

Aim: To investigate the effect of exercise on heart rate and breathing rate, and to measure recovery time.

### Background Theory

- During exercise, muscles need more oxygen and glucose for aerobic respiration.
- Heart rate increases to deliver more oxygenated blood to muscles and remove CO<sub>2</sub>.
- Breathing rate and depth increase to take in more O<sub>2</sub> and remove CO<sub>2</sub> faster.
- Lactic acid builds up if exercise is intense — anaerobic respiration occurs.
- After exercise, heart rate and breathing rate remain elevated to repay the oxygen debt.
- ★ Cardiac output = heart rate × stroke volume. Fitter individuals have a larger stroke volume and lower resting heart rate.
- ★ Oxygen debt: extra O<sub>2</sub> needed after exercise to oxidise lactic acid back to glucose in the liver.

### Equipment

- Stopwatch
- Students (volunteer participants)
- Step or raised platform (optional)
- Record sheet and pencil
- Pulse oximeter or ability to measure pulse manually

### Method

1. Sit quietly for 2 minutes. Measure resting heart rate (count pulse for 1 minute). Record.
2. Measure resting breathing rate (count breaths for 1 minute). Record.
3. Exercise at a set intensity for 3 minutes (e.g. stepping up and down on a step at 1 step per second).
4. Immediately after stopping exercise, measure heart rate for 1 minute. Record.
5. Measure breathing rate for 1 minute. Record.
6. Continue to record heart rate and breathing rate every 1 minute for 5 minutes of recovery.
7. Repeat the experiment with the same participant on a different day for reliability.
8. Compare results between participants of different fitness levels if possible.

### Variables

<b>Independent variable</b>	Exercise intensity or duration (e.g. stepping rate or number of steps)
<b>Dependent variable</b>	Heart rate (bpm) and breathing rate (breaths per minute)
<b>Controlled variables</b>	Same participant, same time of day, same step height, same exercise type, temperature of room

### Results Table

Time point	Heart rate (bpm)	Breathing rate (breaths/min)	Notes


## Analysis

- Plot a line graph of heart rate (y-axis) vs time before, during and after exercise.
- Describe the pattern: increases during exercise, peaks immediately after, decreases during recovery.
- Recovery time = time taken for heart rate to return to resting rate.
- ★ A fitter individual will recover more quickly — their cardiovascular system is more efficient.
- ★ Explain why breathing rate stays elevated after exercise has finished (oxygen debt).

**Exam Tip:** Recovery time is an important variable. Fitter individuals recover more quickly. Always measure both heart rate AND breathing rate — they are separate marks in exam questions.

**Common Mistake:** Do not say "the heart works harder" — say "heart rate increases". Be precise with measurement units: bpm for heart rate, breaths per minute for breathing rate.