The science of exercise

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Educator notes

Learning objectives

- Understanding the cardiovascular system and cellular respiration
- Measuring forces, motion, work and power through a series of physical activities
- Understanding that heart rate increases during exercise and this is linked to increased respiration in muscle cells
- Recap prior learning about the respiratory system

Curriculum links

- Science (Physics)
  - Motion and forces
  - Material cycles and energy
  - Working scientifically
- Mathematics
  - Numbers
  - Geometry and measurement
  - Statistics

Time needed: 60 minutes

Equipment needed

- Whiteboard
- Stopwatch or timer
- Heart rate monitor or smartwatch/FitBit (optional)
- Marker pens or chalks, depending on wall
- Whiteboard markers in various colours
- Measuring tape or a metre ruler
- Plain paper and graph paper to note and plot results (optional if using whiteboard)
- A medicine (or other heavy) ball
- **Optional:** If the ball is not weighted, a scale to measure the mass of the ball

Resources required

- You've got the power student sheet

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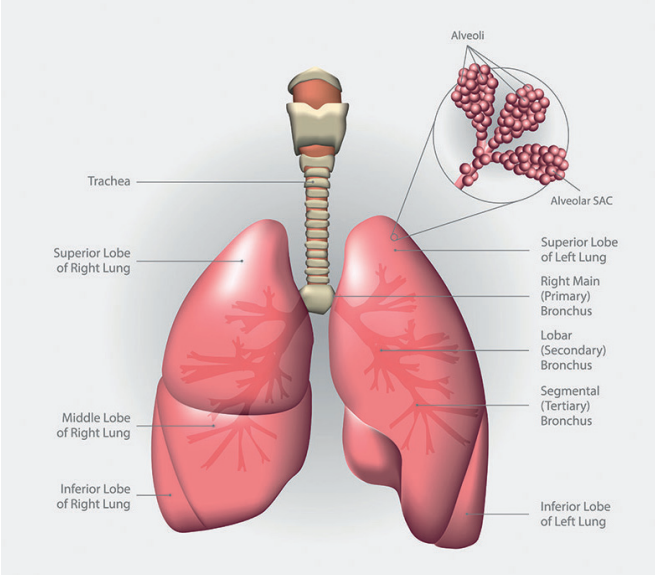
Preparation

Safety: All activities should only be undertaken if a suitably qualified adult is on hand to supervise. Risk assess the activities in line with the requirements of your setting and have a look at the **CLEAPPS website** for further guidance.

Starter activity

What is cardiorespiratory fitness?

- Start by explaining/revisiting the cardiorespiratory system. If you have completed the **How we breathe** starter activity you may be able to skip some of this section on the respiratory system
- Describe cardiorespiratory fitness to the class, telling them it is all about how both the circulatory system and respiratory system supply oxygen to our muscles when we exercise
- Draw the below diagram on the whiteboard



- 'Respiratory' refers to the respiratory system, made up of the lungs and airways
- When we breathe in air into our airways, including our lungs, the oxygen from the air diffuses into our blood, where it is picked up by our red blood cells
- 'Cardio' refers to the cardiovascular system, which includes the heart, blood and blood vessels
- Explain that the heart is a muscle that pumps blood cells around the body:
  - The right side pumps blood to the lungs, where it picks up the oxygen from the air
  - This oxygen-rich blood goes back to the heart's left side, which then pumps it round the whole body
- Nutrients such as glucose go into the blood from the digestive system, or from release of a substance called glycogen which is stored in the liver and muscles
- Blood cells travel all around our body carrying oxygen and glucose, to where it is needed

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Introducing cellular respiration

- Respiration is when oxygen and glucose combine in cells to release energy (in the form of a substance called ATP), carbon dioxide and water. The energy produced is needed for our muscles to contract when we move
- Our blood supply is also responsible for removing waste products such as carbon dioxide, which we breathe out
- Ask the students why they think people work to improve their cardiorespiratory fitness
- As the heart is a muscle, the more it's exercised the stronger it becomes. People can increase their heart's ability to deliver oxygen and nutrients to their working muscles, allowing them to exercise for longer
- Ask the students why they think breathing rates increase too
- Explain this is because exercise results in more oxygen needed in the blood. The respiratory muscles are stimulated to make breathing harder and faster
- If we don't have enough oxygen reaching our muscles, this reduces performance and can lead to cramps and soreness. This is also why warming up before exercise is important
- Let them know that warming up increases the flow of blood to muscles, meaning they get more oxygen, increasing their performance
- It also helps loosen the body, increasing flexibility and activates the connections between the nerves and muscles, making them more responsive

Activity 1
Turn up the beat

25 mins

Part one: Heart rate

Optional: If you have access to a heart monitor or smartwatch/FitBit, show students and ask them what information they could gain from it. Much more information can be gained from smartwatches and wearable technology these days (for example, time exercised, steps taken), but the most useful measure wearers are interested in, which the heart monitor also provides, is the heart rate.

- Ask students how they might find out their heart rate. The answer is by taking their pulse
- Demonstrate how to measure pulse rate on your own wrist (see diagram) so that all students can try on themselves too, by following your instructions
- Explain that as the thumb has a strong pulse of its own, we always use the two forefingers. We use these fingers on one hand to find the radial artery on the other wrist, located under the base of the thumb
- Remind students that their pulse is caused by their heart beating and pushing blood round their bodies. So, measuring your pulse is an easy way to measure how fast your heart is beating, whether at rest or after exercise

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Activity 1

Turn up the beat Continued…

- Ask for some easy-going volunteers to find out their resting heart rate in beats per minute (bpm), for which they need a clock, or stopwatch. (It may be easier to have those students who could find pulses easily in the previous activity to do the measuring on those students who are willing to do a bit of exercise)
- Draw a graph on the whiteboard that students can populate in different marker pen colours in the next activity, leave the axis blank

Part 1 – Method

1. Instruct students to count the number of beats in 15 seconds, and multiply by four to get the beats per minute
2. Students should be aware of why they are counting the number of pulses in 15 seconds and why this must be multiplied by 4, rather than counting for a minute (i.e. it takes less time, and 4 x 15 seconds = 1 minute)
3. Note the volunteers resting heart rates on the whiteboard
4. Instruct volunteers to do a short burst of exercise such as jogging on the spot for 30 seconds
5. As soon as the 30 seconds is over, ask them or a classmate to measure their heart rate by taking their pulse again. Volunteers can sit back down
6. Note the 'after exercise' heart rates in BPM (beats per minute) on the whiteboard. They will know that their heart rate increases during exercise, but now they must ask why?
7. Ask them to explain why their heart speeds up during exercise (to deliver oxygen and glucose to working muscles) and if their breathing rate changed

Part two: Recovery time

- Now, ask if students know what recovery time is?
- Explain that experienced athletes have a fast recovery time, i.e. the quicker their heart rate returns to their resting heart rate after exercise
- Coaches and fitness trainers measure the heart rate and recovery time of their athletes during and after exercise. This tells them how fit the athletes are and how well their training is going

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Part 2 – Method

1. Get the volunteers back up and explain that this time they will see how quickly their heart rate returns to normal after doing exercise. We already know their resting heart rates
2. The volunteers will jog on the spot at a steady rate for 90 seconds. Then ask them to sit down, take their pulse straight away and note it down
3. Get other members of the class to help the volunteers record their pulse every minute until it has returned to their resting heart rate, or until 10 minutes has passed, whichever is shorter
4. As their heart rates return to normal, ask students to work as a group to come up with how they can use the graph on the board to communicate this information
5. They should plot heart rate in BPM (y-axis) against time after exercise in minutes (x-axis), with each volunteer being a different colour. Connect each plot point with a line to show each volunteer's return to resting heart rate

Discussion

- Explain that top athletes tend to have both a quicker recovery time and a lower resting pulse rate. A typical resting pulse rate for a healthy adult would fall between 60 and 80 BPM. In teenagers, resting heart rates can be a bit higher and fall between 60 and 100 BPM
- When looking at the results, you can help the students understand that quicker recovery times can mean they are used to more exercise. It doesn't even have to be high intensity exercise, perhaps find out who walks to school, and who doesn't?
- Knowing recovery rate is important for understanding cardiovascular fitness. The faster the recovery time, the more resistant people are to fatigue

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Activity 2
You've got the power

20 mins

- Explain to the students that scientific vocabulary contains many of the same words that we use in our daily lives but can mean something quite different
- For example, in physics, 'work' is done whenever a force is used to move an object along a distance (in the same direction as the force). This is a unit of energy and is measured in joules (J)
- 'Power' on the other hand, is used to describe the rate of doing work, or the amount of work done over an amount of time. The faster the work, the greater the power. This is measured in watts (W)
- It is possible to measure the amount of power used with a simple equation: Power = Work/Time. Using the example of jumping in the air, the amount of force used to jump, divided by the time it takes to jump is the amount of power
- Work is a measure of the energy transferred when an object is moved by an external force
- In sports that require power, competitors may use their strength in a rapid burst to accelerate something like a javelin or discus. Or people exercising in a gym use power to move things like dumbbells and medicine balls

Method

1. Ask the class to get into teams of three and hand each group a copy of the **You've got the power student sheet** to make recordings
2. If the weight of the ball is not already known, students should use a scale to register the mass of the ball
3. Groups should decide who will be the subject, the observer recording the measurements and the timekeeper
4. The subject should stand with their feet shoulder width apart and hold the ball against their chest
5. Next, the subject throws the ball as far away as possible. They must try to throw the ball horizontally away from their body, not upwards or downwards
6. The observer should measure the horizontal distance that the ball has been thrown using the measuring tape or metre ruler. They can measure this based off where the ball hits the ground
7. The timekeeper should use a stopwatch or watch to time how long it takes the ball to hit the ground, giving them the time recording
   a. The timekeeper should use the **You've got the power student sheet** to record the distance and time to help them complete their calculations when they have finished
8. Rest for around 30 seconds
9. Repeat two more times and draw a table to record the results

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Method Continued…

10. They can now calculate the average distance the ball was thrown, and the average time it took to fall
11. To calculate the amount of power used to throw the ball, direct the students to use the following equations, provided on their **You've got the power student sheet**, to calculate force, work and power
    a. Force = Distance x Mass
    b. Work = Force x Distance
    c. Power = Work / Time

- **Optional:** Students can switch roles in order to compare their group results and give others an opportunity to try the different roles. Some students may not want to, or be able to, participate. It may help prevent this activity becoming a competition if only one student per group is the subject

Discussion

- Can students think of any way to improve this experiment? For example, was it hard to tell how long the ball took to drop? Perhaps filming it and using the video to tell how long it took would be more consistent?

Try next: Further learning about biomechanics and the body will complement this lesson well, or you can learn more about forces through GSK STEM Education's three **Forces at work** modules.