Experiment HC-2: Blood Pressure, Peripheral Circulation, and Imposed Conditions

Equipment Required

PC or Mac Computer

IXTA, USB cable, IXTA power supply

PPG-320 Pulse sensor

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

BT-220 Black tygon tubing with Luer connectors

Ice packs, cold water, warm water

Caffeinated, regular and sugar free sodas

Decaffeinated, regular and sugar free sodas

Drinking Water (control)

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. To 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-2-S1: The BP-220A Automated non-invasive blood pressure transducer.

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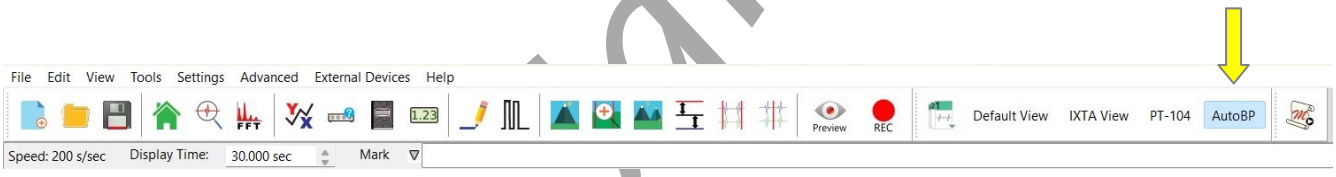
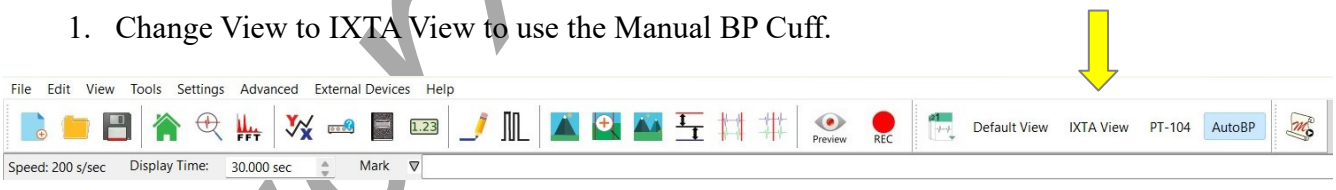
Figure HC-2-S2: The PT sensor plugged into the PT port of the IX-TA-ROAM



Manual Blood Pressure and Pulse Transducer Setup

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



2. Locate the BP-220 non-invasive blood pressure (NIBP) transducer and PPG-320 pulse plethysmograph.

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Figure HC-1-S3: The BP-220 manual non-invasive blood pressure transducer.

2. Plug the connector of the PPG-320 into the PT port.
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.

Figure HC-2-S4: The PPG-320 pulse sensor and the BP-220 blood pressure cuff connected to the TA.

Sample Lab

Calibration of the Manual Non-Invasive Blood Pressure Transducer

Procedure

1. Lay the cuff of the BP-220 flat on the lab table.
2. Click on the Record button. Record 10 seconds of data.
3. Click on the AutoScale All button.
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.

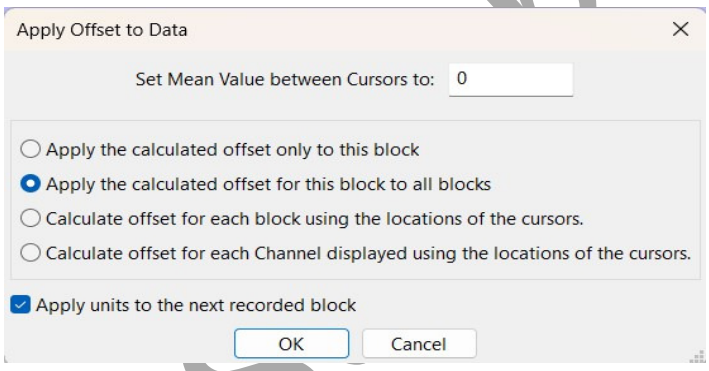

Figure HC-2-S5: The Units Offset dialogue window with the mean values set to "0".

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Experiment HC-2: Blood Pressure, Peripheral Circulation, and Imposed Conditions

Exercise 1: Measuring Blood Pressures

Aim: To determine the systolic and diastolic blood pressures in a reclining subject.

Approximate Time: 15 minutes

Procedure

1. Instruct the subject to rest in the supine 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 firmly 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.
4. Inflate the blood pressure cuff until the finger pulse wave on the Pulse channel disappears.
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. If listening with a stethoscope, also click the mark button when you hear the Korotkoff sounds and again when they disappear.
7. Click the Stop button.
8. The subject should continue to rest in the supine 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.
9. 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 blood pressure cuff was inflated.
2. Use the Display Time icons to adjust the Display Time of the Main window to show the pulse, cuff pressure, and heart rate from the time prior to the occlusion of the artery to the 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. The mathematical functions, V2-V1 and T2-T1 should appear on screen. Values for V2-V1 and T2-T1 on each channel are seen in the table across the top margin of each channel, or to the right of each graph.

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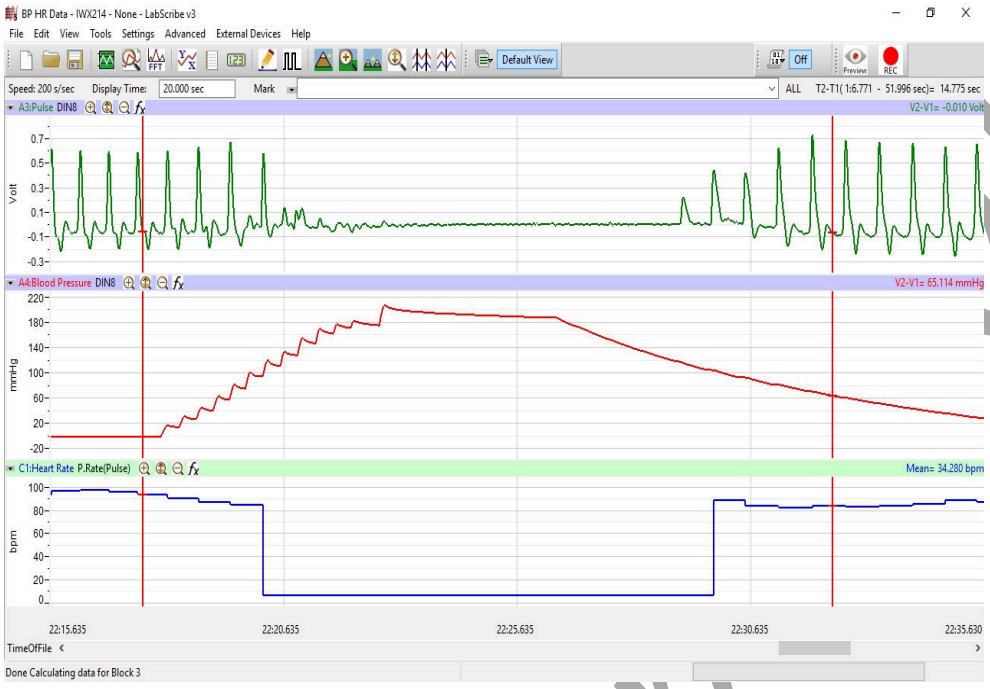

Figure HC-2-L1: The pulse wave, the cuff pressure, and heart rate recorded before, during, and after the occlusion of the brachial artery. Pulses disappear as the pressure in the cuff exceeded the pressure in the artery. As the pressure in the cuff is released, the pulse wave reappears.

4. 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.
5. 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:
6. Place the cursors at the locations used to measure the cuff pressures from the Blood Pressure channel.
7. 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.
8. 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. 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 Steps 5 or 6.

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10. 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. To measure the pulse pressure, switch to Double cursors and position the cursors the same as above. The value for V2-V1 on the Blood Pressure channel is the subject's pulse pressure. Enter this pressure in the table.
    - Heart rate. To measure the heart rate, place the cursors on either side of six adjacent pulses that occurred before the blood pressure cuff was inflated. The value for Mean on the Heart rate channel is the subject's average heart rate. Enter the heart rate in the table.
11. Determine the subject's blood pressure class from Table 1. List it in Table 2.

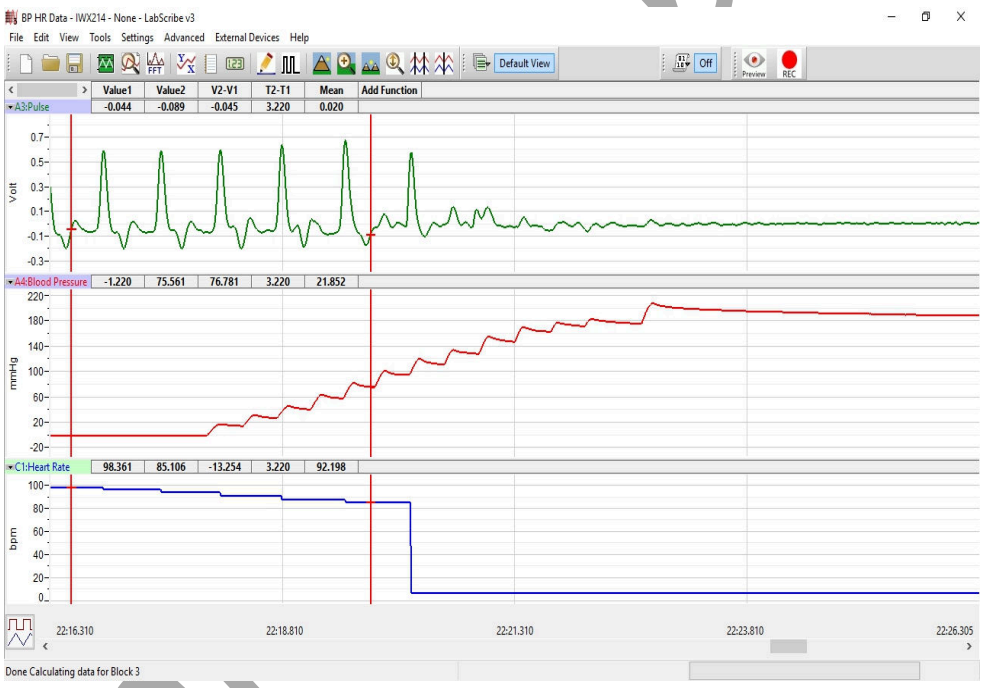

Figure HC-2-L2: The pulse wave, the cuff pressure, and heart rate recorded just before the occlusion of the brachial artery as displayed on the Analysis window. Optional - the cursors are in positions to measure the subject's average heart rate.

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Table HC-2-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

Table HC-2-L2: Blood Pressures and Heart Rates from Subjects in the Class.

Subject	HR (BPM)	Systolic Pressure (mmHg)	Diastolic Pressure (mmHg)	Pulse Pressure (mmHg)	BP Class

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Long and Short Term Experiments

Two types of experiments will be performed in this lab and student subjects should participate in only one type of experiment:

- Long-term experiment—in which measurements are taken every 20 minutes throughout the lab.
- Short-term experiments—in which measurements are taken during a manipulation conducted in the periods between the long-term experiment.

Exercise 2: Effects of Food Additives

Approximate Time: minimum 60 minutes

The effect of food additives will be examined as a class project. If there are 10 lab groups, one individual from each group should participate in the long-term project. One suggestion includes having each willing individual drink 12 ounces of one of the following:

- Caffeinated, regular soda
- Caffeinated, sugar-free soda
- Decaffeinated, regular soda
- Decaffeinated, sugar-free soda
- Water (control)

Other possible studies could include the effects of eating foods with monosodium glutamate (MSG) or drinking sports drinks with different levels of sugars and salts.

Procedure

1. Instruct the subject to sit and relax for at least five minutes before his or her blood pressure is taken.
2. 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 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. Use the same procedures outlined in Exercise 1 to record the subject's blood pressures and heart rate from his or her upper left arm while sitting.
4. After recording the subject's blood pressure while sitting and relaxing, have the subject consume his or her designated drink or food in a short period of time.
5. Every 20 minutes after the food or drink was consumed, have the subject sit down and relax. Record the subject's blood pressures and heart rate for 15-20 seconds. Mark the recording by entering comments in the Mark box and clicking the mark button.
6. Select Save in the File menu.

Data Analysis

1. Use the same techniques used in Exercise 1 to determine and record the systolic, diastolic, and pulse pressures and heart rates of the subject at all the time intervals throughout the long-term experiment.
2. Enter the subject's blood pressures and heart rates at each time interval in Table 3.

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Questions

1. Are there any differences among your subject's blood pressures and heart rates at different time intervals?
2. Check the data from other subjects. Which treatment caused the greatest percentage change in the subject's blood pressure?
3. Which treatment caused the greatest percentage change in the subject's heart rate?

Table HC-2-L3: The Effect of Food Additives on Blood Pressure and Heart Rate

Treatment _____ Time (mins)	Heart Rate (BPM)	Systolic Pressure (mmHg)	Diastolic Pressure (mmHg)	Pulse Pressure (mmHg)
0				
20				
40				
60				
80				
100				
120				

Warning: The subjects participating in the long-term project, Exercise 2: Effects of Food Additives, should not be subjects in the remaining exercises of this experiment. The subjects in the long-term project should function as data collectors for the remaining short-term exercises.

Exercise 3: Effects of Exercise

Aim: To examine the effects of exercise on blood pressure.

Approximate Time: 30 minutes

Procedure

1. Select a new subject and instruct the subject to sit and relax for at least five minutes before his or her blood pressure is taken.

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2. 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 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. Use the same procedures outlined in Exercise 1 to record the subject's blood pressures from his or her upper left arm.
4. After recording the subject's resting blood pressure, remove the blood pressure cuff and pulse sensor from the subject. Leave these devices connected to the iWorx box.
5. Instruct the subject to exercise vigorously enough to elevate his or her heart rate. Running up and down stairs or doing jumping jacks are suitable exercises.
6. While the subject is exercising, type Recovery from Exercise in the Mark box to the right of the Mark button.
7. Immediately after exercising, the subject should sit in a chair. Other members of the group should attach the pulse sensor and blood pressure cuff to the subject as done in Step 2.
8. Click on the Record button, 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. 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.
9. Every thirty seconds after the beginning of the recovery period, pump up the blood pressure cuff and record the subject's blood pressure. Continue to record the subject's blood pressure until the pressures are similar to the resting pressures.
10. Click Stop to halt recording. Select Save from the File menu.

Data Analysis

1. Use the same techniques used in Exercise 1 to determine and record the systolic, diastolic, and pulse pressures and heart rates of the subject at all the time intervals throughout the exercise and recovery experiment.
2. Enter the subject's blood pressures and heart rates at each time interval in Table 4.

Questions

1. Compare the blood pressures before and after exercise. How long does it take your subject's blood pressure to return to the resting level? How does the time it takes your subject's blood pressure to return to normal compare to the times of other subjects?
2. Compare the heart rates before and after exercise. How long does it take your subject's heart rate to return to the resting level? How does your subject's recovery time compare to those of other subjects.

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Table HC-2-L4:The Effect of Aerobic Exercise on Blood Pressure and Heart Rate

Treatment _____ Time (secs)	Heart Rate (BPM)	Systolic Pressure (mmHg)	Diastolic Pressure (mmHg)	Pulse Pressure (mmHg)
Before Test				
0				
30				
60				
90				
120				
150				
180				
210				
240				
270				

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Exercise 4: Effects of Apnea

Aim: To examine the effects of apnea (holding one's breath) on blood pressure.

Approximate Time: 15 minutes

Procedure

1. Use the same methods used in Exercise 1 to record the subject's resting blood pressures from the upper left arm.
2. Instruct the subject to take a deep breath, hold it for as long as possible, and then return to breathing normally. While the subject is holding his or breath, use the same methods used in other exercises to record the subject's blood pressures.
3. As soon as the subject stops holding his or her breath, record the subject's blood pressures and heart rate.
4. Record the subject's blood pressure and heart rate every 30 seconds after the subject stops holding his or her breath.
5. Select Save in the File menu.

Data Analysis

1. Use the same techniques used in Exercise 1 to determine the systolic, diastolic, and pulse pressures of the subject at all the time intervals throughout the long-term experiment.
2. Enter the subject's blood pressures and heart rates at each time interval in Table 5.

Questions

1. What effect does apnea have on the subject's blood pressure?
2. How does the subject's blood pressure change when the subject resumes breathing after apnea?
3. What are the physiological causes of the changes you see in the blood pressure and heart rate.

Table HC-2-L5: The Effect of Apnea on Blood Pressure and Heart Rate

Treatment _____ Time (secs)	Heart Rate (BPM)	Systolic Pressure (mmHg)	Diastolic Pressure (mmHg)	Pulse Pressure (mmHg)
Before Test				
0				
30				
60				
90				
120				
150				

Exercise 5: Effects of Cooling the Forearm

Aim: To measure the effects of cold temperatures on the pulse amplitude and blood pressure.

Approximate Time: 15 minutes

Procedure

1. Use the same methods used in other exercises to record blood pressures from the subject's right forearm. Mark the recording with comments to indicate the subject's name, the location of the blood pressure cuff, and the temperature of the room.

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2. After the blood pressures from the subject's right forearm are recorded, remove the blood pressure cuff from the arm. Leave the pulse sensor attached to the subject's finger to monitor any changes in the subject's pulse amplitude.
3. Type Ice Pack On in the Mark box to the right of the Mark button. Place an ice pack on the ventral side (inside) of the subject's right forearm. Put a couple of paper towels between the ice pack and the subject's arm. Remind the subject to remain motionless during the recordings.
4. As soon as the ice pack is in place, click on the Record button. Click the mark button to mark the recording. Record the subject's pulse for about 10 seconds. Click on the Stop button.
5. At every minute into the ten-minute cooling period, record the subject's pulse for about 10 seconds as it was done in Step 4.
6. Before the end of the ten-minute cooling period, type Ice Pack Removed in the Mark box. Be ready to wrap the blood pressure cuff around the subject's right forearm as soon as the ice pack is removed.
7. At the end of the ten-minute cooling period, remove the ice pack from the subject's arm, and wrap the blood pressure cuff around the subject's right forearm as quickly as possible.
8. Click on the Record button and click the mark button. Use the same methods used earlier to record and identify the blood pressures from the subject's right forearm.
9. At every minute after the end of the cooling period, record and identify the subject's blood pressures. Record every minute for five minutes.
10. Select Save in the File menu.

Data Analysis

1. Use the same techniques used in Exercise 1 to determine and record the systolic, diastolic, and pulse pressures and heart rates of the subject before and after the cooling period.
2. Measure the amplitudes of the pulses prior to the cooling period, during cooling at one-minute intervals, and after cooling at one-minute intervals:
3. Scroll through the recording and find the section of data recorded at the beginning of the cooling period.
4. Use the Display Time or Zoom between Cursors functions to adjust the Display Time of the Main window to show the first ten seconds of the pulse and heart rate at the beginning of cooling period
5. Measure the pulse amplitude by placing one cursor at the beginning of the pulse wave and the other cursor at the peak of the pulse wave. The value for V2-V1 on the Pulse channel is the pulse amplitude. Use one of the two techniques described earlier to record this pulse amplitude in the Journal.
    - Measure the amplitudes of two additional pulse waves adjacent to the first pulse wave measured. Enter these values in the Journal.
    - Calculate the average of these three pulse amplitudes at this time interval. Record this mean in the Journal.

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6. Use the same methods to calculate and record the mean pulse amplitudes at the other time intervals in the cooling period.
7. Enter the subject's blood pressures, heart rates, and mean pulse amplitudes at each time interval in Table 6.

Questions

1. By examining the pulse data during the cooling period, determine if cooling has any effect on pulse amplitude. Explain your conclusion.
2. Determine if cooling has any effect on heart. Explain your conclusion.
3. Determine if cooling has any effect on blood pressure. Explain your conclusion.

Exercise 6: Effects of Warming the Forearm

Aim: To examine the effects of warming the forearm on blood pressure, heart rate and peripheral circulation.

Approximate Time: 15 minutes

Procedure

Use the same methods used in Exercise 5 to test the effects of warming the forearm of a new subject.

Data Analysis

1. Use the same methods used in Exercise 5 to analyze the data recorded in Exercise 6. Record the results in Table 7.

Questions

1. By examining the pulse data during the warming period, determine if warming has any effect on pulse amplitude? Explain your conclusion.
2. Determine if warming has any effect on heart? Explain your conclusion.
3. Determine if warming has any effect on blood pressure? Explain your conclusion.

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Table HC-2-6: The Effects of Cooling on Blood Pressure, Heart Rate, and Pulse Amplitude.

Cooling Time (Mins)	Heart Rate (BPM)	Systolic Pressure (mmHg)	Diastolic Pressure (mmHg)	Pulse Pressure (mmHg)	Pulse Amplitude (V)
Prior					
0					
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
After					
1					
2					
3					
4					
5					

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Table HC-2-L7: The Effects of Warming on Blood Pressure, Heart Rate, and Pulse Amplitude.

Warm. Time (Mins)	Heart Rate (BPM)	Systolic Pressure (mmHg)	Diastolic Pressure (mmHg)	Pulse Pressure(mmHg)	Pulse Amplitude (V)
Prior					
0					
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
After					
1					
2					
3					
4					
5					

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