

Physical activity, rate and depth of breathing

Investigate and describe the effects of physical activity on the rate and depth of breathing

For Cambridge IGCSE Biology 0610 (and 0970, which has the same content). Teacher answers start on a new page.

Name

Date

Aim

To investigate how different levels of physical activity affect the rate of breathing and the depth of breathing.

Background

The **rate of breathing** is the number of breaths taken in one minute. The **depth of breathing** is the volume of air moved in one breath. Both can change when we are more active.

During physical activity the muscles respire faster, so they use more oxygen and produce more carbon dioxide. Breathing rate and depth increase, so more oxygen enters the blood and more carbon dioxide is removed.

Supplement: the increase is caused by an increased concentration of carbon dioxide in the blood, which is detected by the brain, leading to an increased rate and greater depth of breathing.

Hypothesis

As physical activity becomes harder, both the rate and the depth of breathing will increase, because the muscles respire faster and make more carbon dioxide.

Variables

Independent	The level of physical activity (rest, walking, jogging, running on the spot), each for 2 minutes
Dependent	The rate of breathing (breaths per min, from the number of breaths in 30 s) and the depth of breathing (volume of one breath / cm ³)
Control	• The same person for every activity • The same length of time (2 minutes) for each activity • Counting breaths straight after the activity, for the same time (30 s) • The same calibrated bottle, filled with water in the same way • Full rest before each activity until breathing is back to the resting rate

Equipment

- Stop-clock reading to 1 s or better
- A 5 dm³ clear plastic bottle, marked every 100 cm³ (calibrated by pouring in 100 cm³ of water at a time from a measuring cylinder and marking the level)
- Measuring cylinder, 100 cm³, for calibrating the bottle
- A large trough or washing-up bowl, half full of water
- About 50 cm of clean rubber tubing and a new mouthpiece for each person
- Clamp and stand, or a partner, to hold the bottle
- Paper towels and a tray
- Chair

Risk assessment

Hazard	Risk	Precaution
Physical exercise	Dizziness, breathlessness or muscle strain, especially for a person with asthma or a heart condition.	Do not take part if you have a breathing or heart condition. Stop at once if you feel dizzy or unwell.
Breathing through tubing that dips under water	Water could be sucked into the mouth.	Only ever breathe out through the tubing, never in. Take the mouthpiece away from your mouth before you breathe in.
Sharing mouthpieces and tubing	Spread of infections.	Each person uses a new mouthpiece and their own tubing, or tubing disinfected between users.
Spilt water	Slipping.	Work over a tray and wipe up spills at once.

Method

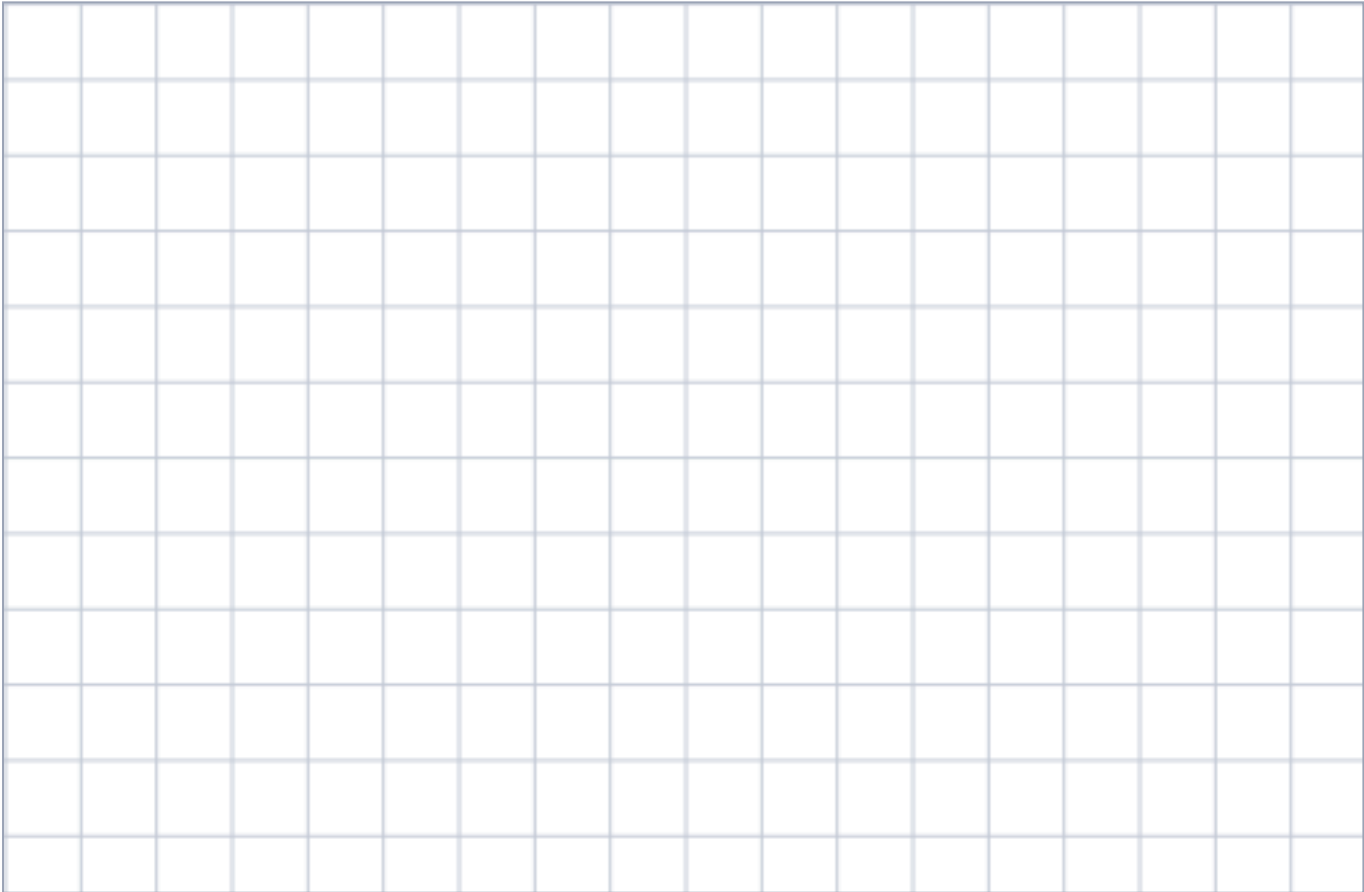
1. Calibrate the bottle: pour in 100 cm³ of water at a time from the measuring cylinder and mark each level on the side. Label the marks so that they read upwards from the base.
2. Sit on a chair and rest for 5 minutes.
3. Ask a partner to count the number of breaths you take in 30 s. Multiply by 2 to give the resting breathing rate in breaths per min.
4. Fill the bottle with water, cover the neck, turn it upside down and lower the neck under the water in the trough. Clamp it or ask a partner to hold it. Put one end of the tubing up into the neck.
5. Breathe in normally, then breathe out one normal breath through the mouthpiece into the bottle. Take the mouthpiece away before you breathe in. Read the volume of air collected from the marks, to the nearest 100 cm³. This is the depth of breathing at rest.
6. Refill the bottle with water.
7. Walk on the spot for 2 minutes.
8. Sit down at once. Your partner counts your breaths in 30 s. Straight after the count, breathe out one normal breath into the bottle and read its volume.
9. Rest until the breathing rate is back to the resting value.
10. Repeat steps 6 to 9 for jogging on the spot and then for running on the spot, each for 2 minutes.
11. Calculate the breathing rate for each activity (breaths in 30 s × 2), and the volume of air breathed per min = breathing rate × volume of one breath. Convert cm³ to dm³ by dividing by 1000.
12. Repeat with the other members of the group, then plot bar charts of breathing rate and of depth of breathing against activity.

Results

Rate and depth of breathing at different levels of activity				
activity	breaths in 30 s	breathing rate / breaths per min	depth of breathing (volume of one breath) / cm ³	volume of air breathed per min / dm ³
rest				
walking on the spot				
jogging on the spot				
running on the spot				

Graph

Two bar charts. Chart 1: activity (rest, walking, jogging, running) on the x-axis and breathing rate / breaths per min on the y-axis. Chart 2: activity on the x-axis and depth of breathing / cm³ on the y-axis. The activities are separate categories, so draw bars of equal width that do not touch, in the order of increasing activity. Use a scale so that more than half of the grid is used and label each axis with the quantity and unit.



Exam questions 11 questions · 29 marks

1 State what is meant by (a) the rate of breathing and (b) the depth of breathing. **[2 marks]**

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2 A student investigates the effect of physical activity on breathing. (a) State the independent variable. [1] (b) State the dependent variable. [1] (c) State one variable that must be kept constant. [1] **[3 marks]**

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3 After jogging, the breathing rate was 24 breaths per min and the volume of one breath was 1100 cm³. Calculate the volume of air breathed in one minute. Give your answer in dm³. **[3 marks]**

Answer =

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4 The breathing rate was 14 breaths per min at rest and 32 breaths per min after running. Calculate the percentage increase in breathing rate. Show your working. **[3 marks]**

Answer =

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- 5** The table shows the results of an investigation. Describe the effect of physical activity on the rate and depth of breathing. **[3 marks]**

Rate and depth of breathing		
activity	breathing rate / breaths per min	depth of breathing / cm ³
rest	14	500
walking	18	700
jogging	24	1100
running	32	1500

- 6** The student measures the resting rate first and waits for the breathing to return to the resting rate before the next activity. Explain why each of these is done. **[2 marks]**

- 7** Supplement. Explain why the rate and depth of breathing increase during physical activity. **[3 marks]**

- 8** The bottle is filled with water and turned upside down in the trough. Explain why it is filled with water before the breath is collected. **[2 marks]**

9 Suggest three ways in which the investigation could be improved.

[3 marks]

10 Describe two safety precautions for the people doing the exercise.

[2 marks]

11 Describe how the results in question 5 should be presented as a graph.

[3 marks]

Teacher answers

Practical skill 12: Physical activity, rate and depth of breathing. The example results are practice data, not real measurements.

Example results

Example results (practice data): one student				
activity	breaths in 30 s	breathing rate / breaths per min	depth of breathing (volume of one breath) / cm ³	volume of air breathed per min / dm ³
rest	7	14	500	7.0
walking on the spot	9	18	700	12.6
jogging on the spot	12	24	1100	26.4
running on the spot	16	32	1500	48.0

Conclusion

As the activity became harder, both the rate of breathing (from 14 to 32 breaths per min) and the depth of breathing (from 500 cm³ to 1500 cm³ per breath) increased, so the volume of air breathed per minute increased from 7.0 dm³ to 48.0 dm³. This supports the hypothesis. During activity the muscles respire faster, so they use more oxygen and produce more carbon dioxide. Breathing faster and more deeply takes more oxygen into the blood and removes more carbon dioxide. Supplement: the carbon dioxide concentration in the blood increases, this is detected by the brain, and the brain causes an increased rate and greater depth of breathing.

Errors and improvements

Error	Effect on the results	Improvement
Breathing slows quickly after exercise, and the count does not start at once.	The rate recorded is lower than the rate during the exercise.	Start counting the moment the exercise stops, or use a data logger with a breathing sensor.
The breath collected in the bottle may not be a normal one, and the volume is read only to the nearest 100 cm ³ .	The depth is not accurate; a breath taken a little later after exercise is also smaller.	Collect and measure three breaths and take a mean, use a bottle marked every 50 cm ³ , or use a spirometer. Chest expansion measured with a tape measure is another way to compare depth.
The level of exercise is judged by eye and is not the same for each person.	The rate and depth vary, so the results are not comparable.	Use a fixed exercise such as step-ups on a step of fixed height at a set rate with a metronome.
The person does not recover fully between activities.	The next activity starts with a higher breathing rate, so its results are too high.	Wait until the breathing rate is back to the resting rate before starting the next activity.

Mark scheme

One mark for each point unless a maximum is given. Words in brackets are not needed for the mark.

1. [2]

- (a) the number of breaths (taken) per minute (1) allow in a set time
- (b) the volume of air breathed in or out in one breath (1) reject how deep the lungs are

2. [3]

- (a) the level / type / intensity of physical activity (1)
- (b) breathing rate / depth of breathing (1)
- (c) any one from: same person / same time for each activity / same time for counting breaths / same bottle / full recovery between activities (1)

3. [3]

- 24×1100 (1)
- $= 26\,400\text{ cm}^3$ (1)
- 26.4 dm^3 (per min) (1) allow 26 dm^3 ; unit required

4. [3]

- $32 - 14 = 18$ (1)
- $18 \div 14 \times 100$ (1)
- 129% (1) allow 128.6%

5. [3]

- the harder the activity, the greater the breathing rate (1)
- the harder the activity, the greater the depth of breathing (1)
- quotes paired data, e.g. rate rises from 14 to 32 breaths per min / depth from 500 to 1500 cm^3 (1)

6. [2]

- a resting measurement is needed for comparison / to show the effect of the activity (1)
- so that each activity starts at the same breathing rate / the previous activity does not affect the next (1)

7. [3]

- muscles respire faster, so more carbon dioxide is produced (1)
- the carbon dioxide concentration in the blood increases and is detected by the brain (1) reject brain detects lack of oxygen
- (the brain causes) an increased rate and greater depth of breathing (1)

8. [2]

- the breath pushes the water out of the bottle / the air collects in place of the water (1)
- the volume of water pushed out equals the volume of the breath, so it can be read from the scale (1)

9. [3]

- more repeats / more people, and calculate a mean (1)
- use a fixed exercise such as step-ups at a set rate (1)
- use a spirometer / data logger / a bottle with smaller divisions (1)
- start counting the moment the exercise stops (1)
- measure several breaths and take a mean (1)
- Max 3

10. [2]

- do not take part if they have asthma / a breathing or heart condition (1)
- stop if they feel dizzy / unwell (1)
- only breathe out through the tubing, never in (1)
- use a new mouthpiece / do not share mouthpieces (1)
- Max 2

11. [3]

- bar chart, because the activities are separate categories (1)
- activity on the x-axis and breathing rate / breaths per min (or depth / cm^3) on the y-axis (1)
- bars of equal width that do not touch (1)
- suitable scale using more than half the grid (1)
- Max 3

Exam tips

- Learn both definitions: rate is the number of breaths in a set time (per minute), and depth is the volume of air in each breath.
- Use a bar chart for activities. Bars have equal width and do not touch.
- Head columns with quantity / unit, for example breathing rate / breaths per min. Leave units out of the table body.
- Supplement: write that the carbon dioxide concentration in the blood increases and is detected by the brain. Do not say that the brain detects a lack of oxygen.
- Always mention both rate and depth when describing the effect of exercise, and quote figures from the table.