Ventilation and Heart Rate

In this experiment, you will investigate the effect of altering the levels of oxygen and carbon dioxide on the rate at which the heart beats. Two different methods of ventilation will be used to investigate this phenomenon. The first method, *hyperventilation*, is when the breathing rate of an organism is greater than what is necessary for proper exchange of oxygen and carbon dioxide. This will be achieved by a period of rapid breathing by the test subject. The second method, *hypoventilation*, occurs when there is a decrease in ventilation without a decrease in oxygen consumption or carbon dioxide production by the body. True hypoventilation is usually the result of a disease. The test subject will simulate this condition by holding his or her breath for a period of time. Heart rate will be monitored using a Heart Rate Monitor.

OBJECTIVES

In this experiment, you will

- Monitor the heart rate of the test subject using a Heart Rate Monitor.
- Evaluate the effects of hyperventilation and hypoventilation on heart rate.

MATERIALS

TI-Nspire handheld **or**
computer and TI-Nspire software
data-collection interface
Vernier Hand-Grip Heart Rate Monitor **or**
Vernier Exercise Heart Rate Monitor
dropper bottle with saline solution
(only for use with the Exercise HRM)

PROCEDURE

Each person in a lab group will take turns being the subject and the tester. When it is your turn to be the subject, your partner will be responsible for recording the data on your lab sheet.

1. Connect the receiver module of the Heart Rate Monitor to the data-collection interface. Connect the interface to the TI-Nspire handheld or computer.
2. Choose New Experiment from the Experiment menu. Choose Collection Setup from the Experiment menu. Choose the Data Marker option and select OK.
3. Set up the Heart Rate Monitor. Follow the directions for your type of Heart Rate Monitor.

   Using a Hand-Grip Heart Rate Monitor

   a. Grasp the handles of the Hand-Grip Heart Rate Monitor. Place the fingertips of each hand on the reference areas of the handles (see Figure 1).
   b. The left hand grip and the receiver are both marked with an alignment arrow. When collecting data, be sure that the arrow labels on each of these devices are in alignment (see Figure 2) and that they are not too far apart. The reception range of the plug-in receiver is 80–100 cm, or 3 feet.

Figure 1

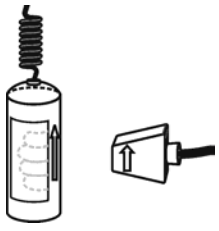

Figure 2

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 3). The POLAR logo on the front of the belt should be centered. Adjust the elastic strap to ensure a tight fit.
d. Take the receiver module of the Heart Rate Monitor in your right hand. Remember that the receiver must be within 80 cm of the transmitter in the Heart Rate Monitor belt.

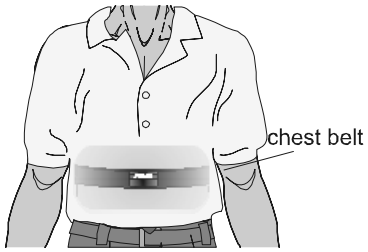

Figure 3

4. Start data collection (). Determine that the sensor is functioning correctly. The readings should be consistent and within the normal range of the individual, usually between 55 and 80 beats per minute. When you have determined that the equipment is operating properly, stop data collection () and proceed to Step 5.

Part I Hyperventilation

5. Collect data while the subject hyperventilates.
   a. Instruct the subject to sit still in a chair and breathe normally.
   b. Start data collection ().
   c. After collecting data for 30 seconds, click the Add Data Marker button () and have the subject make rapid shallow breaths for the next 30 seconds.
   d. After 30 seconds of hyperventilation, click the Add Data Marker button () and have the subject breathe normally until data collection stops.
6. Labeling the marked data points.
   a. After data collect is complete. Double click on the point marked in Step 5c. Label this point **Start**.
   b. Double click on the point marked in Step 5d. Label this point as **Stop**.
7. Click any data point and use ► and ◄ to examine the data pairs on the displayed graph. The coordinates of the points are displayed in the Graph View details box. Record the heart rate data in Table 1 for every 10 second interval.

Part II Hypoventilation (simulated)

8. Click the Store Latest Data Set button () to save the hyperventilation data.
9. Collect data while the subject hypoventilates.
   a. Instruct the subject to sit still in a chair and breathe normally.
   b. Start data collection ().
   c. After collecting data for 30 seconds, click the Add Data Marker button () and have the subject take a large breath and hold it as long as possible. *Note: the subject should not hold his or her breath longer than 60 seconds.*
   d. When the subject releases their breath, click the Add Data Marker button (). The subject should breathe normally until data collection stops.

10. Labeling the marked data points.
    a. After data collect is complete. Double click on the point marked in Step 9c. Label this point **Hold**.
    b. Double click on the point marked in Step 9d. Label this point as **Release**.
11. Examine the data and record the heart rate data in Table 1 for every 10 second interval.
12. Click **run2** and select All. Both runs will now be displayed on the same graph axes.
13. (optional) Print a graph of heart rate *vs*. time (with two curves displayed). Label each curve as "hyperventilation" or "hypoventilation".

DATA

Table 1												
Time (s)	10	20	30	40	50	60	70	80	90	100	110	120
Hyperventilation												
Hypoventilation												

QUESTIONS

1. What happens to the heart rate during hyperventilation?
2. How long did it take the subject's heart rate to respond to hyperventilation?
3. What happens to the heart rate during hypoventilation?
4. How long did it take the subject's heart rate to respond to hypoventilation?
5. List several factors that you think may have caused the test subject's heart rate to change in each of the trials.
6. What happens to the oxygen levels in your lungs during hyperventilation? Carbon dioxide levels?
7. In what way would the change in heart rate that corresponds with holding your breath be advantageous in other types of organisms? What organisms might commonly exhibit such an adaptation?