Experiment HH-1: The Electrocardiogram and Peripheral Circulation

Equipment Required

PC or Mac Computer

IXTA, USB cable, IXTA power supply

iWire-B3G ECG cable and electrode lead wires

PPG-320 Pulse plethysmograph

Disposable ECG electrodes

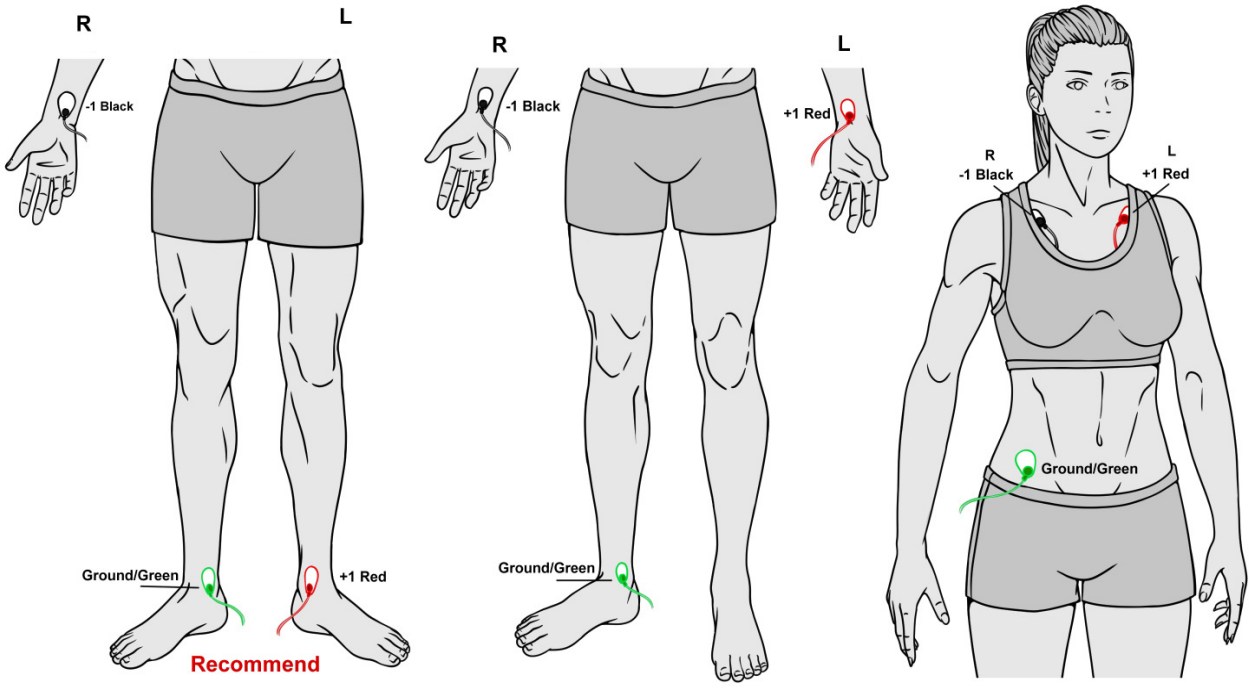
Ice, cold and hot water, plastic bags

Note – You must connect the iWire-B3G to the IXTA prior to turning it on.

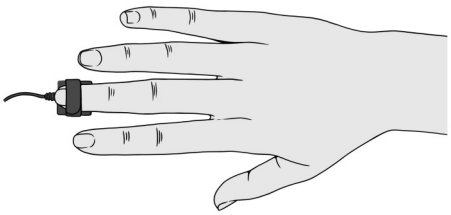
ECG Cable and Pulse Transducer Setup

1. Locate the PPG-320 pulse plethysmograph and iWire-B3G ECG cable and electrode lead wires.
2. Plug the PPG-320 into the PT port on the front of the TA.
3. Insert the connector on the end of the iWire-B3G ECG cable into the iWire 1 input on the front of the IXTA.
4. Insert the connectors on the red, black, and green electrode lead wires into the matching sockets on the ECG cable.
5. Instruct the subject to remove all jewelry from their wrists and ankles. Another option is to use the area just under each clavicle which will give a better recording.
6. Use an alcohol swab to clean and scrub a region with little or no hair, on the inside of the subject's right wrist/clavicle. Let the area dry.
7. Repeat for the inside of the left wrist/clavicle and the inside of the right ankle or lower right abdomen.
8. Snap the lead wires onto the electrodes, so that:
    - the red (+1) lead is attached to the left ankle, left wrist or just under the left clavicle,
    - the black (-1) lead is connected to the right wrist or just under the right clavicle,
    - the green (ground) lead is connected to the right leg or on the abdomen.

IWorX Sample Lab



9. Place the plethysmograph on the volar surface (where the fingerprints are located) of the distal segment of the subject's middle finger or thumb, and wrap the Velcro[tm] strap around the end of the finger to attach the unit firmly in place.



10. Instruct the subject to sit quietly with their hands in their lap. If the subject moves, the ECG trace will move off the top or bottom of the screen. If the subject moves any muscles in the arms or upper body, electromyograms (EMGs) from the muscles will appear as noise.

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Figure HH-1-S2: The ECG cable and pulse sensor connected to an IXTA.

iWorx Sam

Experiment HH-1: The Electrocardiogram and Peripheral Circulation

Exercise 1: The ECG and the Pulse in a Resting Subject

Aim: To measure and correlate the ECG and the pulse in a resting individual.

Approximate Time: 15 minutes

Procedure

1. Click on the Record button. The signal should begin scrolling across the screen.
2. Click on the AutoScale button at the upper margin of the ECG and Pulse channels. Your recording should look like the image below.

   • 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.
3. When you have a suitable trace, type **Resting ECG/Pulse** 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.

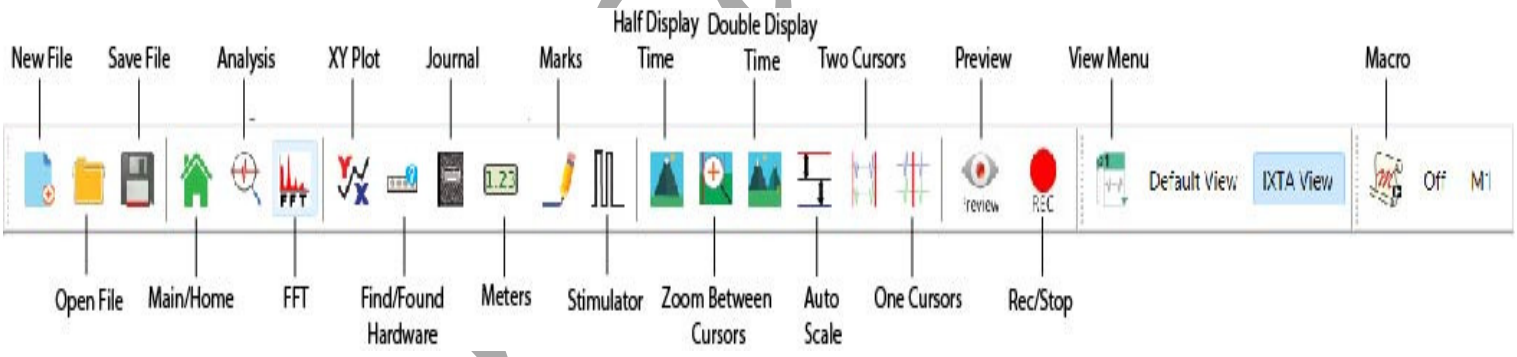

Figure HH-1-L1: The LabScribe toolbar.

Work Sample Lab

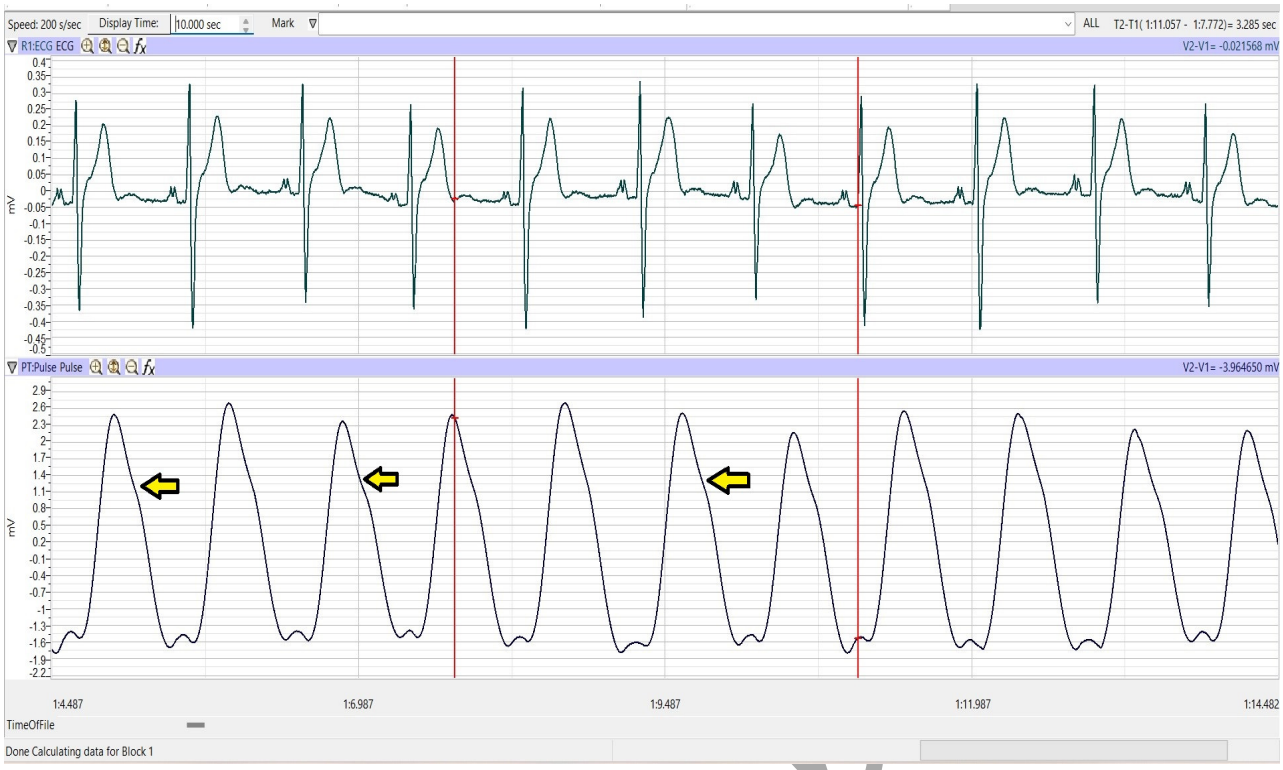

Figure HH-1-L2: ECG and pulse displayed on the Main window. The arrows are showing the small indent of the dicrotic notch.

5. Select Save As in the File menu, type a name for the file. Click on the Save button to save the data file.

Data Analysis

1. Scroll through the recording and find a section of data with 10 exemplary ECG/pulse cycles in succession.
2. Use the Display Time icons to adjust the Display Time of the Main window to show the 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 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 in the Analysis window, or to the right of each graph on the Main screen.
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, or on a separate data table.

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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 amplitudes and period of the ECG/Pulse cycle.
    - Transfer the names of the mathematical functions used to determine the amplitudes and time interval to the Journal using the Add Title to Journal function in the ECG Channel pull-down menu.
    - Transfer the values for the amplitudes and beat period to the Journal using the Add Ch. Data to Journal function in the ECG Channel pull-down menu.

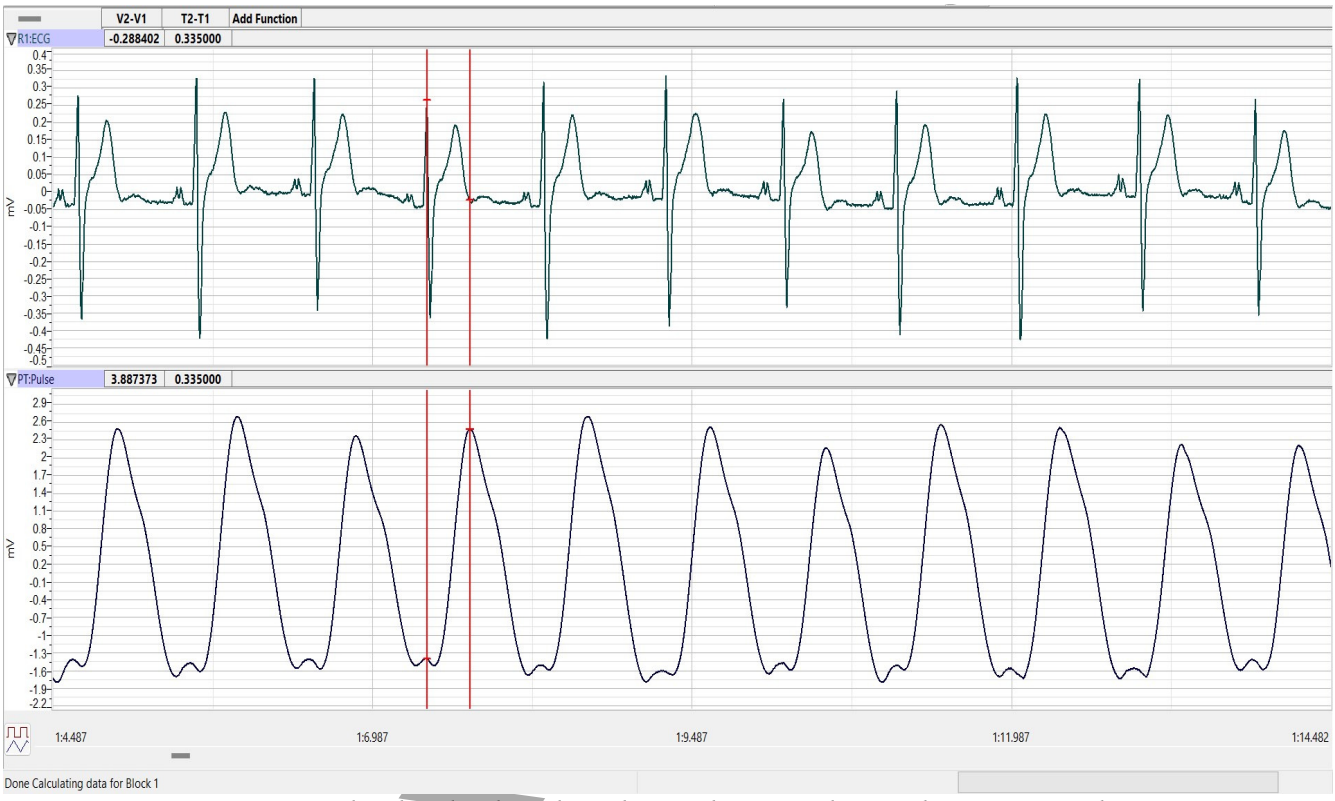

Figure HH-1-L3: ECG and pulse displayed on the Analysis window with cursors in place to measure the R-Pulse interval with the T2-T1 function.

7. Use the mouse to click on and drag the cursors to specific points on the ECG/Pulse recording to measure the following (measure at least 5 ECG cycles):
    - The beat period, which is the time interval between two adjacent R waves. Place one cursor on the peak of an R wave and the second cursor on the peak of the adjacent R wave. The value for T2-T1 on the ECG channel is the beat period.

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- 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. Place one cursor on the peak of an R wave and the second cursor on the peak of the pulse wave to its right as shown in Figure HH-1-L3. The value for T2-T1 is this interval.

8. Calculate the following values and record your results into the Journal or on a separate data table:
    - The average beat period, in seconds/beat.
    - The heart rate, which is expressed in beats per minute and calculated from the average beat period by using the following equation:

$$\textbf{Heart Rate (beats/minute)} = \frac{\textbf{60 seconds/minute}}{\textbf{\# seconds/beat}}$$

    - The average R-Pulse interval.

Questions

1. What electrical and mechanical events take place during the R wave?
2. What events take place in the cardiovascular system during the R and pulse waves?
3. The signal recorded on the Pulse channel is rate of change of the blood pressure entering the subject's finger tip. Is there a short plateau or dip during each cycle (see Figure HH-1-L2). This plateau or dip is called the dicrotic notch. If you optimized the tension on the plethysmograph strap to record a large, clean pulse wave from your subject, you should see a dicrotic notch a bit better.
4. What event recorded on the Pulse channel corresponds to the dicrotic notch? What causes a dicrotic notch?

Exercise 2: The ECG and the Pulse in Other Subjects

Aim: To measure and correlate the ECG and the pulse in other subjects.

Approximate Time: 15 minutes per subject

Procedure

Repeat Exercise 1 on other subjects.

Data Analysis

Analyze the data for each subject using the same techniques used in Exercise 1.

Questions

1. Is the time interval between the R wave and the peak of the pulse wave the same for each subject? Does this time interval differ with heart rate?
2. Do you see any differences in the size or shape of dicrotic notches from different subjects? Remember: the tension on the plethysmograph strap affects the shape of the pulse recording.

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3. Is the time interval between the peak of the pulse wave and the bottom of the dicrotic notch the same for each subject?
4. What factors would affect the shape or position of the dicrotic notch?

Exercise 3: The Effect of Cold on the Pulse

Aim: To measure the effects of cold on the pulse and heart rate.

Approximate Time: 30 minutes

Procedure

1. Attach the plethysmograph to the middle finger of the subject's left hand. Instruct the subject to sit quietly with their hands in their lap.
2. Click on the Record button.
3. Click on the AutoScale button at the upper margin of the ECG and Pulse channels. Your recording should look like Figure HH-1-L4. Use the same techniques used in Exercise 1 to display the signals properly.
4. When you have a suitable trace, type **RoomTempECG/Pulse** in the Mark box. Click the mark button. Record for a minute or two.
5. Type **Cold ECG/Pulse** in the Mark box. Place a bag containing a mixture of ice and cold water on the subject's left forearm. At the same time, click the mark button to attach the comment to the data. Record for two minutes while the cold pack is on the subject's forearm.
6. Type **Remove** in the Mark box. Simultaneously remove the ice bag and click the mark button.
7. Record for an additional two minutes; then, click Stop to halt recording.
8. Select Save in the File menu on the LabScribe window.

Data Analysis

1. Analyze the data using the same techniques used in Exercise 1.
2. Use the mouse to click on and drag the cursors to specific points on the ECG/Pulse recording to measure the following:
   - The pulse wave amplitude. To measure the pulse wave amplitude, place one cursor on the baseline that precedes the pulse wave and the second cursor on the peak of the pulse wave as shown in Figure HH-1-L4. The value for V2-V1 on the Pulse channel is this amplitude. Determine the pulse amplitude for three pulse waves.
   - The beat period. Measure the time between two adjacent R waves using the same technique employed in Exercises 1 and 2. Determine the beat period for three. ECG/Pulse cycles.
   - The R-Pulse interval. Measure the time between the peak of the R wave and the peak of the pulse wave using the same technique employed in Exercises 1 and 2. Determine this interval for three ECG/Pulse cycles.

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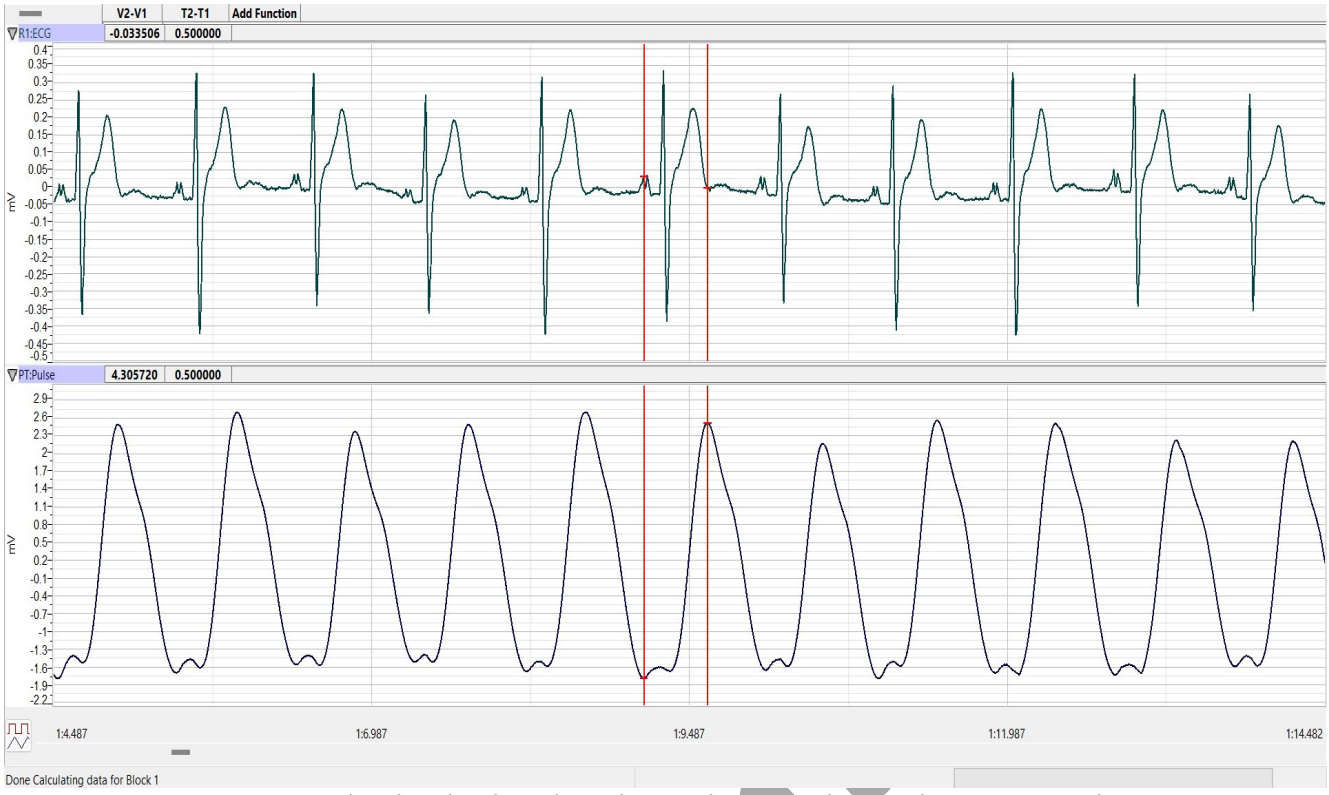

Figure HH-1-L4: ECG and pulse displayed on the Analysis window with cursors in place to measure the pulse amplitude with V2-V1 function.

3. Repeat Steps 5 and 6 from Data Analysis in Exercise 1 for the data at 1 and 2 minutes into the cooling period, and at 1 and 2 minutes into the rewarming period
4. Calculate the following values and type your results into the Journal or on a separate data table:
    - The average pulse wave amplitude while the forearm was at room temperature, cooled for 1 and 2 minutes, or rewarmed for 1 and 2 minutes.
    - The heart rate while the forearm was at room temperature, cooled for 1 and 2 minutes, or rewarmed for 1 and 2 minutes.
    - The average R-Pulse interval while the forearm was at room temperature, cooled for 1 and 2 minutes, or rewarmed for 1 and 2 minutes.

Questions

1. What effect does cooling have on the amplitude of the pulse wave?
2. Does cooling of the forearm affect the heart rate, or the time interval between the R wave and the peak of the pulse wave?
3. Through what mechanism does cooling affect the peripheral circulation?
4. What other factors may affect peripheral circulation?

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Exercise 4: The Effect of Heat on the Pulse

Aim: To measure the effects of heat on the pulse and heart rate.

Approximate Time: 30 minutes

Procedure

1. Move the plethysmograph to the middle finger or thumb of the subject's right hand.
2. Follow the directions used in Exercise 3 to do an experiment on the right forearm of the subject with a bag of warm water. Mark the recording to indicate when the bag of warm water was applied and removed from the forearm.

Questions

1. What effect does warming have on the amplitude of the pulse wave?
2. Does warming of the forearm affect the heart rate, or the time interval between the R wave and the peak of the pulse wave?
3. Through what mechanism does warming affect the peripheral circulation?

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