EKG: HEART RATE RECOVERY

How does the heart respond to increased physical activity?

Objectives

• Compare EKG waves and intervals before and after exercise.

Materials and Equipment

• Data collection system
• EKG sensor
• Electrode patches (3)
• Soap and water or non-alcohol wipe
• Paper towels
• Conductivity gel (optional)

Safety

Follow these important safety precautions in addition to your regular classroom procedures:

• Do not perform this activity if vigorous exercise will cause discomfort. If you experience discomfort or pain, immediately stop exercising.

• The electrode patches are intended for use with a single student and cannot be re-used after completing this investigation.

• The EKG sensor is not intended for use as a medical instrument.

Procedure

Part 1: Resting Heart Rate

1. Connect the EKG sensor to your device and choose the EKG and Heart Rate file from the Templates menu.

   **NOTE:** If the file is not available, create a two-pane display and assign a Graph to the large pane. Select Voltage (mV) for the y-axis measurement. Assign a Digits display to the small pane and select the Heart Rate (Beats/Min) measurement.

2. Work in pairs. One student will collect data and keep track of time while the subject or person whose EKG is being measured will stay comfortably seated.

3. The subject must cleanse the inside forearms just below the elbow folds and inside right wrist with a wipe or soap and water. The areas to wash are labeled as positions 1, 2, and 3 in Figure 1. Positions 1 and 2 are located on the right arm and position 3 is on the left arm.

4. Grasp the electrode patches by their non-adhesive tabs. Firmly place in positions 1, 2, and 3 with tabs toward the inside of the arms.

5. Find the black (R), green (-), and red (+) alligator clips at the ends of the EKG sensor wires. On the right arm, attach the black (R) alligator clip to the tab at position 1 and attach the green (-) alligator clip at position 2. On the left arm, attach the red (+) alligator clip at position 3. Make sure the electrode wires can move freely while the alligator clips are securely attached to each electrode tab.

   **NOTE:** If necessary, pull the plastic cover away from each alligator clip tip to maximize clip-tab contact.

6. Have the subject sit quietly in a chair with their legs un-crossed, arms on a table, and palms facing up as shown in Figure 1. Remind the subject to relax, remain still and quiet, and to not look at the data as it is recorded.
7. Select Start to begin collecting data. After one minute, stop data collection and record the resting heart rate in beats per minute (bpm) in Table 1.

**NOTE:** If the EKG does not show distinct waves or the heart rate fluctuates by 10 or more bpm, apply new electrode patches with conductivity gel or choose a different test subject.

8. Find 5 seconds of data where heartbeats appear consistent. Open the Graph Tools menu and toggle from Move mode to Select mode.

9. Draw a box around the data portion to select it. Scale the selection.

10. Adjust the x-axis scale to view about 3 seconds of data that clearly shows a P wave, QRS complex, and T wave (refer to Figure 2).

11. Scale further to show only one complete heartbeat. Sketch your results in Graph 1 and label P, Q, R, S, and T waves. Include numbers, labels, and units on the x- and y-axes. If the waveform is difficult to interpret, try one or more of the following:
   - Toggle data markers: Open Graph Tools, choose Properties, and set the Data Point Marker to the desired state.
   - Increase smoothing: (available only if the EKG and Heart Rate template was used) Select Voltage (mV) on the y-axis. Choose the User-entered tab from the menu that opens on the right. Select the SmoothedVoltage (mV) measurement under Calculated Data.
   - Further increase smoothing: After completing the above bullet, return to the User-entered tab and choose Create/Edit Calculation under Calculated Data. Change the value of 13 to a higher odd number then select OK.

12. Refer to Figure 2. Use the Coordinates Tool to help you determine the time duration of the PR interval, the QRS complex, and the QT interval (in seconds). Label these areas in Graph 1 and record results in Table 1.

13. Adjust the scale of the x-axis to show the R wave of the next cardiac cycle to the right. Record the duration of one RR interval (time between successive R peaks) in Table 1.

**Part 2: Estimated Maximum Heart Rate and Target Range**

1. Apply the following age-based mathematical formula to estimate the subject's maximum heart rate (in bpm) and enter the result in the space provided below Table 1:

   Estimated maximum heart rate (bpm) = 220 − age

2. Target heart rate indicates the highest number of times your heart can safely beat per minute during exercise. The following formula is the most common method for calculating the upper and lower bounds of your target heart rate range:

   Minimum target heart rate (bpm) = Estimated maximum heart rate (bpm) × 0.50
   Maximum target heart rate (bpm) = Estimated maximum heart rate (bpm) × 0.85

   These formulas convert the estimated maximum heart rate to a range of 50% to 85% intensity. Determine the subject's target heart rate range (round answers to whole numbers) and enter the result below Table 1.

3. Record your prediction of how exercise will affect the subject's heart rate and explain your reasoning below Table 1.

4. Record your prediction of how long it will take for the subject's heart rate to return to resting below Table 1. Identify one or more factors that weighed into your prediction.

**Part 3: Heart Rate During Exercise and Recovery**

1. Remove the alligator clips from the electrode patches.
2. Make sure the area is free of obstacles and have the subject jog in place or do jumping jacks for 30 seconds.
3. After 30 seconds of exercise, have the subject return to the seated position shown in Figure 1.
4. Remind the test subject to relax, remain still and quiet, and to not look at the data as it is recorded while you help the subject reattach the alligator clips.

5. Start collecting data and record the heart rate immediately after exercise in Table 1.

6. Allow data collection to continue until the subject's heart rate returns to the resting heart rate you recorded in Table 1, then stop collecting data. Record the time elapsed to reach heart rate recovery in the space provided below Table 1.

7. Select the Voltage measurement on the y-axis of the graph. Choose Heart Rate from the menu that appears on the right. Scale the data.

8. Use the Coordinates Tool to locate the subject's actual maximum heart rate value on the graph. Report the maximum heart rate in the space provided below Table 1.

   **NOTE:** If the maximum heart rate appears to be an erroneous data point such as a single spike above 200 bpm, ignore it.

9. Change Heart Rate on the y-axis to the same measurement used in Part 2 (either Voltage (mV) or SmoothedVoltage (mV)).

10. Scale the beginning of the run to identify the first readable, complete heartbeat waveform.

11. Use the Coordinates Tool to help you determine the immediate post-exercise time duration of the PR interval, the QRS complex, QT interval, and RR interval (in seconds). Record results in Table 1 and make note of changes in these areas directly on Graph 1.

12. Consider different parts of the waveform. How do the shape of these parts differ between the pre- and post-exercise waveform? Make note of any differences between the shape or amplitude (height) of the P, Q, R, S or T waves directly on Graph 1.

**Data Collection**

Graph 1: Resting Heart Rate Intervals
### Table 1. EKG Data Before and After Exercise

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Resting / before exercise</th>
<th>Recovery / after exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate (bpm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PR interval duration (s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>QRS complex duration (s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>QT interval duration (s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RR interval duration (s)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Estimated maximum heart rate (bpm): ____________

Target heart rate range (bpm) = ____________ to ____________

Prediction: How will exercise affect heart rate? Explain your reasoning.

Prediction: How long will it take for the subject's heart rate to return to resting (recovery time)? Explain your reasoning.

Time elapsed for heart rate recovery (s): ____________

Actual maximum heart rate (bpm): ____________

### Questions and Analysis

1. What factors might affect an individual's resting heart rate?

2. How does the duration of the resting PR interval, QRS complex, QT interval and RR interval compare to the duration of those regions during post-exercise recovery? Relate these time differences to the body’s response to exercise. *Note: Individual results may vary widely; use the subject's data to answer this question.*
3. Elaborate on your notes left on Graph 1 to describe the observed changes in P, Q, R, S, and T waves between resting and recovery.

4. How accurately did you predict the effect of exercise on heart rate and recovery time? At the end of a post-exercise recovery period, how would you expect the P, Q, R, S, and T waves to differ from the same waves measured at rest? Explain the basis of your prediction.

5. Assume the subject is not a professional athlete and is trying to improve their cardiovascular health. What advice might a personal trainer give the subject based on the intensity of their 30-second exercise period? Use the subject's data to formulate your answer.

6. What could the subject do to reduce their heart rate recovery time? Why do you think this would work?

7. During an exercise stress test, medical professionals compare EKG waves collected during rest with EKG waves collected during exercise. Using online resources, determine how an exercise stress test can be used to identify exercise-induced ST interval depression. What might an exercise-induced ST interval depression indicate? Summarize your findings in 1-2 sentences.