Personal record

Record this information about the person who will be doing the exercise.

a Would you describe yourself as physically fit?

No ☐ (I exercise infrequently)

Yes ☐ (I exercise frequently)

Very ☐ (I take vigorous exercise (e.g. cycling, swimming) frequently)

b Measure the exerciser's pulse at rest (sitting down) for 15 seconds. Multiply the number of beats by 4 to get the heart rate (beats per minute). Record this in the table below.

c Measure the exerciser's breathing rate at rest for 15 seconds. Multiply the number of breaths by 4 to get the breathing rate (breaths per minute). Record this in the table below.

d The person exercising should now begin to exercise (as directed by your teacher). Start the stop clock.

e After 4 minutes, stop exercising. **Immediately**, measure and record the heart rate and breathing rate as before.

f Take the heart rate and breathing rate again at 2 minutes after exercise and 4 minutes after exercise.

(If you have a pulse meter, you may be able to record pulse rate *during* exercise too, e.g. after 2 minutes, adding this to your table).

Heart rate (beats per minute)				
At rest	**(During exercise)**	**Immediately after exercise**	**2 min after exercise**	**4 min after exercise**

Breathing rate (breaths per minute)				
At rest	**(During exercise)**	**Immediately after exercise**	**2 min after exercise**	**4 min after exercise**

Extension: If you finish your data collection early, answer these questions.

Will the combined class data be enough to evaluate any claim about fitness?

Are there any problems with method used to collect the data?

Will these problems affect the validity of the data?

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Answer these questions

1 Write down the claim you are evaluating.

.....

.....

.....

2 Look at the evidence that you have collected as a class and work in a pair to discuss these questions.

a Does the available evidence support the claim?
b Can you explain *how* the evidence does or doesn't support the claim?
c Do you have enough evidence to decide whether you agree or disagree with the claim?
d If a claim is not supported by the available evidence what additional evidence you would need to support it?

3 Do you agree or disagree with the claim? Explain your answer.
(Make sure you include the points you have just discussed)

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Peer review

Read the argument and decide whether it meets the success criteria. For each of the criteria use the comment box to say how well it has been met. Do not just tick.

Success criteria	Comments (Not just ticking!)
Is the claim clear?	
Is the claim linked to evidence?	
Does the evidence support the claim?	
If the data is not sufficient to support the claim, has it been suggested what other data would need to be collected?	
Are you convinced by the argument?	
How could the argument be improved?	

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Secondary data about heart rate and exercise

Scientists often look at data collected by other people to find out more about an area of science they are studying.

Data you have collected yourself is called **primary data**.

Data collected by other people is called **secondary data**.

Your task is to:

- select one claim for your argument
- summarise your conclusions from each set of secondary data
- use the secondary data to evaluate your chosen claim
- use the primary data collected last lesson as additional evidence to support or reject the claim.

You need to think about whether there is enough data for you to be certain of the claim's accuracy.

Claims

1 Men are more physically fit than women.

2 Walking does not affect breathing rate.

3 People who do more physical activity have a lower resting heart rate.

4 Resting heart rate decreases with age.

Complete the argument frame at the end of this sheet once you have examined and summarised the secondary data.

Secondary data

Figure 1

A pair of students wanted to find out about the effect of exercise on heart rate and breathing rate. They measured their heart rate and breathing rate at rest, after walking up and down two flights of stairs, and after running up and down two flights of stairs. Here are the results.

	Heart rate			Breathing rate		
	At rest (bpm)	Walking (bpm)	Running (bpm)	At rest (breaths/min)	Walking (breaths/min)	Running (breaths/min)
Student 1	68	63	112	12	12	16
Student 2	72	86	120	12	12	14

http://serendip.brynmawr.edu/biology/b103/f00/lab5.html

1 The data in figure 1 shows…..

.....

.....

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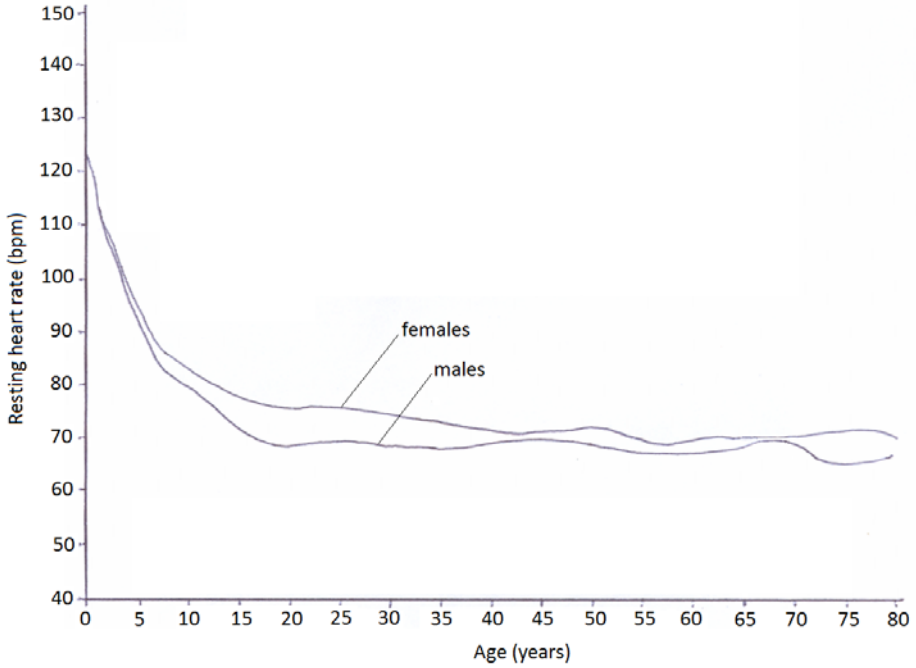
Figure 2

The resting heart rates of 35 000 people in the US were measured. These graphs show how the average resting heart rate varies with age. One line shows the data for females and one for males.



US Department of Health and Human Services, National Health Statistics Reports No. 41, 24/8/2011.

2 The data in figure 2 shows…..

.....

.....

Figure 3

Seventeen adult men (ten young, and seven middle-aged) were studied in controlled conditions. At the start of the study they all did very little exercise. Their resting heart rate was measured. They then took part in a three-month physical training programme. After three months their resting heart rate was measured. Here are the results.

	Young men (average age 21)	**Middle-aged men (average age 53)**
Average resting heart rate *before* physical training programme	69 bpm	72 bpm
Average resting heart rate *after* physical training programme	60 bpm	62 bpm

Brazilian Journal of Medical and Biological Research (2002) 35: 741-752

3 The data in figure 3 shows…..

.....

.....

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Argument frame

Claim	Evidence from secondary data and how this supports the claim	Evidence from primary data and how this supports the claim	Is the data sufficient to *fully* support the claim? Can you rewrite the claim so that it is fully supported by the data?

Summary activity

Use what you have learnt from these lessons to write a short paragraph explaining the effect of exercise on heart and breathing rate.

Write down what you understand by 'fitness'.

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Heart rate, breathing rate, physical fitness – Teacher guidance

Learning structure of the lesson

The big picture

This sequence of two lessons is designed to exemplify an argumentation approach to practical work, using an 'analysing and interpreting data' framework.

Students use primary data about heart rates and breathing rates, alongside secondary data from children and adults, to assess and argue for or against the validity of claims about physical fitness. They consider whether the evidence is sufficient in itself to support the claims, particularly when the sample size is small, or whether more data is needed. They justify their decisions through argumentation.

Age range: 14–16

Timing: 2 x 50 minutes

1: Learning episode 1 (teacher-led) 10 mins

Show students how to find heart rate and breathing rate. Discuss what they think happens to heart and breathing rate when you exercise and why. Introduce the learning outcomes for the lesson.

1: Learning episode 2 (student-led) 20 mins

Assign students to groups and give each a claim to investigate. Students carry out the practical activity and class data is collated on a spreadsheet.

1: Learning episode 3 (student-led) 20 mins

Groups split into pairs and use the success criteria to evaluate their claim and develop an argument. Challenge students to justify their responses. Pairs swap arguments for peer assessment.

2: Learning episode 4 (teacher-led) 10 mins

Students reflect on what they learnt in lesson 1. Present the four claims which they will evaluate this lesson, using both primary and secondary data.

2: Learning episode 5 (student-led) 25 mins

Each pair evaluates one or more of the claims. Some feedback to the class. Encourage others to ask questions, and challenge them to justify their arguments. Pairs write down their arguments and swap for peer assessment.

2: Learning episode 6 (student-led) 15 mins

Class discussion drawing together ideas about fitness, validity of evidence, and strong scientific arguments.

Learning outcomes

Students will be able to:

- collect and analyse data about heart rate, breathing rate, and self-assessed fitness level
- decide whether evidence supports or does not support claims about physical fitness
- decide whether evidence supports or does not support claims about physical fitness
- state what further evidence would be needed to support a claim
- describe the effect of exercise on heart rate and breathing rate

Equipment and materials

Teacher guidance

Practical guidance

Slide presentation

Spreadsheet

Student sheet 1

Student sheet 2

Per group

Stopwatch or stopclock

Per class

Access to computer running Microsoft Excel to collate data and analyse it

Refer to the health and safety advice and practical guidance

Key words

Argument, claim, evidence/data, correlation

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Prior knowledge

It is assumed that students know the following.

- How to interpret line graphs and tables of data.
- The heart pumps blood around the body, and blood provides tissues with oxygen and glucose needed for cellular respiration.
- Respiration provides energy to the tissues for activity such as muscle contraction.
- The lungs allow gas exchange between the blood and the atmosphere, providing a source of oxygen for respiration.

Background information

Breathing rate increases to provide the body (exercising muscles) with oxygen at a higher rate. Heart rate increases to deliver the oxygen (and glucose) to the respiring muscles more efficiently. The heart, lungs and circulatory system working together make up the cardiovascular system.

There are many different definitions of fitness. Key ideas include being able to manage regular physical demands on the body without feeling fatigue and having the capacity to increase activity when demand requires.

Factors to consider are:

- stamina or endurance of the cardiovascular system
- muscle strength
- muscle endurance – ability of the muscle to perform without fatigue
- suppleness or flexibility.

When people exercise regularly their muscle strength and endurance increases. Regular exercise increases the strength of the muscles in our cardiovascular system (heart, diaphragm and muscles between the ribs) making them more effective at moving blood around the body (heart muscle) and getting oxygen into our lungs (diaphragm and rib muscles).

Someone who is physically fit can supply their muscles with enough blood, carrying glucose and oxygen, for an activity at a lower heart and breathing rate. The fitter you are the lower your resting heart rate.

Use of student data

When student data is part of the investigation it is good practice to:

- give individuals an opportunity to opt out of the physical activity, or opt out of having their data included in the final collation
- keep individual data anonymised in the collation
- check students' medical details before carrying out
- liaise with P.E. department who might help to provide a more suitable place to carry this out.

Behaviour management

Having half a class exercising in a crowded lab can make behaviour difficult to

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manage. Minimise the number of physically active students by defining other roles (pulse-taker, breathing-rate counter, timer, recorder) and having students work in groups of up to five. If you can trust the behaviour of some groups, they could exercise in another area.

Terminology

The terms which students needed to understand and use in this lesson are:

argument – the process that students use to articulate, support and justify claims or conclusions

claim – a conclusion, idea, proposition or assertion

evidence/data – the observations and accepted scientific theories used to support the claim

correlation – a link between two factors, e.g. if one factor increases (or decreases) as another factor increases there is a correlation

Differentiation

- In lesson 2, processing the data to argue for or against any of the four claims could be a challenge both in terms of logic and in the use of a spreadsheet to show correlations. Some students could use only the secondary data, while others could be challenged to use both secondary and primary data in their arguments.
- Some students could be challenged to write questions which can be answered using the secondary data. They can swap these with other students.
- Some students will be able to make their own claim to test using the data.

Optional extension activities

- Students could self-assess their work before the peer-assessment exercise. They could then compare and reflect on their skills of self-assessment.
- Evaluate information from a news report about exercise and health (e.g. www.bbc.co.uk/news/health-18335173). Decide if there is enough evidence in the report to be confident of the claims made. What more evidence would you want?

Related practical activities on Practical Biology

There are detailed instructions for the activity in this lesson on Practical Biology: www.nuffieldfoundation.org/practical-biology/observing-effects-exercise-human-body

Lung function:
www.nuffieldfoundation.org/practical-biology/modelling-human-ventilation-system
www.nuffieldfoundation.org/practical-biology/dissecting-lungs

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Other measures of lung function:
www.nuffieldfoundation.org/practical-biology/using-spirometer-investigate-human-lung-function

Heart function:
www.nuffieldfoundation.org/practical-biology/looking-heart

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Lesson details – lesson 1

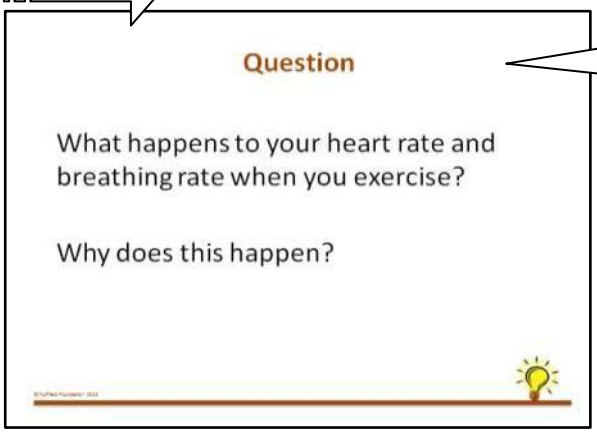
Slide 2

Task: Display **slide 2** as the students arrive. This shows them how to take a pulse and asks them to try taking their own.

Explain: Once all students have managed to find their pulse, explain that pulse rate (number of pulse counts per minute) is a measure of heart rate. Explain that you can find your breathing rate by counting breaths per minute.

You can make a count for 15 seconds and multiply the answer by 4 (to get the count for 60 sec/1 min).

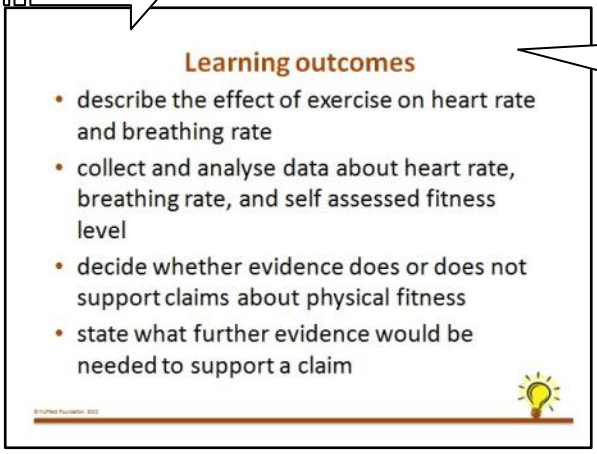
Slide 3



Task: Ask the questions on **slide 3**. Give students 2 minutes to 'think, pair, share' their answers to the questions, then end with a short class discussion on their ideas.

Differentiation: Students could jog on the spot, or stand then sit repeatedly, for 30 seconds to give them physical experience of slight exercise and help bring out their ideas.

Slide 4



Explain: Show students the learning outcomes on **slide 4** and explain that over the next two lessons, they will be using data to investigate claims about fitness.

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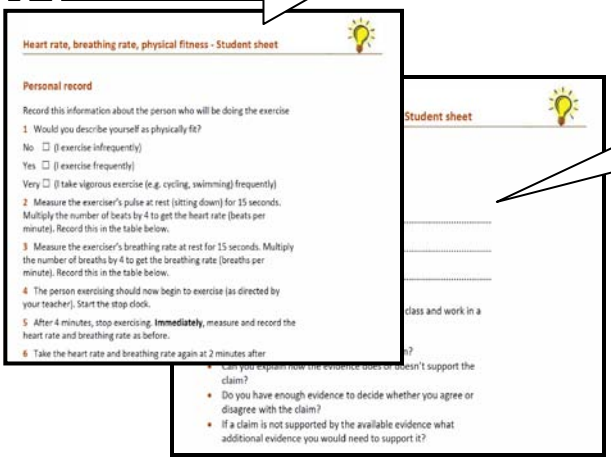
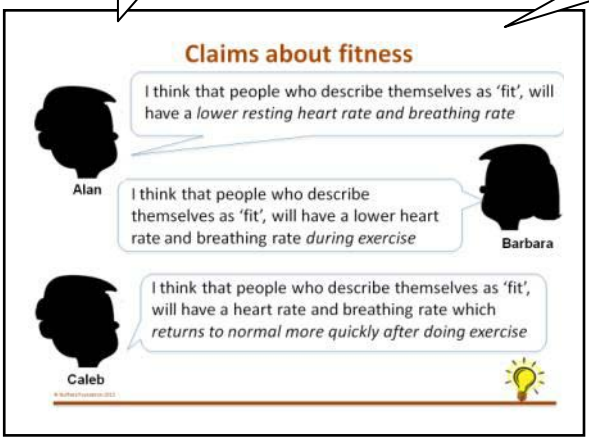
Student sheet 1



Task: Place students in groups of two to five (see guidance on behaviour management). Give each group **Student sheet 1** pages 1 and 2.

Slide 5

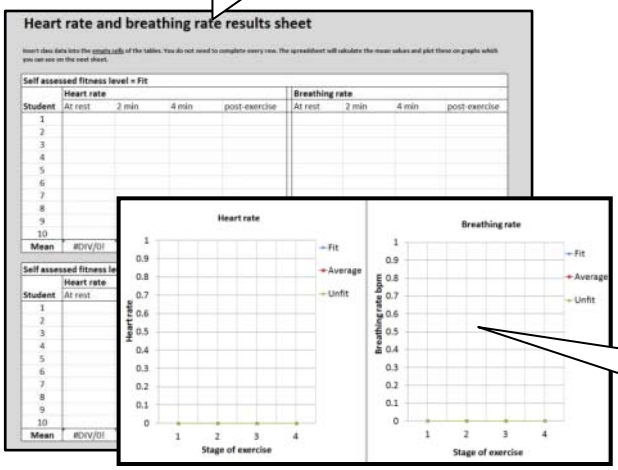


Task: Present the claims on **slide 5**. Assign each group one of the three claims to evaluate. They write this on **Student sheet 1** at the top of page 2.

Differentiation: Caleb's claim is more complex to analyse and could be given to a group that is stronger at mathematical manipulation. To assess recovery, students could calculate the '4 minutes after exercise' value as a percentage of resting rate and compare this percentage with the self-assessed fitness level.

Explain: Explain that students are going to collect information about their heart rate and breathing rate before and after some exercise. All groups will collect all the data then share it as a class. They will use the class data to evaluate the claims.

Spreadsheet



Task: Assign roles to students, so that each group has one exerciser and one or more students measuring pulse, measuring breathing rate, keeping track of time and recording the results.
Students follow the instructions on page 1 of **Student sheet 1** to collect their data. (See **Practical Guidance**).

If a pulse meter is available it is possible to also record the pulse during exercise.

Task: Collate class data using the **spreadsheet** projected on a whiteboard or displayed on a computer screen.

The mean values are automatically calculated. Click the 'Graphs' tab at the bottom of the spreadsheet to view line graphs of the mean values. Make the graphs available to the class.

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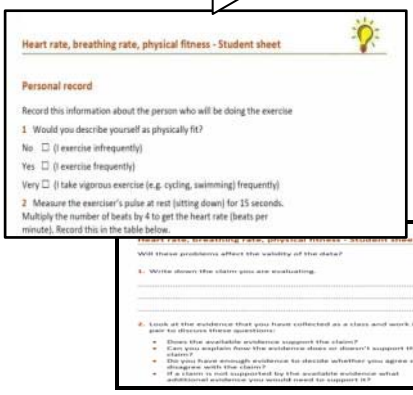
Student sheet 1


Heart rate, breathing rate, physical fitness - Student sheet

Personal record

Record this information about the person who will be doing the exercise

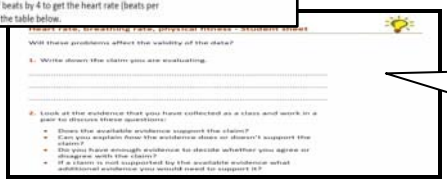
1 Would you describe yourself as physically fit?

No ☐ (I exercise infrequently)

Yes ☐ (I exercise frequently)

Very ☐ (I take vigorous exercise (e.g. cycling, swimming) frequently)

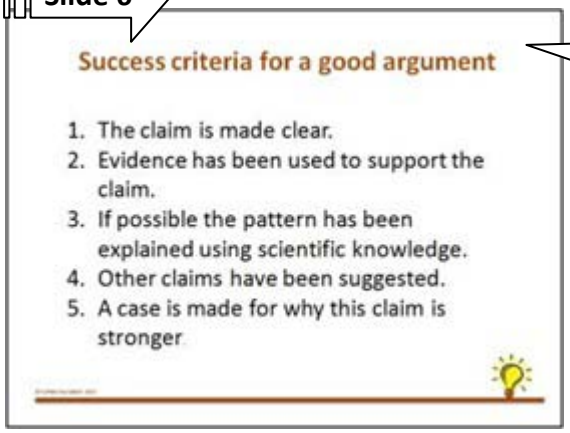
2 Measure the exerciser's pulse at rest (sitting down) for 15 seconds. Multiply the number of beats by 4 to get the heart rate (beats per minute). Record this in the table below.



Differentiation: If some groups have completed the practical work and are waiting for others to finish, ask them to think about the extension questions on **Student sheet 1**.

Task: Split groups into pairs or threes, and give them 5 minutes to discuss questions 2a–d on page 2 of **Student sheet 1.**

Slide 6


Success criteria for a good argument

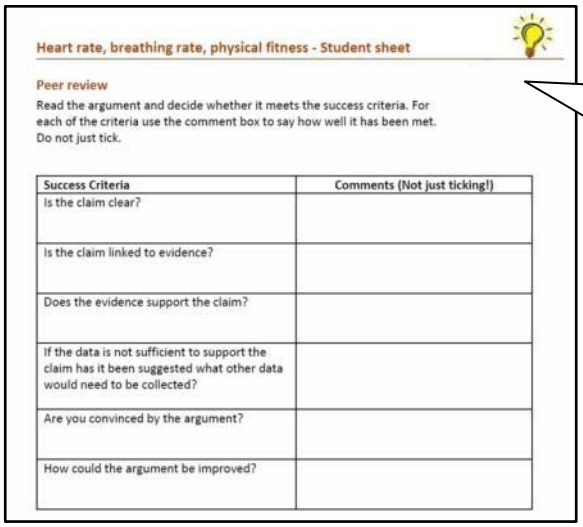
1. The claim is made clear.
2. Evidence has been used to support the claim.
3. If possible the pattern has been explained using scientific knowledge.
4. Other claims have been suggested.
5. A case is made for why this claim is stronger

Task: Use **slide 6** to introduce the success criteria for a good argument.
Ask each pair of students to write down their argument either supporting or rejecting their claim. They must use evidence from the practical work.

Circulate and challenge students to justify their responses using prompting questions, e.g.

- Did everyone's data follow the same pattern?
- Do you think people are good at assessing their own fitness level?
- Do you think the pulse rate and breathing rate measurements were accurate?
- Do you think enough people were tested to allow us to draw conclusions from the results?

Student sheet 1


Heart rate, breathing rate, physical fitness - Student sheet

Peer review

Read the argument and decide whether it meets the success criteria. For each of the criteria use the comment box to say how well it has been met. Do not just tick.

Success Criteria	Comments (Not just ticking!)
Is the claim clear?	
Is the claim linked to evidence?	
Does the evidence support the claim?	
If the data is not sufficient to support the claim has it been suggested what other data would need to be collected?	
Are you convinced by the argument?	
How could the argument be improved?	

Task: Give out **Student sheet 1** page 3. Each pair swaps their argument with another to peer assess, referring to the success criteria provided. They should use the table on the sheet to provide useful feedback. The arguments and feedback are returned to the original pairs to read and if necessary to improve their work.

The peer review sheet includes the question 'Does the evidence support the claim?' A good argument will not only refer to evidence but also include statements which explain the connections between the data and the claim.

Task: Each pair sets themselves a goal for the next time they are using argumentation skills, and writes this at the bottom of the sheet.

Discuss what students have learnt from looking at how other people develop arguments. Share some of this thinking as a class.

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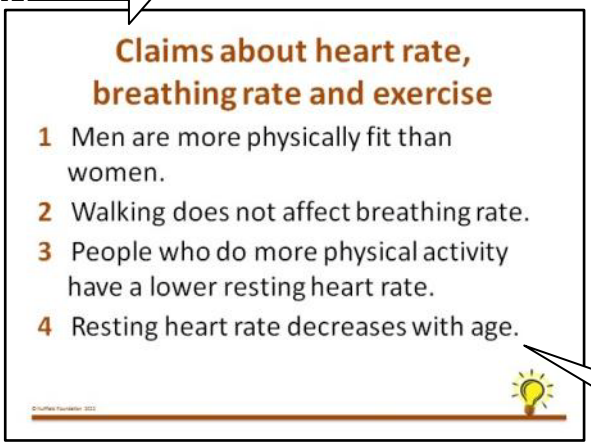
Lesson details – lesson 2

Slide 8

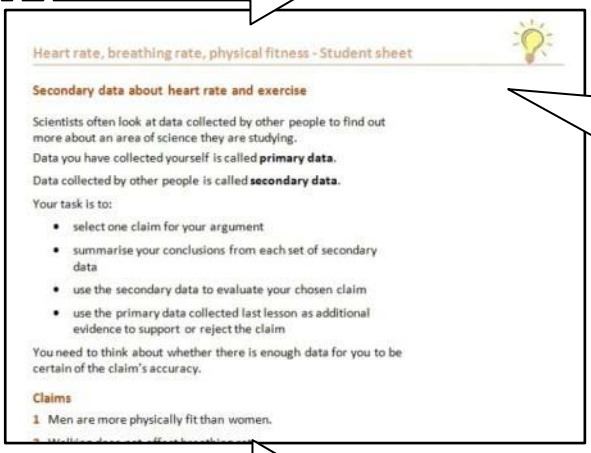


Task: Students reflect on their performance in Lesson 1, in particular their development goal for improving argumentation skills. Encourage them to think how they could implement this goal in this lesson.

Explain: Explain to students that they will be working in their pairs (the same as in lesson 1), and will use secondary data (collected by other people) in addition to their own primary data, to evaluate claims about heart rate, breathing rate and exercise.

Task: Present the claims on **slide 8** and ask: 'What do you think about these claims? Do you think they are true? If so, why?'

Student sheet 2


Heart rate, breathing rate, physical fitness - Student sheet

Secondary data about heart rate and exercise

Scientists often look at data collected by other people to find out more about an area of science they are studying.

Data you have collected yourself is called **primary data**.

Data collected by other people is called **secondary data**.

Your task is to:

- select one claim for your argument
- summarise your conclusions from each set of secondary data
- use the secondary data to evaluate your chosen claim
- use the primary data collected last lesson as additional evidence to support or reject the claim

You need to think about whether there is enough data for you to be certain of the claim's accuracy.

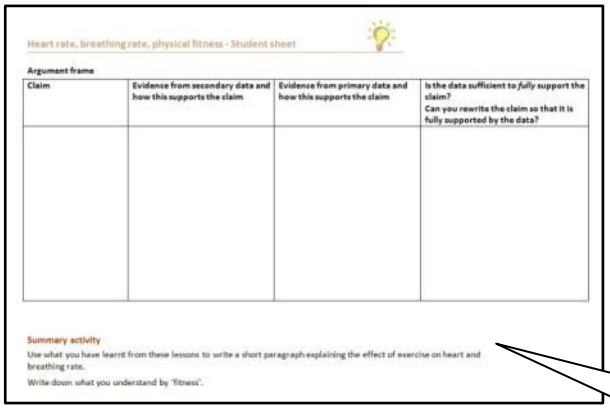
Claims

1 Men are more physically fit than women.

Task: Give out **Student sheet 2** pages 1 to 3. Ask pairs to choose a claim to evaluate, or assign a claim (or claims) to each pair. Their task is to look at the secondary data and decide whether or not they agree with the claim. They should think about what they learnt last lesson about the validity of evidence, and the goal they set themselves.

Students should first look at each figure and discuss what it shows, then write this down as a short summary. They then use the secondary data to evaluate the claim(s). Again they discuss first, then write. Students can also refer to primary data collected last lesson.

Student sheet 2


Heart rate, breathing rate, physical fitness - Student sheet

Argument frame

Claim	Evidence from secondary data and how this supports the claim	Evidence from primary data and how this supports the claim	Is the data sufficient to *fully* support the claim? Can you rewrite the claim so that it is fully supported by the data?

Summary activity

Use what you have learnt from these lessons to write a short paragraph explaining the effect of exercise on heart and breathing rate.

Write down what you understand by 'fitness'.

Task: Ask some pairs to feedback on their thoughts about the claims. Encourage other students to ask questions and model this yourself.

Challenge students to really explain why, to think about whether the data is sufficient (e.g. fig. 1 only has a sample size of 2) and to think about whether they need to add any qualifiers to the claims (e.g. resting heart rate decreases with age, but only up to the age of 20. It then stays relatively steady through to old age).

Task: Ask students to then write down their arguments using the writing frame on page 3 of **Student sheet 2.**

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Student sheet 2


Heart rate, breathing rate, physical fitness - Student sheet

Argument frame

Claim	Evidence from secondary data and how this supports the claim	Evidence from primary data and how this supports the claim	Is the data sufficient to *fully* support the claim? Can you rewrite the claim so that it is fully supported by the data?

Summary activity

Use what you have learnt from these lessons to write a short paragraph explaining the effect of exercise on heart and breathing rate.

Write down what you understand by 'fitness'.

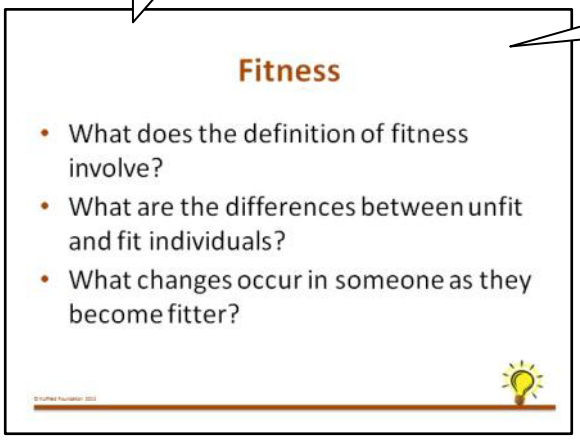
Task: Students swap their argument with another pair for peer assessment using a second copy of **Student sheet 2** page 3.

Feedback is returned to the original pairs to read and if necessary improve their arguments.

Task: Students reflect on how their argumentation skills, in analysing and interpreting data, have developed since the start of lesson 1.

Each pair sets themselves a goal for the next time they are using argumentation skills and writes this at the bottom of the page. What have they learnt from looking at how other people develop arguments?

Slide 9

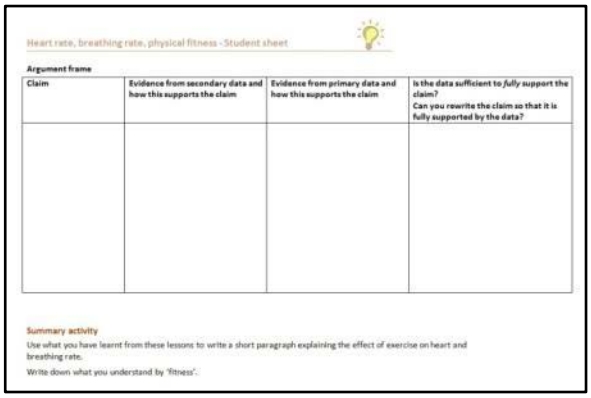


Task: Returning to the idea of fitness, students answer the questions on **slide 9**.

Make sure students understand that:

- 'Fitness' means different things to different people. If we are discussing 'fitness' we need to be sure we have agreed what it means. We might disagree with a claim because we are using a different idea of what fitness is.
- Data from a sample of people can be used as evidence to support claims about fitness.
- Data from a small sample does not support general claims about the population, but might be a starting point for further study.

Student sheet 2


Heart rate, breathing rate, physical fitness - Student sheet

Argument frame

Claim	Evidence from secondary data and how this supports the claim	Evidence from primary data and how this supports the claim	Is the data sufficient to *fully* support the claim? Can you rewrite the claim so that it is fully supported by the data?

Summary activity

Use what you have learnt from these lessons to write a short paragraph explaining the effect of exercise on heart and breathing rate.

Write down what you understand by 'fitness'.

Task: Ask students the following questions and discuss the answers as a class:

- What do you need to argue a claim successfully?
- How would you argue against someone else's claim?

We can successfully argue for a claim when we have evidence to support it.

We would argue against someone else's claim if we didn't accept their evidence or didn't agree that the evidence really does support the claim or have evidence to support a counter claim.

Task: The summary question on page 3 of **Student sheet 2** can be completed for homework.

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Equipment and materials

Per group
Stopwatch or stopclock

Per class
Access to computer running Microsoft Excel to collate data and analyse it

Health and safety and technical notes

Before carrying out this practical, users are reminded that it is their responsibility to carry out a risk assessment in accordance with their employer's requirements, making use of up-to-date information. Relevant risk assessment guidance is provided in the teacher's notes.

Read our standard health & safety guidance.

1 Exercises should be appropriate to footwear and clothing worn by students, for example, walking briskly up and down stairs or steps up onto a low bench in the lab or jogging on the spot.

2 Ensure that any equipment used on which students exercise is well-constructed and stable. If you choose a staircase as the site for exercise, instruct them to use the handrail and ensure by supervision that this is obeyed.

3 Doing low impact exercise as described in notes 1 and 2 should be safe for most students. Ensuring that any individuals with identified physical and/or health issues do not take the role of exerciser, and ensuring that the activity does not become competitive (and hence boisterous) should reduce the risk of the activity causing damage or injury. Students who would be excused PE at the time may well also be exempted from this activity. Asthmatics may be able to take part if they use their inhalers before starting the exercise.

4 Pulse meters were supplied to all schools in the Wellcome Trust 'In the Zone' packs, and may be used for this activity if sufficient numbers are available. These would enable the pulse to be recorded *during* exercise, as well as before and after.

Procedure

SAFETY: Supervision of this activity by teachers will ensure that it does not become competitive or too boisterous.

Preparation

1 Check students' health status, and discuss any issues with colleagues in PE.

Heart rate and breathing rate

2 Students work in groups and decide who will be the 'exerciser' and who will be the pulse-taker, breathing-rate counter, timer, and recorder. (One student could have more than one non-exercising role. The exerciser may be able to count their own breaths in a 15 second interval).

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3 The 'pulse-taker' takes the resting pulse of the exerciser. The exerciser should be sitting down and holding their left hand out with their palm facing up and their elbow straight.

The pulse-taker puts the index and middle fingers of their right (or left) hand together, and presses the pads of their fingers lightly on the underside of the exerciser's left wrist, just at the base of their thumb. With their fingers in this position, they should be able to feel a pulse.

Once the pulse has been found, the pulse-taker starts the stopwatch and counts the number of beats in 15 seconds.

4 While the pulse-taker is counting the pulse, the 'breathing-rate counter' should count the number of breaths the exerciser takes in the same time.

5 To find the heart rate in beats per minute, the pulse count for 15 seconds is multiplied by 4.

6 To find the breathing rate in breaths per minute, the breath count for 15 seconds is multiplied by 4.

7 The exerciser exercises for 4 minutes (as directed by the teacher – see health and safety and technical notes).

8 The pulse-taker and 'breathing-rate counter take heart rate and breathing rate measurements as before. They do this immediately after exercise has stopped, then 2 minutes after exercise stopped and then 4 minutes after exercise stopped. These rates should be taken with the exerciser sitting down.

9 Optional – Assessment of recovery can be made by calculating the '4 minutes after exercise' values as a percentage of resting rates and comparing the percentage with the measure of fitness. This should give an inverse correlation – the fitter the subject, the lower the percentage.

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