

Response to exercise

4.4.2.2 · Bioenergetics · revision notes

How your body meets the extra energy demand of exercise: heart rate, breathing rate and breath volume increase, and if the muscles run short of oxygen they respire anaerobically, causing lactic acid to build up and muscle fatigue. Expect data on heart rate or breathing, often with a calculation.

Key facts

- Exercise → heart rate, breathing rate and breath volume increase
- Not enough oxygen → anaerobic respiration: glucose → lactic acid
- Percentage change = $(\text{new} - \text{original}) \div \text{original} \times 100$
- Purpose: more oxygenated blood to the muscles for respiration
- Long vigorous exercise → muscles fatigue and stop contracting efficiently

Notes

Changes during exercise

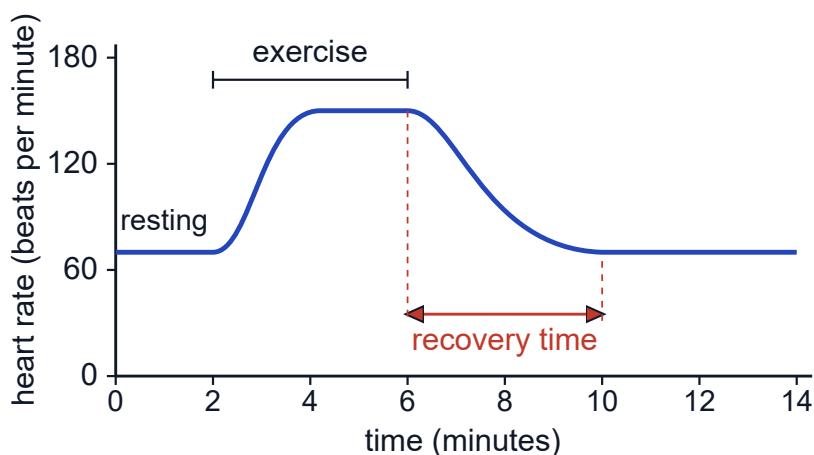
- During exercise your muscles contract more, so they need more energy from respiration.
- Your **heart rate**, **breathing rate** and **breath volume** (how much air each breath moves) all increase.
- This supplies the muscles with more **oxygenated blood**, bringing more oxygen and glucose for aerobic respiration and removing the extra carbon dioxide.

When oxygen runs short

- In vigorous exercise the heart and lungs cannot supply oxygen fast enough, so muscle cells also respire **anaerobically**: glucose → lactic acid.
- The oxidation of glucose is incomplete, so **lactic acid** builds up in the muscles.
- During long periods of vigorous activity, muscles become **fatigued** and stop contracting efficiently.
- Anaerobic respiration adds to aerobic respiration; it does not replace it.

Working with exercise data

- Heart rate is measured in beats per minute: count your pulse for 15 seconds and multiply by 4.
- Breathing rate is measured in breaths per minute.
- Percentage increase = $(\text{value during exercise} - \text{resting value}) \div \text{resting value} \times 100$.
- Recovery time is how long the rate takes to return to its resting value after exercise. A fitter person usually has a lower resting heart rate and recovers more quickly.



Heart rate stays high for a while after exercise stops. A fitter person recovers sooner.

How to answer each type of question

Explain why heart rate and breathing rate increase

2 to 3 marks

Grade 5

1. Start with the muscles: they contract more, so they need more energy.
2. Say that more respiration is needed.
3. Link the changes to supplying more oxygen (and glucose) in the blood, and removing carbon dioxide.

Example. During a race a runner's heart rate and breathing rate increase.
Explain why.

Model answer. The muscles are contracting more, so they need more energy (1). This energy comes from more (aerobic) respiration (1). So more oxygenated blood must be pumped to the muscles, to supply more oxygen (and glucose) (1).

Calculate a percentage change from exercise data

2 marks

Grade 5

1. Find the change: new value – original (resting) value.
2. Divide by the original value, not the new one.
3. Multiply by 100 and add the % sign.

Example. A student's resting heart rate was 64 beats per minute. After 3 minutes of running it was 112 beats per minute.

Calculate the percentage increase in heart rate.

Model answer. $112 - 64 = 48$ (1)

$48 \div 64 \times 100 = 75\%$ (1)

Don't lose marks

- ✗ Saying you breathe faster 'to get more energy'. Breathing supplies oxygen; respiration transfers the energy.
- ✗ Saying 'the heart pumps oxygen to the muscles'. The heart pumps oxygenated blood.
- ✗ Saying muscles switch from aerobic to anaerobic respiration. In hard exercise they respire aerobically and anaerobically at the same time.
- ✗ In percentage change questions, dividing by the value during exercise instead of the resting value.

More tips

Memory tricks

- Three things go up: heart rate, breathing rate and breath volume.
- Fatigue chain: not enough oxygen → anaerobic respiration → lactic acid builds up → fatigue.

Exam technique

- Link every change to its purpose: heart rate increases → more oxygenated blood to the muscles → more aerobic respiration.
- When you describe data, quote figures with units, for example 'rose from 70 to 150 beats per minute'.
- Treat breathing rate and breath volume as two separate changes; each can be a separate mark.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3

State how exercise changes heart and breathing

Heart rate, breathing rate and breath volume all increase.

Grade 4

Explain why heart and breathing rates increase

To supply the muscles with more oxygenated blood for the extra respiration needed to contract.

Grade 5

Explain when muscles respire anaerobically

When oxygen cannot be supplied fast enough for aerobic respiration alone, as in vigorous exercise.

Grade 5

Calculate changes from exercise data

Work out increases, percentage changes and recovery times from tables and graphs of heart rate or breathing rate.

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