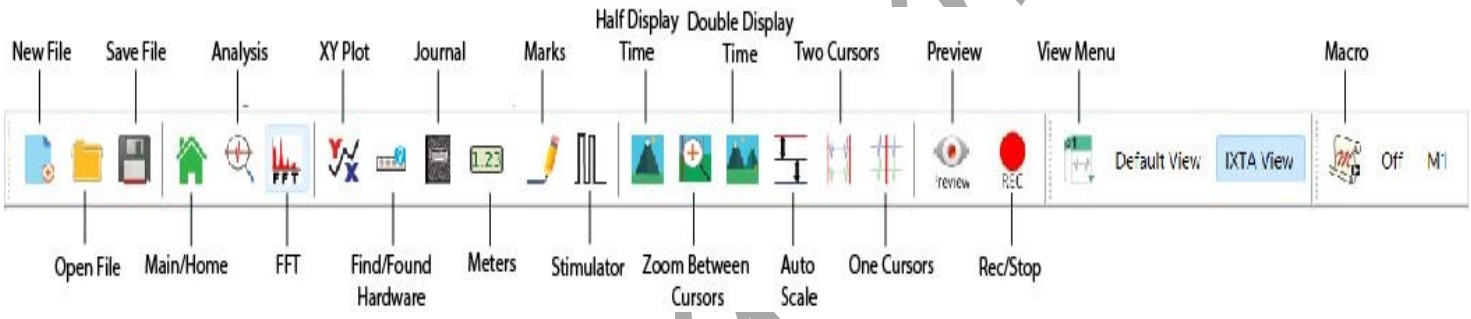


*Figure HC-1-S4: The LabScribe toolbar.*

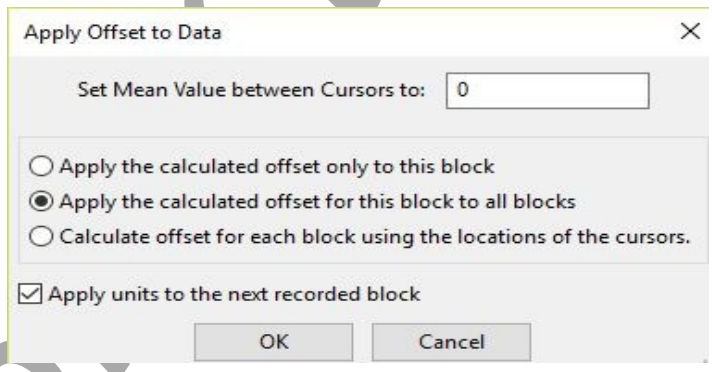


*Figure HC-1-S5: The Units Offset dialogue window with the mean values set to "0".*

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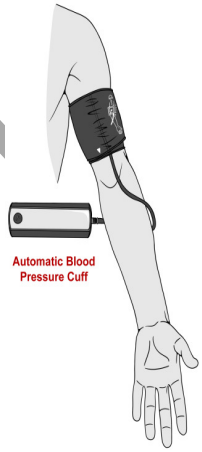
# Experiment HC-1: Blood Pressure, Peripheral Circulation, and Body Position

## Exercise 1: Blood Pressures from the Left Arm

Aim: To determine the systolic and diastolic blood pressures in a reclining subject, and if the subject is hypotensive (low blood pressure), normotensive, or hypertensive (high blood pressure).

Approximate Time: 15 minutes

### *Procedure*




1. Have the subject sit and relax for a few minutes.
2. Place the blood pressure cuff around the upper portion of the left arm, just above the elbow. Fasten the cuff securely.
3. Place the pulse sensor on the fleshy part of the left thumb. Tighten the velcro strap so the subject can just feel the pulse in their thumb. It should not be too tight or too loose. Wrap the Velcro strap around the end of the finger to attach the unit firmly in place.
4. Click Record.
5. Make sure the pulse channel show good, clean pulse waves with no noise. If not, click Stop, and check the tension on the pulse sensor.

There will only be a pulse channel. BP is measured on the LCD screen of the automated cuff.

6. Measure Blood Pressure:
   - AUTOMATED BP CUFF: Push the "Start" button the front of the unit. The LCD screen will turn on and the unit will automatically inflate the cuff and slowly deflate the cuff as it measures both the systolic and diastolic pressures.
   - Record data until the BP cuff totally deflates and you get a reading on the LCD screen.
   - Read the systolic and diastolic blood pressures on the LCD screen of the BP monitor. Heart rate can also be measured automatically. Record these values.

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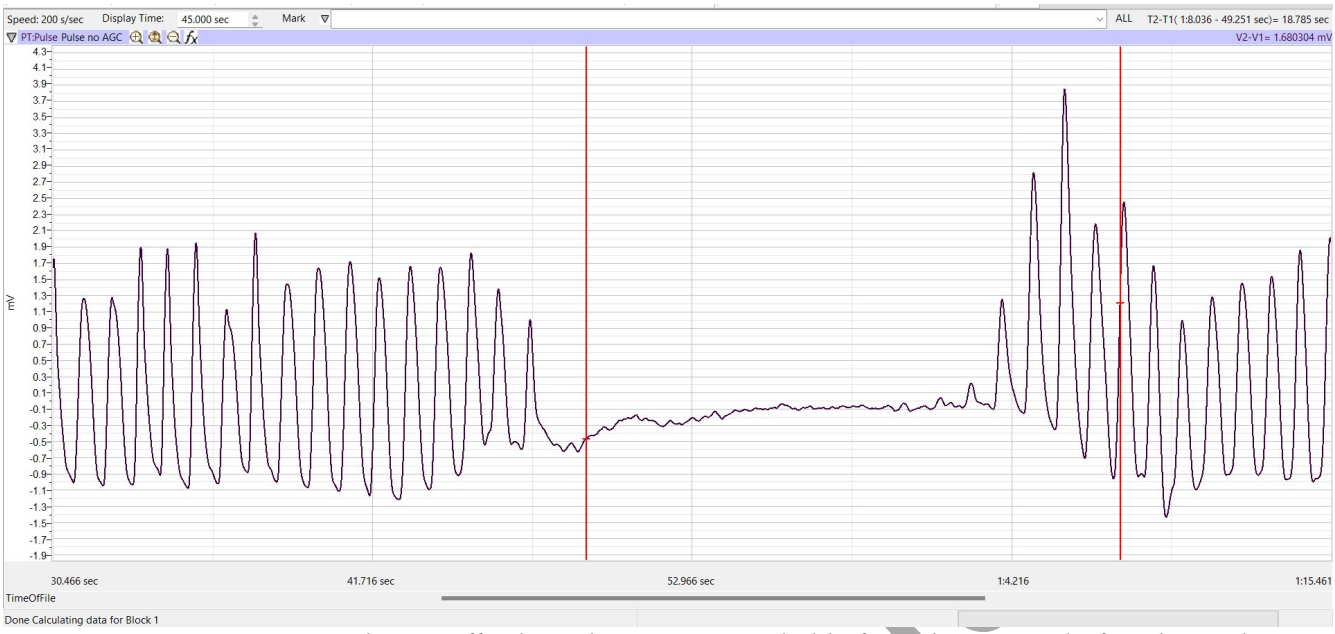
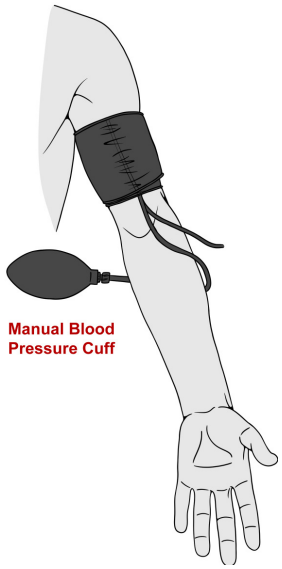



*Figure HC-1-S1: Automated BP Cuff - the pulse wave recorded before, during, and after the occlusion of the brachial artery. Pulses disappeared as the pressure in the cuff exceeded the pressure in the artery. As the pressure in the cuff is released, the pulse wave reappears.*

- MANUAL BP CUFF: Once there is a clean pulse recording, inflate the blood pressure cuff to about 180 mmHg. This value will be shown on the right side of the blood pressure channel. As the cuff is inflated, the pulse wave will disappear.
    - Once the pulse wave disappears, SLOWLY release the air in the cuff at a rate of about 10mmHg per second.




7. Once the pulse waves reappear and the blood pressure cuff has been sufficiently deflated, click the Stop button. Make sure the blood pressure cuff is completely deflated and is not putting any unnecessary pressure on the subject's arm. Click AutoScale All.
8. Save your data file.

Warning: If you decide to slow the release from the cuff pressure, remember that restricting circulation for a prolonged period can be dangerous. Do not release the pressure in the cuff at a rate any slower than 5 mmHg/sec.

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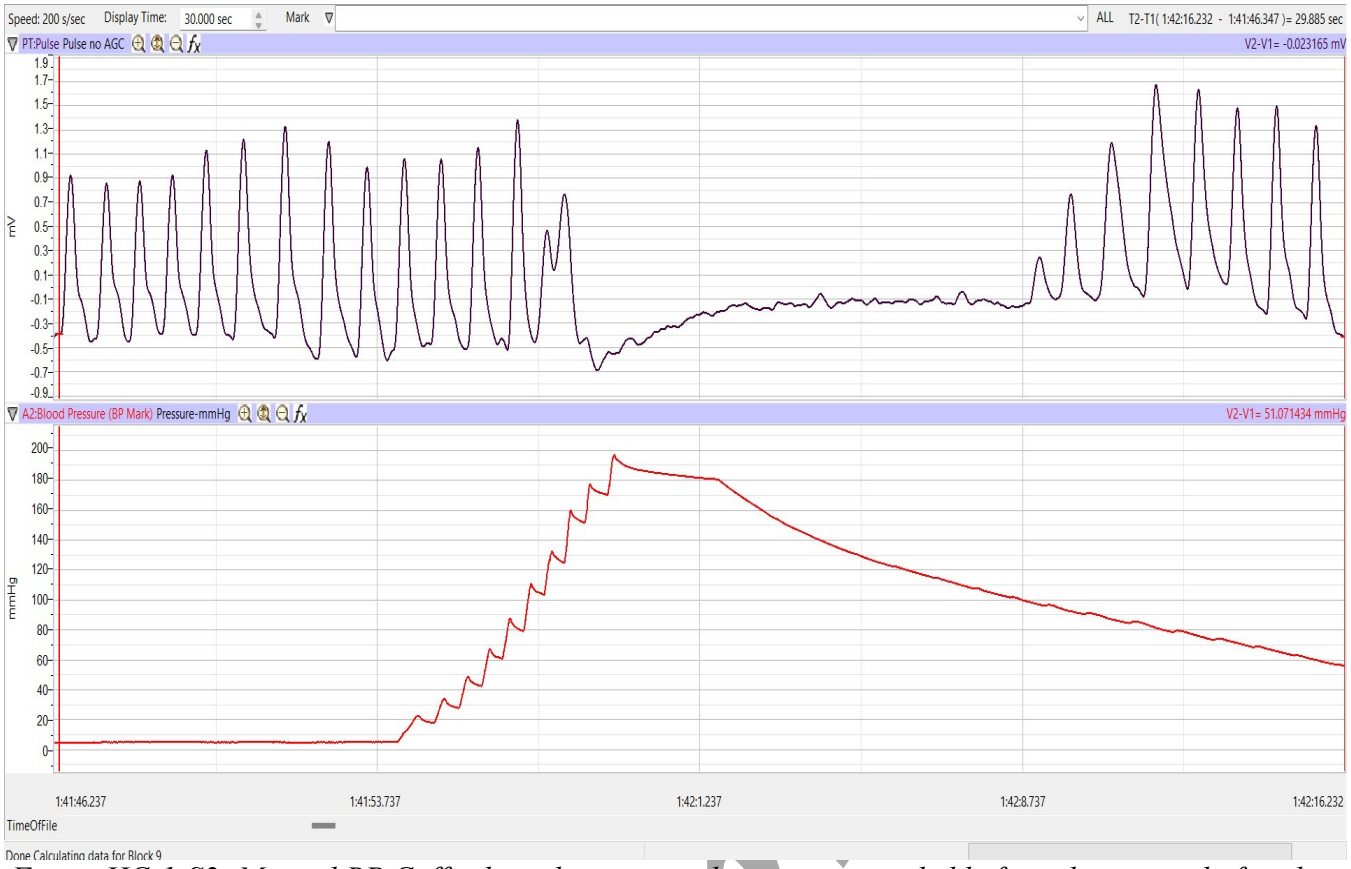


*Figure HC-1-S2: Manual BP Cuff - the pulse wave and pressure recorded before, during, and after the occlusion of the brachial artery. Pulses disappeared as the pressure in the cuff exceeded the pressure in the artery. As the pressure in the cuff is released, the pulse wave reappears.*

### *Data Analysis*

1. Scroll through the recording and find the section of data recorded before, during, and after 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 and the pressure in the cuff from the occlusion of the artery to the blood pressure cuff being deflated.
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. **Automated BP Cuff:**
   - Look at the pulse waves. You should notice that the pulse is occluded during the measuring of the BP by the automated cuff. The pulse waves return as the cuff deflates.
   - Read the systolic and diastolic blood pressures on the LCD screen of the BP monitor. Heart rate can also be measured automatically.

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5. **Manual BP Cuff:**
    - Pulses
        - Measure the average amplitude of a few pulse waves before the cuff was inflated.
        - Place one cursor on the trough before the pulse wave, and the other cursor on the peak of the pulse wave.
        - Look at V2-V1 on the right side of the pulse channel to get this value.
        - Determine a mean value for 3 good pulse waves.
    - Blood Pressure:
        - Use the single cursor mode in the Main window, use the mouse to click on and drag the cursor 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 the cursor on the first of the smallest pulse waves that reappear after the pressure from the cuff is released. Value on the Blood Pressure channel is the subject's systolic blood pressure. Enter this pressure in Table 2.
        - Diastolic blood pressure. To determine the subject's diastolic blood pressure, more the cursor to the first of the largest pulse waves that reappear as the pressure from the cuff is released. Value on the Blood Pressure channel is the subject's diastolic blood pressure. Enter this pressure in the table.
        - Pulse pressure, which is the difference between the systolic and diastolic pressures. find the difference of the recorded systolic and diastolic blood pressure, and enter the value into the table
6. Once the cursors are placed in the correct positions for determining the blood pressures, the values for the blood pressures can be recorded in the on-line notebook of LabScribe by typing the names and values directly into the Journal.
7. 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 cuff pressures from the Blood Pressure channel.
    - Transfer the name of the mathematical function used to determine the blood pressure to the Journal using the Add Title to Journal function in the Blood Pressure Channel pull-down menu.
    - Transfer the value for the blood pressure to the Journal using the Add Ch. Data to Journal function in the Blood Pressure Channel pull-down menu.
8. 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 above.
9. Determine the subject's blood pressure class from Table 1. List it in Table 2.

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**Table HC-1-L1: Classification of Blood Pressure Levels According to the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7).**

| Class | Systolic Pressure (mmHg) | Diastolic Pressure (mmHg) |
|---|---|---|
| Hypotensive | <90 | <60 |
| Normal | 120 | and 80 |
| Prehypertensive | 120-139 | or 80-89 |
| Hypertensive Stage 1 | 140-159 | or 90-99 |
| Hypertensive Stage 2 | >160 | or >100 |

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### Exercise 2: Repeatability of Blood Pressure Measurements

Aim: To determine the repeatability of the blood pressure measurement from the upper left arm of the same subject.

Approximate Time: 15 minutes

#### *Procedure*

1. Repeat the procedures outlined in Exercise 1 on the same subject.
2. The subject should continue to rest in the sitting position between Exercises 2 and 3.

#### *Data Analysis*

Use the same techniques used in Exercise 1 to determine the systolic and diastolic blood pressures of the subject.

#### *Questions*

1. Are the systolic and diastolic blood pressures from Exercises 1 and 2 identical? What are the possible sources of variation?
2. Since the pressures are determined using changes in the pulse amplitude, would slowing the rate at which pressure is released from the cuff make your readings more accurate?

***REMINDER: If you decide to slow the release from the cuff pressure, remember that restricting circulation for a prolonged period can be dangerous. Do not release the pressure in the cuff at a rate any slower than 5 mmHg per second.***

**Exercise 3: Blood Pressures from the Right Arm**

Aim: To measure blood pressure from the right arm.

Approximate Time: 15 minutes

***Procedure***

1. The subject should continue to rest in the sitting position before and during this exercise.
2. Place the blood pressure cuff around the upper portion of the right arm, just above the elbow. Place the pulse sensor on the volar surface of the distal segment of the right middle finger or thumb. Wrap the Velcro strap around the end of the finger to attach the unit firmly in place.
3. Use the same procedures outlined in Exercise 1 to record the subject's blood pressures from their upper right arm.
4. The subject should continue to rest in the supine position between Exercises 3 and 4.

***Data Analysis***

Use the same techniques used in Exercise 1 to determine the systolic and diastolic blood pressures recorded from the upper right arm of the subject.

***Question***

Are the values the same as those obtained for the left arm? Explain any differences.

**Exercise 4: Blood Pressures from the Forearm**

Aim: To examine whether blood pressure declines with distance from the heart.

Approximate Time: 15 minutes

***Procedure***

1. The subject should continue to rest in the sitting position before and during this exercise.
2. Move the blood pressure cuff from the upper right arm to the lower right arm.
3. Use the same procedures enumerated in Exercise 1 to record the subject's blood pressures from their lower right arm.

***Data Analysis***

Use the same techniques used in Exercise 1 to determine the systolic and diastolic blood pressures recorded from the lower right arm of the subject.

***Question***

Are the values from the forearm the same as those obtained with the cuff on the upper arm? Explain any variations that you see.

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**Exercise 5: Blood Pressures with Different Arm Positions**

Aim: To examine the effects of gravity on blood pressure and peripheral circulation.

Approximate Time: 15 minutes

***Procedure***

1. Select a new subject and instruct the subject to sit and relax for at least five minutes before their blood pressure is taken.
2. While the subject is relaxing, place the blood pressure cuff around the upper portion of the left arm, just above the elbow and the pulse sensor on the volar surface 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.
3. At the end of the relaxation period, use the same procedures used in Exercise 1 to determine the blood pressures of the subject while the subject is resting both hands in their lap.
4. Keeping the cuff on the left arm, instruct the subject to place their right hand on top of their head. Determine the blood pressures of the subject while their right hand in this position. Instruct the subject to return their hand to their lap after the blood pressures in this position are determined.
5. Instruct the subject to place their left hand on top of their head. Determine the blood pressures of the subject while their left hand in this position. Instruct the subject to return their hand to their lap after the blood pressures in this position are determined.
6. Select Save in the File menu.
7. The subject should continue to sit and relax between Exercises 5 and 6.

***Data Analysis***

Use the same techniques used in Exercise 1 to determine the systolic and diastolic blood pressures recorded from the upper left arm of the subject.

***Question***

What is the effect of raising each hand on the blood pressure in the left arm? Explain your results.

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**Table HC-1-L2: Blood Pressures from Different Arms in Different Positions**

| Subject_____<br>Cuff Location/Hand Position | Systolic Pressure (mmHg) | Diastolic Pressure (mmHg) | Pulse Pressure (mmHg) | BP Class |
|---|---|---|---|---|
| Upper Left Arm/ Hand Low | | | | |
| Lower Left Arm/ Hand Low | | | | |
| Upper Right Arm/ Hand Low | | | | |
| Lower Right Arm Hand Low | | | | |
| Left Arm/ Left Hand Low | | | | |
| Left Arm/ Right Hand High | | | | |
| Left Arm/ Left Hand High | | | | |

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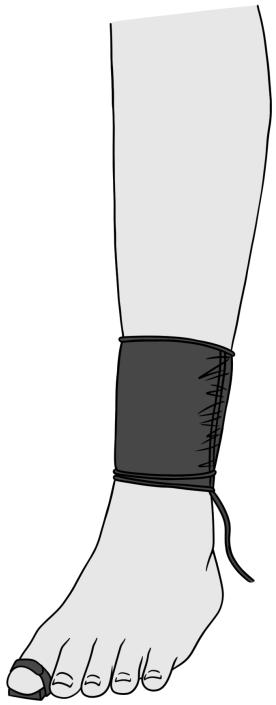
**Exercise 6: Blood Pressures from the Leg**

Aim: To measure blood pressures from the leg.

Approximate Time: 30 minutes

***Procedure***

1. Instruct the subject used in Exercise 5 to sit and relax before their blood pressure is taken.
2. While the subject is relaxing, place the blood pressure cuff around the lower left leg, just above the ankle, and the pulse sensor on the volar surface of the distal segment of the left large toe. Wrap the Velcro strap around the end of the toe to attach the unit firmly in place.
3. At the end of the relaxation period, use the same procedures used in Exercise 1 to determine the blood pressures in the subject's left leg while they are sitting with the left foot on the floor.



4. Determine the blood pressures in the subject's left leg when he or she is:
    - reclining in the supine position.
    - lifting their left leg perpendicular to the bench while reclining; support the leg with a chair.
    - standing.
    - standing for three minutes.
5. Select Save in the File menu.

***Data Analysis***

*Use the same techniques used in Exercise 1 to determine the systolic and diastolic blood pressures recorded from the left leg of the subject.*

***Questions***

1. Are the blood pressure values from the leg the same as those obtained from the arms? Explain any differences.
2. What happens to the blood pressures in the subject's left leg when the subject reclines? When the subject lifts their left leg perpendicular to the bench? When the subject stands? After the subject has been standing for three minutes?
3. What is happening physiologically to cause the changes discussed in Question 2?

**Table HC-1-L3: Blood Pressures from the Left Leg in Different Positions**

| Subject_____<br>Leg Position | Systolic Pressure (mmHg) | Diastolic Pressure (mmHg) | Pulse Pressure (mmHg) | BP Class |
|---|---|---|---|---|
| Sitting | | | | |
| Reclining | | | | |
| Leg Vertical | | | | |
| Standing | | | | |
| Standing 3 Mins | | | | |

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