

Group No. \_\_\_\_\_

Date: \_\_\_\_\_

Names: \_\_\_\_\_

## EHA Physiology: Challenges and Solutions Lab 1

### Heart Rate Response to Baroreceptor Feedback

One of the homeostatic mechanisms of the human body serves to maintain a fairly constant blood pressure. Major determinants of blood pressure are heart rate, amount of blood pumped with each beat (*stroke volume*), and the resistance of the arterial system which is receiving the blood. The heart rate is influenced by **baroreceptors**, special sensors in tissues in the **aortic arch** and **carotid sinuses** which contain nerve endings that respond to stretching (see Figure 1). An increase or decrease in stretch sends signals to the **medulla oblongata** in the **brain stem** which in turn acts on the heart through the **vagus nerve** and **cardiac accelerator nerve**, completing what is called a **negative feedback loop**. Sudden increase in pressure in the heart or carotid sinuses causes an increase in stretch of the baroreceptor sensors and results in a decrease in heart rate. Sudden lowering of pressure causes the opposite effect. This feedback loop enables us to function in a gravity environment.

Most people have experienced the sensation of dizziness after standing abruptly from a seated or squatting position. This effect can be seen in healthy individuals, but it is accentuated in the elderly and in certain conditions including dehydration and Parkinson's disease. In these cases, the increase in heart rate may be significant but is still not able to make up for an insufficiency of the other two contributors to blood pressure (i.e., low blood volume or poor regulation of the resistance of the arterial system by the **sympathetic nervous system**). One of the first tests performed by doctors on patients who complain of dizziness is to check the blood pressure and pulse with the patient lying down and then standing. **A drop in blood pressure of 20 points or an increase in heart rate of 20 points with standing is considered significant.** This condition is called **orthostatic hypotension**.

In this experiment, you will observe **heart rate** response to squatting and to standing from a squatting position. In the former, there is a rapid increase in **venous return** to the heart as veins in the leg muscles are compressed. This causes a sudden increase in **stroke volume** and pressure sensed by the

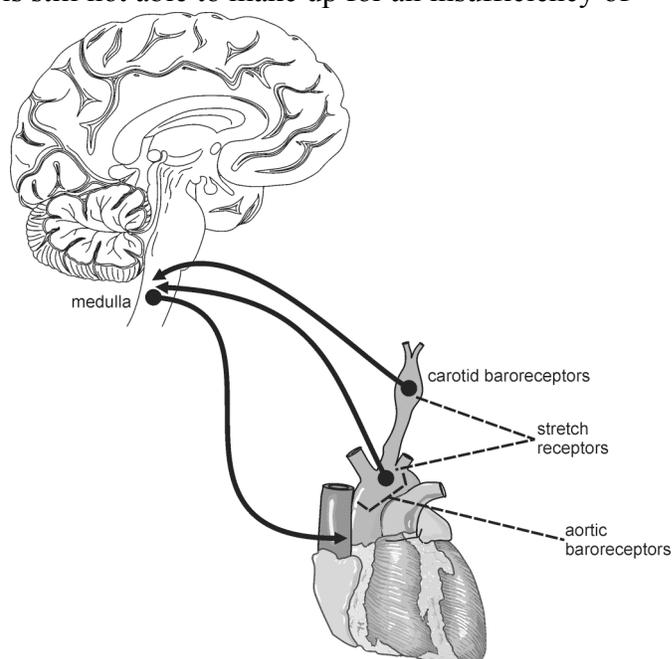


Figure 1

baroreceptors. In standing from a squatting position, there is a sudden

reduction in venous return to the heart because of “pooling” of blood in the legs. This results in a decrease in stroke volume and pressure.

**Important:** Do not attempt this experiment if you suffer from knee pain or dizzy spells. Inform your instructor of any possible health problems that might be exacerbated if you participate in this exercise.

## OBJECTIVES

In this experiment, you will

- Observe pulse response to sudden squatting.
- Observe pulse response to sudden standing from a squatting position.
- Correlate pulse response to sympathetic nervous parasymphathetic nervous system functions.

## MATERIALS

1. Computer
2. Vernier computer interface
3. Logger *Pro*
4. Vernier Hand-Grip Heart Rate Monitor

## PROCEDURE

1. Connect the **receiver module** of the Heart Rate Monitor to the **LabQuest unit**. Open the file “05 Heart Rate Response” from the *Human Physiology with Vernier* folder. **Note: the file should open automatically when the receiver module is connected with the LabQuest unit.**
2. Set up the 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 2. 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 3. 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 2. **Note:** The receiver must stay within 60 cm of the handles during data collection.



Figure 2

Figure 3

3. To determine that everything is set up correctly, click  on the screen of the LabQuest unit to begin monitoring heart rate. Note that there may be up to a 30 second delay before data are seen. The readings should be within the normal range of the individual, usually between **55 and 80 beats per minute**. Click  when you have determined that the equipment is operating properly, and proceed to Step 4.
4. After at least 60 s of stable baseline data has been collected, rapidly lower yourself into a squatting position. Maintain this position until your heart rate returns to the initial baseline rate.
5. After obtaining 10–20 s of stable heart rate values, rise rapidly to a standing position. Continue to record data until the baseline heart rate has been achieved, or until the end of the run. Data will be collected for 400 s.
6. Using the stylus attached to the LabQuest unit, click and drag to highlight the **baseline data** prior to squatting. Click the Statistics button,  , and record the **mean value** (to the nearest whole number) as the Baseline heart rate in Table 1.
7. Drag the right bracket to include the last data point of the run. Record the minimum and maximum heart rates for the total run (to the nearest whole number) in Table 1. These values will be displayed in the Statistics box.
8. On the graph, drag the Statistics brackets to select the region between the heart rate immediately prior to squatting and the maximum or minimum heart rate (first peak or valley) that follows squatting. Record the  $\Delta x$  value (time) displayed in the lower left corner of the graph in Table 2 (to the nearest whole number) as “Response time 1.”
9. Repeat Step 8 for the following regions:
  - a. From the maximum or minimum heart rate following squatting to the beginning of a new stable heart rate. Record the  $\Delta x$  value (time) displayed in the lower left corner of the graph in Table 2 as “Recovery time 1.”
  - b. The region just prior to standing and the maximum heart rate after standing. Record the  $\Delta x$  value (time) displayed in the lower left corner of the graph in Table 2 as “Response time 2.”
  - c. The region between the maximum heart rate after standing and the point at which the heart rate has re-stabilized (i.e., stable for at least 40 s). Record the  $\Delta x$  value (time) displayed in the lower left corner of the graph in Table 2 as “Recovery time 2.”

## DATA

Table 1		
Baseline heart rate (bpm)	Minimum heart rate (bpm)	Maximum heart rate (bpm)

Table 2			
Baroreceptor response time 1: Squatting (s)	Recovery time 1 (s)	Baroreceptor response time 2: Standing (s)	Recovery time 2 (s)

## DATA ANALYSIS

1. After collecting and saving the data for Tables 1 and 2 above for each member of your group during this laboratory session on your flash drive, you will analyze the data and construct the tables and graphs in the EHA computer class.
  2. Construct Table 3 so that it includes all the pertinent for each member of your group. Properly label your graph.
  3. Representative from each lab group will then work together and construct Table 4 that includes the data for the entire class. Properly label the class data graph.
  4. Construct Graph 1 showing the heart rate range (baseline, minimum and maximum) for each student. Be sure to properly set up and label your graph.
  5. Construct Graph 2 showing the recovery time 1 and recovery time 2 for each student. Be sure to properly set up and label your graph.
  6. Each individual lab group is to analyze the class data contained in Table 4 and Graphs 1 and 2 and answer the questions 1 through 11. Class time in both the EHA Physiology and Computer Science classes will be allotted to answering the questions.
1. How much and in which direction (increase or decrease) did the heart rate change as a result of
    - a. standing?

- b. squatting?
2. Changing the heart rate is only one of a variety of homeostatic mechanisms that maintain a fairly constant blood pressure during changes in body position. The sympathetic nervous system helps by adjusting peripheral resistance in the arterial system. As this occurs the heart rate is able to normalize again. Compare the duration of the initial direction of heart rate change after standing to the recovery time. What does your data tell you about the relative speed of the change in peripheral vascular resistance as compared to that of the heart rate response?
  3. Dizziness may result from low blood pressure and can occur in patients who take medicines which impair the ability of the heart to increase its rate. Given what you have learned from your data, which daily activities would be most likely to cause dizziness in people who take these medications?
  4. Using your knowledge of heart rate response to a decrease in blood volume returning to the heart, suggest a way to evaluate (without the use of medical equipment) whether significant blood loss has occurred in an accident victim.
    5. The majority of astronauts who are in a microgravity environment for several weeks will experience orthostatic hypotension and dizziness on return to Earth. What are possible mechanisms for this?
    6. Which afferent nerves conduct electrochemical impulses to the Cardiovascular Center in the medulla oblongata?
    7. Explain the physiological significance of having the baroreceptors located in the carotid arteries.
    8. Explain why the homeostatic maintenance of heart rate and blood pressure is achieved through a negative feedback mechanism.
    9. What would be the result on cardiac output with increased parasympathetic stimulation? Explain in detail the parasympathetic nervous system effects on heart rate, stroke volume and peripheral resistance

10. Why is the vagus nerve (N. X) classified as a mixed nerve?
  
11. What is tachycardia? In a patient suffering from tachycardia, does his cardiac output increase or decrease? Explain.