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# Exercise and Heart Rate

## Driving Questions

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The rate of heart beat is usually directly related to the volume of blood flowing through the body.

- ◆ Does heart rate change based on your activity level?

## Background

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Heart rate is a term used to describe the frequency of the cardiac cycle. Usually, heart rate is calculated as the number of contractions (beats) of the heart in one minute. Therefore, heart rate is usually expressed as beats per minute (bpm). When resting, the typical adult human heart beats at about 70 bpm in males and 75 bpm in females, although this rate varies among people. The pulse is one way of measuring heart rate.

The body increases heart rate in response to a wide variety of conditions in order to increase the cardiac output (the amount of blood ejected by the heart per unit time). Exercise causes a person's heart rate to increase above the resting heart rate. As the physical activity becomes more vigorous, the heart rate continues to increase. With sufficiently vigorous exercise, the heart rate reaches its maximum rate.

The reference range for resting heart rate is between 60 bpm and 100 bpm. Less than 60 bpm is termed bradycardia. Greater than 100 bpm is termed tachycardia.

### ***Estimated Maximum Heart Rate***

You can apply a mathematical formula, based on your age, to estimate your maximum heart rate, as follows:

$$220 - \text{age} = \text{estimated maximum heart rate.}$$

### ***Target Heart Rate Range***

Target heart rate range (also known as training heart rate range or exercise heart rate range) is the range of heart rates reached during aerobic exercise that enables one's heart and lungs to receive the most benefit from a workout. The most common method for calculating the target heart rate range is by multiplying the estimated maximum heart rate times the percent intensity that produces maximum cardiovascular benefits, generally considered to be a range of 50% to 85% intensity.

The following example assumes a maximum heart rate of 180:

- ◆ 50% intensity:  $180 \times 0.50 = 90$  beats per minute
- ◆ 85% intensity:  $180 \times 0.85 = 153$  beats per minute

## Materials and Equipment

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**For each student or group:**

- ◆ Data collection system
- ◆ Hand Grip Heart Rate Sensor

## Safety

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**Add these important safety precautions to your normal laboratory procedures:**

- ◆ If the exercise causes discomfort or pain, stop exercising and data collection.

## Sequencing Challenge

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The steps below are part of the Procedure for this lab activity. They are not in the right order. Determine the proper order and write numbers in the circles that put the steps in the correct sequence.

○	○	○	○	○
Use graphing tools to determine average heart rate and recovery time.	Hold handles comfortably in hands.	Record heart rate during exercise.	Record resting heart rate.	Record heart rate during recovery period.

## Procedure

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After you complete a step (or answer a question), place a check mark in the box () next to that step.

**Note:** When you see the symbol "◆" with a superscripted number following a step, refer to the numbered Tech Tips listed in the Tech Tips appendix that corresponds to your PASCO data collection system. There you will find detailed technical instructions for performing that step. Your teacher will provide you with a copy of the instructions for these operations.

### Set Up

1.  Start a new experiment on the data collection system. ◆<sup>(1.2)</sup>
2.  Connect the sensor to the port on the data collection system. ◆<sup>(2.1)</sup>
3.  Display Heart Rate in beats per minute on the y-axis versus Time in seconds (s) on the x-axis of a graph. ◆<sup>(7.1.1)</sup>

**Collect Data**

There are three parts to data recording.

- ◆ Measure the resting heart rate for 1 minute.
- ◆ Measure heart rate during exercise for 3 minutes.
- ◆ Measure the recovery heart rate after exercise for 2 minutes.

**Note:** This activity is easier to do if one person is in charge of recording data and keeping track of time while another person is being measured.

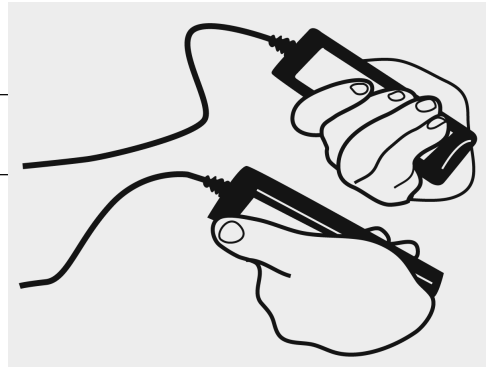
**Note:** Once you begin to collect data, continue to collect data until the end of the experiment. Do not stop collecting data as you change activities.

**Note:** During data collection, only 1 data point will be recorded every 5 seconds.

4.  What is your control data point in this experiment?

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5.  Grasp the hand grip sensors with both hands. Remind the person who is being monitored to relax, to remain as still as possible, and not to look at the data as it is recorded.

6.  Start data recording. ◆<sup>(6.2)</sup>

7.  Adjust the scale of the graph to show all data. ◆<sup>(7.1.2)</sup>

8.  Describe your graph for the first 60 seconds?

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9.  After 1 minute, the person who is being measured stands up and runs in place for 3 minutes while data collection continues.

10.  Describe your graph for this 180-second interval.

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11.  After exercise, the person who is being measured sits for 2 minutes while data collection continues.

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12.  What is the unit of measurement that your data is being recorded in?
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13.  Remind the person who is being monitored to relax, to remain as still as possible, and not to look at the data as it is recorded.
14.  Describe your graph for this 120-second interval?
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15.  Continue collecting data until the test subject's heart rate returns to that person's initial resting heart rate.
16.  If your results are not satisfactory, repeat the procedure for a second trial.
17.  Stop data recording. ♦<sup>(6.2)</sup>
18.  If time allows, switch roles and repeat the procedure to allow another person in your group to be monitored.
19.  Save your experiment ♦<sup>(11.1)</sup> and clean up according to your teacher's instructions.

## Data Analysis

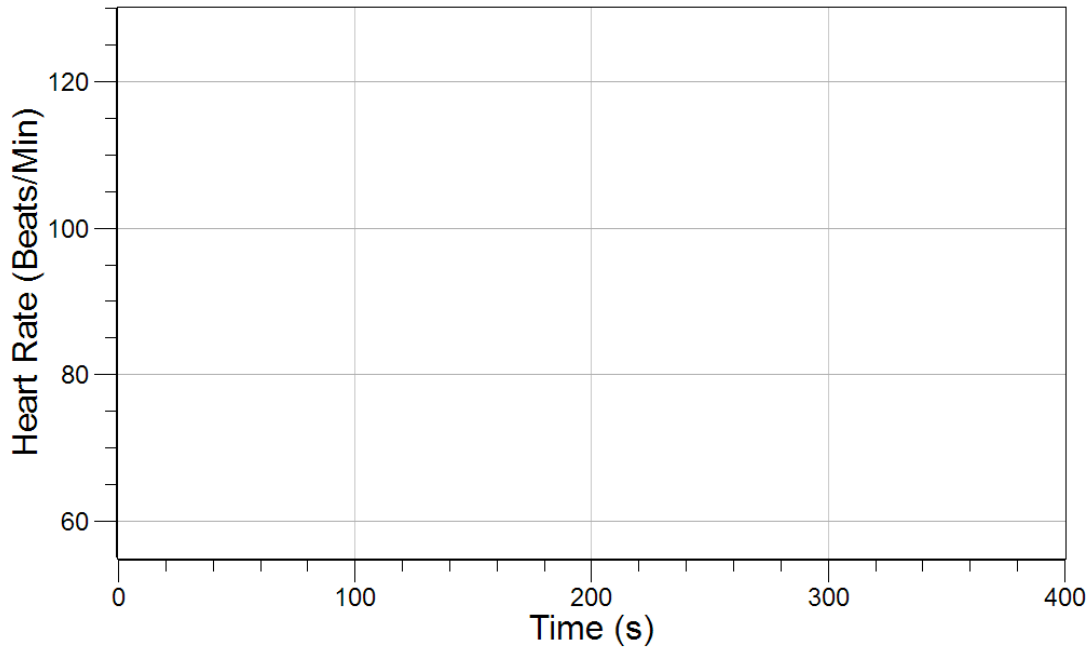
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1.  Using available tools on your data collection system, find your average resting and exercise heart rates ♦<sup>(9.4)</sup> and your heart rate recovery time. ♦<sup>(9.2)</sup> Record these in Table 1.

Table 1: Resting and exercise heart rates plus recovery time

Item	Value
Resting Heart Rate (average)	67 bpm
Exercise Heart Rate (maximum)	109 bpm
Recovery Time (time from end of exercise to initial resting heart rate)	3.5 minutes

2.  Make a sketch of your data for Heart Rate versus Time. Label the points at which exercise started and stopped.



Use of a graph tool to determine the average exercise heart rate during exercise (109 bpm).

### Analysis Questions

1. How does the heart rate for exercise compare with the heart rate at rest?

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2. How does the heart rate after the designated 2-minute recovery period compare with the heart rate at rest?

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**3. Before, during, and after exercise, how did the heart rate for females compare with the heart rate for males?**

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**4. How did the heart rate change of people who tend to be physically active compared with the heart rate change of people who have a more sedentary lifestyle?**

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## Synthesis Questions

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Use available resources to help you answer the following questions.

**1. Calculate your own exercise (target) heart rate range.**

- ◆ Calculate your estimated maximum heart rate:  $220 - (\text{your age}) =$  \_\_\_\_\_
- ◆ Using this estimated maximum heart rate, multiply times 0.5 to determine the lower limit of your target heart rate range: \_\_\_\_\_
- ◆ Multiply times 0.85 to determine the upper limit: \_\_\_\_\_

**2. How does the data you collected relate to fitness level? Is it within the calculated target heart rate range? Explain.**

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**3. Why must an athlete exercise longer or more vigorously to reach a maximum heart rate compared to a less fit individual?**

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**4. Using your resting heart rate, calculate the beats within a lifetime of 80 years:**

- Beats/minute = \_\_\_\_\_ (cardiac output)

- Beats/hour = \_\_\_\_\_
- Beats/day = \_\_\_\_\_
- Beats/year = \_\_\_\_\_
- Beats/lifetime = \_\_\_\_\_

### Multiple Choice Questions

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Select the best answer or completion to each of the questions or incomplete statements below.

**1. The upper limit of target heart rate, in beats per minute, is 85% of the theoretical maximum heart rate. The maximum heart rate can be estimated by subtracting the person's age, in years, from 220. To the nearest whole number, what is the upper limit of target heart rate of a person who is 26 years old?**

- A.** 134
- B.** 155
- C.** 165
- D.** 194.

**2. Which of the following might cause an increase in average resting heart rate?**

- A.** Age
- B.** Stress
- C.** Medication
- D.** All of the above

**3. How would you predict the maximum heart rate?**

- A.** 220 minus a person's age
- B.** 220 times the percentage intensity
- C.** 220 minus the reserve heart rate
- D.** None of the above

**4. While resting, the average female human heart rate is about:**

- A.** 120 over 80
- B.** 120
- C.** 75
- D.** None of the above

## **Key Term Challenge**

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Fill in the blanks from the list of randomly ordered words in the Key Term Challenge Word Bank.

- 1.** Maximum heart rate is related to your age. As we grow older, our maximum heart rate tends to be lower. To estimate the maximum heart rate, subtract the person's age from the number \_\_\_\_\_.
  
- 2.** The \_\_\_\_\_ is the number of beats per minute (bpm) that produces the maximum health benefit during aerobic exercise. For most healthy individuals, this range is \_\_\_\_\_ to \_\_\_\_\_ percent of maximum heart rate. So, if your estimated maximum heart rate is 180 bpm, the low end of the range would be \_\_\_\_\_ bpm, and the high end of the range would be \_\_\_\_\_ bpm
  
- 3.** \_\_\_\_\_ is a term used to describe the frequency of the cardiac cycle. Usually, it is calculated as the number of contractions (beats) of the heart in one minute. Therefore, heart rate is usually expressed as \_\_\_\_\_. When resting, the typical adult human heart beats at about \_\_\_\_\_ bpm (males) and \_\_\_\_\_ bpm (females), although this rate varies among people. The reference range for resting heart rate is between 60 and 100 bpm. The \_\_\_\_\_ is one way of measuring the heart rate.



**Key Term Challenge Word Bank**

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**Paragraph 1**

185  
220  
226  
faster  
slower

**Paragraph 2**

50  
77  
85  
90  
100  
153  
180  
maximum heart rate  
target heart rate range

**Paragraph 3**

60  
70  
75  
85  
beats per minute  
breaths per minute  
heart rate  
heart rhythm  
pulse  
your aerobic number