Heart rate by accelerometer

FizziQ activity · Middle school · 30 min

Scan to open in FizziQ

Students place a smartphone on their chest and use the FizziQ accelerometer to record heartbeat vibrations, comparing heart rate at rest and after exercise.

Learning objectives

- Detect and record cardiac-induced chest wall vibrations using the smartphone accelerometer
- Determine the resting heart rate from accelerometer data
- Compare heart rate before and after physical exercise
- Identify the periodic nature of the cardiac signal in accelerometer recordings
- Understand the principle of ballistocardiography and its relationship to the cardiac cycle

Instruments and sensors

Z-axis acceleration (single-axis accelerometer measurement) · Accelerometer

Materials

- Smartphone or tablet with an accelerometer, using the FizziQ application for recording
- Flat surface for lying down
- Note: the protocol remains adaptable to any comparable accelerometer-based measurement tool.

Protocol

1. Open the FizziQ application and select the Accelerometer sensor. Choose the Z-axis (vertical) component for the clearest cardiac signal.
2. Lie down on a flat, stable surface. Place the smartphone face down on your chest, centered over the sternum, and remain as still as possible.
3. Start recording data in FizziQ. Breathe slowly and shallowly to minimize respiratory movement that could mask the cardiac signal.
4. Record for at least 30 seconds while remaining perfectly still. You should see small periodic peaks on the acceleration graph.
5. Stop recording and examine the graph. Count the number of distinct peaks over a known time interval (e.g., 20 seconds).
6. Calculate the resting heart rate using the formula: HR (bpm) = (number of peaks / recording time in seconds) × 60.
7. Save this first measurement in your FizziQ experiment notebook as "Rest".
8. Now perform 2 minutes of moderate physical exercise (jumping jacks, running in place, or climbing stairs).
9. Immediately lie down again, place the smartphone on your chest, and start a new recording within 15 seconds of stopping exercise.
10. Record for 30 seconds and calculate the post-exercise heart rate using the same method.
11. Save this second measurement as "Post-exercise" and compare both heart rates in your notebook.
12. If possible, zoom into the signal to try to identify secondary peaks that may correspond to different phases of the cardiac cycle (atrial contraction, ventricular ejection).

Expected results

The resting accelerometer signal should show periodic peaks with an interval of 0.6 to 1.0 seconds,

corresponding to heart rates of 60-100 bpm for most students. The acceleration amplitude of the peaks typically ranges from 0.01 to 0.05 m/s². After exercise, the heart rate should increase by 30-80% (to roughly 100-160 bpm), and the peaks may appear larger due to stronger cardiac contractions. The signal will contain noise from respiratory movements (slower, larger oscillations at about 0.2-0.3 Hz) and involuntary muscle movements. Students may find it difficult to distinguish individual peaks if there is too much body movement. The post-exercise signal may be noisier due to heavier breathing and residual trembling.

Questions

- Why is it important to lie down rather than sit up for this measurement?
- How does the accelerometer signal differ from a clinical electrocardiogram (ECG)?
- What factors might cause variation in heart rate between different students?
- Why does heart rate increase during physical exercise?
- How could you improve the signal quality to reduce noise in the measurement?
- Could this technique be used for continuous heart rate monitoring? What are the limitations?

Going further

- Compare heart rates in different body positions: lying down, sitting, standing
- Record the cardiac signal from different body locations (chest, neck, wrist) and compare signal quality
- Investigate how caffeine consumption affects heart rate by measuring before and 30 minutes after drinking coffee
- Use the FizziQ frequency analysis tool to extract the heart rate from the Fourier transform of the signal
- Compare the smartphone measurement with a manual pulse count to evaluate measurement accuracy