Experiment HC-5: Body Position, Exercise, and Cardiac Output

Equipment Required

PC or Mac Computer

IXTA, USB cable, IXTA power supply

PPG-320 Pulse plethysmograph

BP-220 or BP-220A Non-invasive blood pressure transducer

BT-220 Black tygon tubing with Luer connectors

Stethoscope – optional for listening to Korotkoff sounds

Blood Pressure and Pulse Transducers Setup

Automated Blood Pressure and Pulse Transducer Setup

1. Find the automatic blood pressure monitor and blood pressure cuff.
2. Slide the gray connector on the tubing of the BP cuff into the port on the left side of the BP monitor.
3. Turn on the BP monitor using the On/Off switch on the right side of the monitor.
4. Plug the pulse sensor into the PT port.

Figure HC-5-S1: The BP-220A Automated non-invasive blood pressure transducer.

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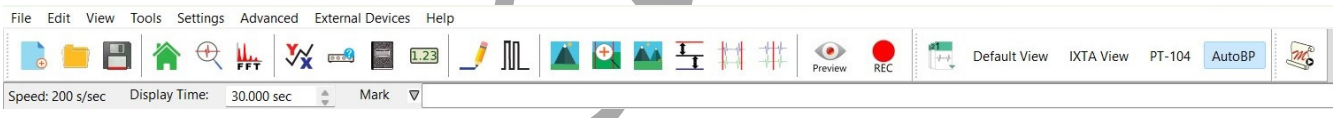
Figure HC-5-S2: The PT sensor plugged into the PT port of the IX-TA-ROAM

5. Click AutoBP on the Views menu on the LabScribe toolbar.



Manual Blood Pressure and Pulse Transducer Setup

1. Locate the BP-220 non-invasive blood pressure (NIBP) transducer and PPG-320 pulse plethysmograph.
2. Plug the connector of the PPG-320 into the PT port. You will put the pulse sensor on the subject's finger after calibration.
3. Plug the tubing connector of the BP-220 into the channel labeled A2.
4. Calibrate the BP-220 and then put it aside until it is needed in Exercise 1.

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Figure HC-5-S3: The BP-220 non-invasive blood pressure transducer.

Figure HC-5-S4: The PPG-320 pulse transducer and the BP-220 non-invasive blood pressure transducer connected to the TA.

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Calibration of the Manual 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.
3. Click on the AutoScale button at the upper margin of the Pulse and Blood Pressure channels.
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.

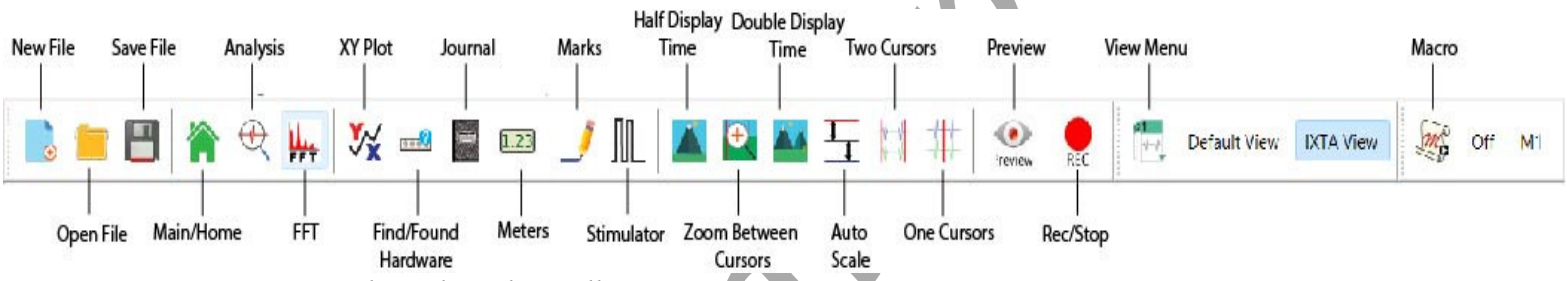

Figure HC-5-S5: The LabScribe toolbar.

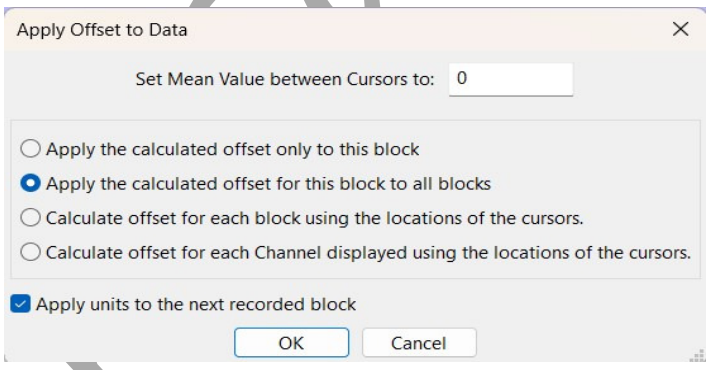

Figure HC-5-S6: The Units Offset dialogue window with the mean values set to "0".

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Experiment HC-5: Body Position, Exercise, and Cardiac Output

Exercise 1: Cardiac Output While Reclining

Aim: To determine the cardiac output of a subject through the measurement of blood pressures and heart rate while the subject is reclining.

Approximate Time: 15 minutes

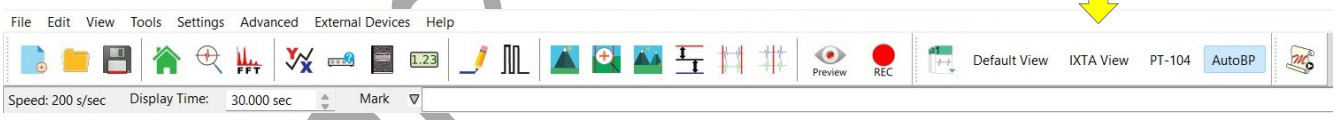
Procedure

1. Instruct the subject to rest in the reclining position for at least five minutes before his or her blood pressure is taken.
2. While the subject is resting, place the blood pressure cuff around the upper portion of the left arm, just above the elbow. Place the pulse sensor 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 in place.
3. At the end of the rest period, click on the Record button to begin recording the subject's pulse, blood pressure and heart rate.

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

4. 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.

   - Change View to IXTA View to use the Manual BP Cuff.



   - 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, release the cuff pressure at the rate of ~10 mmHg/second. Continue to release the pressure in the cuff until the gauge reads 0 mmHg. Continue to record for an additional 30 seconds.

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- If listening with a stethoscope, also click the mark button when you hear the Korotkoff sounds and again when they disappear.

Warning: 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 mm Hg per second.

5. 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.
6. The subject should rest in the sitting position between Exercises 1 and 2. To improve circulation in his or her arm, the subject should flex and extend their fingers to encourage blood circulation.
7. Select Save in the File menu.

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. When using the Manual Cuff, use the Display Time icons to adjust the display time to show the pulse and the pressure in the cuff from the occlusion of the artery to the time 15 seconds after the time point when the diastolic pressure was recorded.
3. When using the Automated Cuff, set the display time to 30 seconds so you can see the pulses before and after the cuff was inflated.

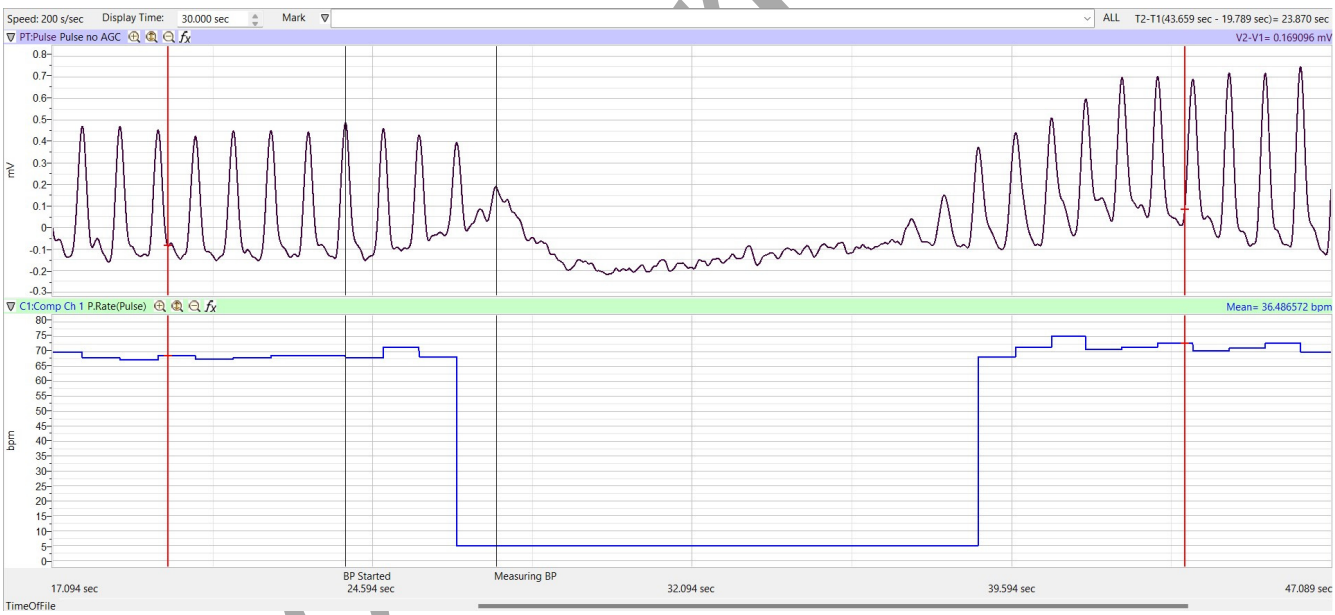

Figure HC-5-L1: Automated BP Cuff - the pulse and heart rate recorded before, during, and after the occlusion of the brachial artery.

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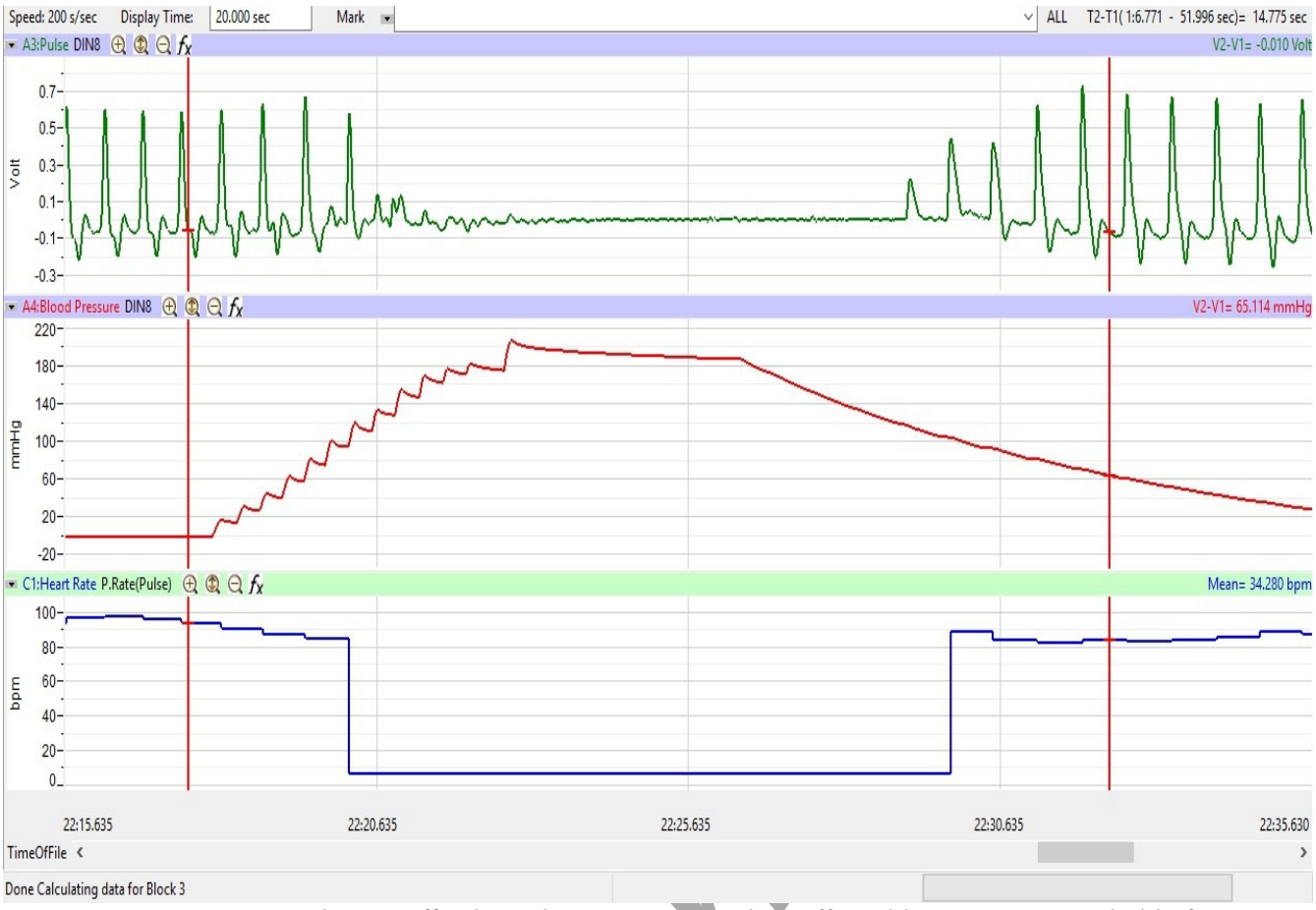

Figure HC-5-L2: Manual BP Cuff - the pulse, pressure in the cuff, and heart rate recorded before, during, and after the occlusion of the brachial artery.

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.
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.

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- 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. The Value on the Blood Pressure channel is the subject's systolic blood pressure. Enter this pressure in Table 1.
    - Diastolic blood pressure. To determine the subject's diastolic blood pressure, move the cursor to the first of the largest pulse waves that reappear as the pressure from the cuff is released. The Value on the Blood Pressure channel is the subject's diastolic blood pressure. Enter this pressure in the data table.
    - Heart Rate. To determine the subject's heart rate, place a cursor on the recording just after the point used to determine the diastolic pressure. Place the other cursor on the recording about 10 seconds after the first cursor. Mean on the Heart Rate channel is the subject's average heart rate after the blood pressure determination. Enter this rate in the data 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.
9. Determine the stroke volume of the subject while they were reclining by using the following equation:

Stroke Volume (ml/beat) = 101 + (0.50 x Systolic Pressure) - (1.09 x Diastolic Pressure) - (0.61 x Age)

10. Enter the value for the stroke volume of the subject in the Journal and on the data table.
11. Determine the cardiac output of the subject while they were reclining using the following equation:

    Cardiac Output (ml/min) = Stroke Volume (ml/beat) x Heart Rate (beats/minute)

12. Enter the value for the cardiac output of the subject in the Journal and on the data table.

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Figure HC-5-L2: The pulse, pressure in the cuff, and heart rate recorded before, during, and after the occlusion of the brachial artery displayed in the Analysis window. Cursors are placed for measuring the systolic and diastolic pressures, which are 115.8 mmHg and 70.4 mmHg, respectively.

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Figure HC-5-L3: The pulse, pressure in the cuff, and heart rate recorded before, during, and after the occlusion of the brachial artery displayed in the Analysis window. Cursors are placed for measuring the mean heart rate in the 10 seconds after the diastolic pressure is measured. The mean heart rate is 85.3 BPM.

Exercise 2: Cardiac Output While Sitting

Aim: To determine the cardiac output of the same subject through the measurement of blood pressures and heart rate while the subject is sitting.

Approximate Time: 15 minutes

Procedure

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

Data Analysis

1. Use the same techniques used in Exercise 1 to determine the systolic and diastolic blood pressures, heart rate, stroke volume, and cardiac output of the sitting subject.
2. Record the values for each parameter in the Journal and on the data table.

Exercise 3: Cardiac Output While Standing

Aim: To determine the cardiac output of the same subject through the measurement of blood pressures and heart rate while the subject is standing.

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Approximate Time: 15 minutes

Procedure

1. Repeat the procedures outlined in Exercise 1 on the same subject while the subject is standing.
2. The subject should continue to rest in the standing position between Exercises 3 and 4.

Data Analysis

1. Use the same techniques used in Exercise 1 to determine the systolic and diastolic blood pressures, heart rate, stroke volume, and cardiac output of the standing subject.
2. Record the values for each parameter in the Journal and on the data table.

Exercise 4: Cardiac Output After Exercise

Aim: To determine the cardiac output of the same subject through the measurement of blood pressures and heart rate while the subject is recovering from exercise.

Approximate Time: 30 minutes

Procedure

1. Remove the blood pressure cuff and pulse sensor from the subject. Leave these devices connected to the box.
2. Instruct the subject to exercise vigorously enough to elevate his or her heart rate. Walking up and down stairs or doing jumping jacks are suitable exercises.
3. While the subject is exercising, type Recovery, Time = 0 in the Mark box.
4. Immediately after exercising, the subject should sit. Other members of the group should attach the pulse sensor and blood pressure cuff to the subject as done in Exercise 1 as quickly as possible, and click on the Record button.
5. Inflate the cuff and record the data needed to determine the subject's blood pressure immediately after exercise. Click the mark button as the subject's blood pressure is recorded.
6. After the data needed to determine the subject's blood pressure is recorded:
    - Deflate the blood pressure completely.
    - Monitor the subject's heart rate by continuing to record.
7. Take 5 total readings for approximately 120 secs after exercise, repeat Steps 5 and 6. Mark each determination with the time of the recovery period. Continue to record the subject's blood pressure until the pressures are similar to the resting pressures.
8. Click Stop to halt recording. Click Save to save your data.

Data Analysis

1. Use the same techniques used in Exercise 1 to determine the systolic and diastolic blood pressures, heart rate, stroke volume, and cardiac output of the subject at the five intervals after the end of exercise.

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2. Record the values for each parameter in the Journal and on the data table.

Questions

1. How do the systolic and diastolic pressures of the subject in the reclining, sitting, and standing positions compare?
2. How do the heart rates of the subject in the reclining, sitting, and standing positions compare?
3. How do the cardiac outputs of the subject in the reclining, sitting, and standing positions compare?
4. How do the systolic and diastolic pressures from the subject at the various times after exercise compare to each other? And, the heart rates and cardiac outputs?
5. How do the systolic and diastolic pressures, heart rates, and cardiac outputs immediately after exercise compare to those recorded while the subject is sitting?
6. How do the systolic and diastolic pressures, heart rates, and cardiac outputs 2 minutes after exercise compare to those recorded while the subject is sitting?
7. From the data recorded, determine which factor, stroke volume or heart rate, has the greatest impact on cardiac output.

Table HC-5-L1: Blood Pressures, Stroke Volumes, and Cardiac Outputs of Subject in Different Body Positions.

Subject's Age_____ years Body Position	Systolic Pressure (mmHg)	Diastolic Pressure (mmHg)	Stroke Volume (ml/beat)	Heart Rate (BPM)	Cardiac Output (ml/min)
Reclining					
Sitting					
Standing					
Sitting, After Exercise					
Sitting, 30 Secs After Exercise					
Sitting, 60 Secs After Exercise					
Sitting, 90 Secs After Exercise					

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Sitting, 120 Secs After Exercise					

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