

# Heart Rate and Blood Pressure as Vital Signs

Since the earliest days of medicine heart rate has been recognized as a *vital sign*—an indicator of health, disease, excitement, and stress. Medical personnel use the heart rate to provide clues as to the presence of many medical conditions. Reflex changes in heart rate are one of the body's most basic mechanisms for maintaining proper perfusion to the brain and other tissues. Low blood volume caused by bleeding or dehydration results in the heart beating faster as it attempts to maintain adequate blood pressure. Excitement, stress, and anxiety activate the nervous system, which may also speed the heart rate and raise blood pressure.

By the second half of the 19<sup>th</sup> century a non-invasive method for measuring blood pressure had been invented. Called a *sphygmomanometer*, this instrument is still in use today allowing us to measure this important vital sign.

Blood pressure is a measure of the changing fluid pressure within the circulatory system. It varies from a peak pressure produced by contraction of the left ventricle, to a low pressure, which is maintained by closure of the aortic valve and elastic recoil of the arterial system. The peak pressure is called *systole*, and the pressure that is maintained even while the left ventricle is relaxing is called *diastole*.

Blood pressure and heart rate are interrelated, and both are influenced by the sympathetic and parasympathetic nervous systems. Sympathetic activation raises blood pressure in addition to pulse. After an initial activation of the sympathetic nervous system, the increase in blood pressure stretches nerve fibers in the baroreceptors (see Figure 1). This results in a reflex activation of the parasympathetic nervous system, which, through actions opposite to those of the sympathetic nervous system, helps to restore homeostasis.

In this experiment, you will observe how the heart and circulatory system respond to cold stimulus applied peripherally. Cold will act as a noxious stimulus, activating the “fight or flight” response through the sympathetic nervous system.

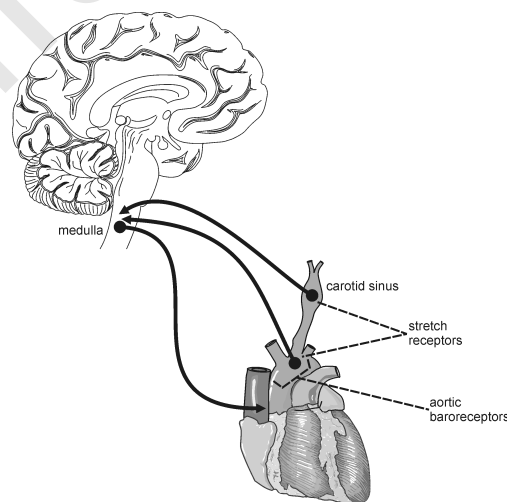


Figure 1

## OBJECTIVES

In this experiment, you will

- Obtain graphical representation of heart rate and blood pressure.
- Compare heart rate and blood pressure before and after exposure to cold stimulus.
- Observe an example of sympathetic nervous system activation (“fight or flight response”).

## MATERIALS

computer	Vernier Blood Pressure Sensor
Vernier computer interface	ice water bath
Logger Pro	towel
Vernier Hand-Grip Heart Rate Monitor <b>or</b>	saline solution in dropper bottle
Vernier Exercise Heart Rate Monitor	(only for use with Exercise HR Monitor)

## PROCEDURE

### Part I Baseline Blood Pressure Determination

1. Connect the Blood Pressure Sensor to Channel 1 of the Vernier computer interface. There are two rubber tubes connected to the pressure cuff. One tube has a black Luer-lock connector at the end and the other tube has a bulb pump attached. Connect the Luer-lock connector to the stem on the Blood Pressure Sensor with a gentle half turn if it is not already attached.
2. Open the file “10a Heart Rate and BP” from the *Human Physiology with Vernier* folder.
3. Attach the Blood Pressure cuff firmly around the upper arm, approximately 2 cm above the elbow. The two rubber hoses from the cuff should be positioned over the biceps muscle (brachial artery) and not under the arm (see Figure 2).
4. Have the subject sit quietly in a chair with forearms resting on his/her lap, or on a table surface. *The person having his or her blood pressure measured must remain still during data collection; there should be no movement of the arm or hand during measurements.*
5. Click  to begin data collection. Immediately begin to pump until the cuff pressure reaches at least 160 mm Hg. Stop pumping. The cuff will slowly deflate and the pressure will fall. During this time, the systolic, diastolic, and mean arterial pressures and the pulse will be calculated by the software. These values will be displayed on the computer screen. When the cuff pressure drops below 50 mm Hg, the program will stop calculating blood pressure. At this point, you can terminate data collection by clicking . Release the pressure from the cuff, but do not remove it.
6. Enter the systolic, diastolic, and mean arterial pressures in Table 1.



Figure 2

### Part II Heart Rate and Blood Pressure Response to Cold

7. Connect the receiver module of the Heart Rate Monitor to Channel 2 of the Vernier computer interface. Open the file “10b Heart Rate and BP” from the *Human Physiology with Vernier* folder.

8. Set an ice water bath on the floor, next to the subject's feet.
9. Prepare to collect data.
  - a. Sit in a chair.
  - b. Prepare to submerge your foot in the ice water bath by removing your shoe and sock.
  - c. Position your foot adjacent to the ice water bath, but do not put it in the bath yet.
10. Set up the Heart Rate Monitor. Follow the directions for your type of Heart Rate Monitor.

**Using a Hand-Grip Heart Rate Monitor**

- a. The receiver and one of the handles are marked with a white alignment arrow as shown in Figure 3. Locate these two arrows.
- b. Have the subject grasp the handles of the Hand-Grip Heart Rate Monitor so that their fingers are in the reference areas indicated in Figure 4. Hold the handles vertically.
- c. Have someone else hold the receiver near the handles so that the two alignment arrows are pointing in the same direction and are at approximately the same height as shown in Figure 3. **Note:** The receiver must stay within 60 cm of the handles during data collection.

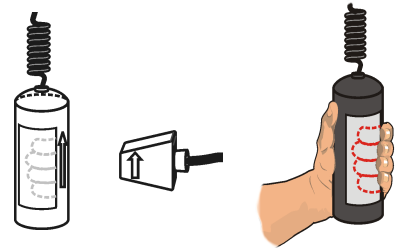


Figure 3

Figure 4

**Using an Exercise Heart Rate Monitor**

- a. Depending upon your size, select a small- or large-size elastic strap. Secure one of the plastic ends of the elastic strap to the transmitter belt. It is important that the strap provide a snug fit of the transmitter belt.
- b. Wet each of the electrodes (the two textured oval areas on the underside of the transmitter belt) with 3 drops of saline solution.
- c. Secure the transmitter belt against the skin directly over the base of the rib cage (see Figure 5). The POLAR logo on the front of the belt should be centered. Adjust the elastic strap to ensure a tight fit.
- d. Affix the receiver module of the Heart Rate Monitor to a ring stand or table within 80 cm of the transmitter in the Heart Rate Monitor belt.

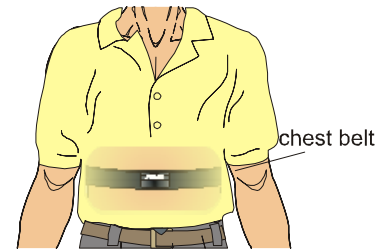



Figure 5

11. With the subject sitting quietly, click  to begin data collection.
  - a. At 40 s, instruct the subject to submerge his/her foot in the ice water bath.
  - b. Immediately pump the bulb pump of the Blood Pressure Sensor until the cuff pressure reaches at least 160 mm Hg. Stop pumping.
  - c. At 70 s instruct the subject to remove his/her foot from the ice water bath.
  - d. As data collection continues, the cuff will slowly deflate and the pressure will fall. During this time, the systolic, diastolic, and mean arterial pressures will be calculated by the software. When the cuff pressure drops below 50 mm Hg, the program will stop calculating blood pressure.
  - e. The subject should remain seated and allow data collection to continue for the full 240 s data-collection period.

12. Enter the systolic, diastolic, and mean arterial pressures in Table 2.
13. Click and drag over the area of the heart rate graph where the resting (“baseline”) heart rate is displayed (15–40 s). Click the Statistics button, . The Statistics box will appear with the statistics calculated for the selected region. Record the mean resting heart rate, to the nearest whole number, in Table 3.
14. Move the statistics brackets to highlight the region of the graph beginning at 40 s (when the foot was immersed in the ice water bath) and ending at the first peak (see Figure 6). Record the maximum heart rate value to the nearest whole number in Table 3. In the corresponding Time column record (to the nearest whole number) the  $\Delta x$  value displayed at the lower left corner of the graph.

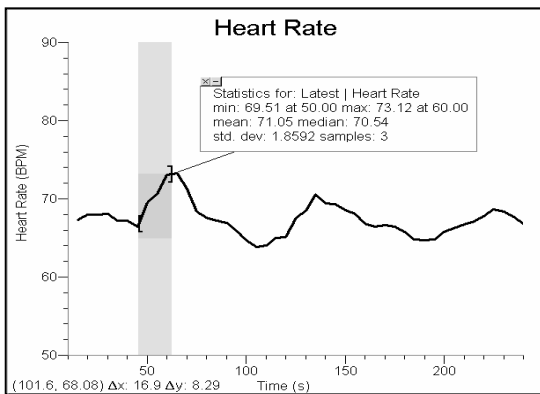


Figure 6

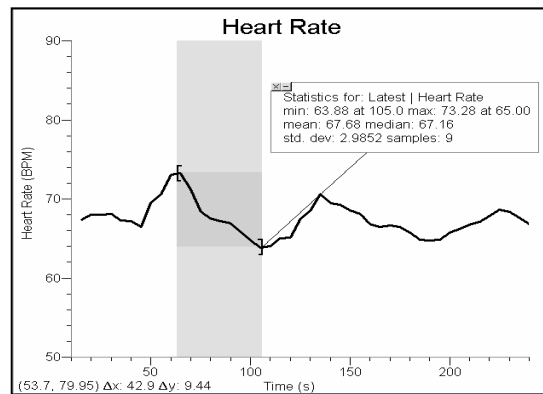


Figure 7

15. Move the Statistics brackets to enclose the region of the graph beginning at the first peak and ending at the lowest point in the valley that follows (see Figure 7). Record the minimum heart rate value to the nearest whole number as the Rebound heart rate in Table 3. Record the  $\Delta x$  value in the corresponding Time column.

**DATA**

Table 1–Baseline Blood Pressure		
Systolic pressure (mm Hg)	Diastolic pressure (mm Hg)	Mean arterial pressure (mm Hg)

Table 2–Blood Pressure Response to Cold		
Systolic pressure (mm Hg)	Diastolic pressure (mm Hg)	Mean arterial pressure (mm Hg)

Table 3		
Condition	Heart rate (bpm)	Time (s)
Resting heart rate		
Maximum heart rate		
Rebound heart rate		

**DATA ANALYSIS**

1. Describe the trends that occurred in the systolic pressure, diastolic pressure, mean arterial pressure, and heart rate with cold stimulus. How might these responses be useful in a “fight or flight” situation?
  
2. As a vital sign, blood pressure is an indicator of general health. A high blood pressure (140/90 or higher) increases the risk of cardiovascular disease and strokes. Collect the systolic and diastolic pressures for the class and calculate the average for each. Rate the class average blood pressure using the follow scale:

Blood Pressure	Category
140/90 or higher	High
120–139/80–89	Pre-hypertension
119/79 or below	Normal

## *Computer 10*

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3. How long after immersion did your heart rate reach its maximum value? Explain the physiologic mechanism that led to this change in heart rate.
  
4. Describe the changes in heart rate that occurred after the maximum value. How can you explain the minimum heart rate value? How would you explain the heart rate variations seen in the remainder of the experiment?
  
5. How long after the maximum heart rate did it take to arrive at your rebound heart rate? What can you say about the relative speed of physiologic response to a stimulus *vs.* the speed of mechanisms that are designed to maintain homeostasis?
  
6. If the heart rate is too slow there is inadequate blood pressure to maintain perfusion to the brain. This can lead to loss of consciousness (fainting). Keeping in mind the autonomic nervous system responses that you observed in this experiment, explain the sequence of events that results in a severely frightened person fainting.

# Vernier Lab Safety Instructions Disclaimer

**THIS IS AN EVALUATION COPY OF THE VERNIER STUDENT LAB.**

This copy does not include:

- Safety information
- Essential instructor background information
- Directions for preparing solutions
- Important tips for successfully doing these labs

The complete *Human Physiology with Vernier* lab manual includes 24 labs and essential teacher information. The full lab book is available for purchase at:

<http://www.vernier.com/cmat/hpa.html>



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