Cardiac auscultation by mic

FizziQ activity · Middle school · 25 min

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Pressed against the chest, a smartphone microphone picks up heart sounds; FizziQ's low-pass filter isolates them so middle school students read their heart rate.

Learning objectives

- Detect heart sounds using the smartphone microphone placed against the chest
- Visualize the characteristic waveform pattern of the cardiac cycle
- Identify the two main heart sounds (S1 and S2) in the recorded signal
- Calculate the heart rate from the time interval between consecutive heartbeat cycles
- Understand the physiological origin of each heart sound

Instruments and sensors

Sound waveform recorder (with low-pass filtering) · Microphone

Materials

- Smartphone or tablet with a microphone sound-recording application (such as FizziQ)
- A calm, quiet environment
- Note: the protocol remains adaptable to any comparable acoustic/sound-recording tool.

Protocol

1. Find a quiet environment with minimal background noise. Sit comfortably and relax for 2 minutes before starting.
2. Open the app and select the Microphone sensor (waveform or sound level mode).
3. Place the smartphone's microphone directly against your bare chest, slightly to the left of the sternum, where the heart sounds are strongest.
4. Press gently but firmly to ensure good acoustic contact. Hold the phone steady with one hand.
5. Start recording. You should see periodic clusters of activity in the sound waveform, corresponding to each heartbeat.
6. If the signal is weak, try activating any signal filtering options in FizziQ to reduce high-frequency noise and enhance the low-frequency heart sounds.
7. Record for at least 30 seconds to capture approximately 30-50 heartbeat cycles.
8. Stop recording and examine the waveform. Each heartbeat should appear as a pair of peaks (S1 and S2) separated by a short interval.
9. Count the number of heartbeat cycles (pairs of peaks) in a 20-second interval.
10. Calculate your heart rate: HR (bpm) = (number of cycles / 20) × 60.
11. Try to identify the S1 sound (the larger, longer first peak, the lub) and the S2 sound (the shorter, sharper second peak, the dub).
12. Compare your result with a manual pulse measurement at the wrist to verify accuracy.

Expected results

The heart sounds should appear as periodic clusters in the microphone signal, with a typical interval of 0.6-1.0 seconds between cycles (60-100 bpm). The S1 sound is usually the larger and longer-duration signal, while S2 is shorter and higher-pitched. The signal quality depends heavily on the phone's microphone sensitivity, the

acoustic coupling with the chest, and the ambient noise level. Some phones produce very clear heart sound recordings, while others may show only faint signals requiring close examination. The calculated heart rate should agree with a manual pulse count within ±3-5 bpm. Students may also observe respiratory modulation: the heart rate increases slightly during inhalation and decreases during exhalation (respiratory sinus arrhythmia), which is a normal physiological phenomenon.

Questions

- What causes the two distinct heart sounds (lub and dub) in each cardiac cycle?
- Why is the first heart sound (S1) typically louder and longer than the second (S2)?
- What is the interval between S1 and S2 within a single heartbeat? What does it represent physiologically?
- How does a clinical stethoscope improve upon simply placing an ear against the chest?
- What cardiac abnormalities can be detected by listening to heart sounds?
- How does the respiratory cycle affect the heart rate (respiratory sinus arrhythmia)?

Going further

- Compare heart sounds recorded at different positions on the chest to identify the optimal listening point
- Record heart sounds before and after exercise and compare the waveform characteristics
- Use frequency analysis (FFT) to determine the dominant frequency components of S1 and S2
- Compare the acoustic heart rate measurement with the accelerometer-based method and the photoplethysmography method
- Investigate the effect of deep breathing on the timing between S1 and S2