I’ve got the power

Lesson 2

Lesson 2 uses a carousel approach to further investigate the body’s response to exercise: CO₂ exhale, pulse rate, and blood pressure are all measured and from the measurements VO₂ max is estimated (in Lesson 3). The carousel comprises Experiments B, C, and D. Experiment D forms part of an exciting national data-collecting experiment that your students can take part in using the ‘Live Data Zone’ section of the In the Zone website.

Students will need to carefully carry out the investigation to ensure standardisation with data collected from other classes and schools, so that when they analyse the national data their results are more reliable. Instructions for using the pulse oximeter and blood pressure monitor are given on pages 7–9 of this guide.

Be aware of any student with any blood oxygen abnormality who may be distressed by having to take part in the pulse oximeter activity. Students should do warm-up exercises and stretches before they begin the carousel activities. Suggested warm-up exercises are walking on the spot and then raising it up to a gentle jog on the spot, followed by stretches for the quadriceps, hamstrings, and calves (see diagram on page 57).

What does being fit mean?

Student notes for this experiment are on page 85.

Aim

Students will explore what aerobic fitness is and how they can measure their own aerobic fitness using a step test. The step test involves measuring the heart rate after a period of exercise and gives an indication of aerobic fitness based on previous studies where the aerobic fitness values have been calculated and placed in normative tables. They will also use the data from the experiments to estimate VO₂ max as a measure of fitness (in Lesson 3). No student should feel under pressure to take part, for example if they are sensitive about their fitness level.

Equipment

<table>
<thead>
<tr>
<th>From the kit box</th>
<th>From your school</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 1 pulse oximeter</td>
<td>• stopclock</td>
</tr>
<tr>
<td>• tape measure</td>
<td>• gym bench/step stool/sturdy box/stair of height 0.25–0.3 m</td>
</tr>
<tr>
<td></td>
<td>optional:</td>
</tr>
<tr>
<td></td>
<td>• stadiometer</td>
</tr>
<tr>
<td></td>
<td>• metronome</td>
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</tbody>
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Safety

- If anyone begins the activity and starts to feel unwell they should stop immediately.
- Identify students with asthma so they can have their inhaler close at hand and use it if required.
- Ensure students are dressed appropriately for the activities – for classroom-based activities, normal school uniform with sensible shoes will be fine. Trainers are required for some of the aerobic activities.
- Identify any student (such as those with heart/lung problems) not able to take part in school PE/games lessons. They may need to be excused from taking part in the physical part of this activity but can take on a time-keeper or data recording role.
Healthy competition is encouraged but be aware of and discourage excessive competition between students as it can lead to overexertion and possible fainting or injury.

Ensure students carry out the activities in a suitable place, clear of any obstruction. If using stairs, students should use a handrail.

Running the experiment

1. The step test can take place in the classroom or outside. You could liaise with your PE department to ensure that there is enough space and equipment.

2. Test the pulse oximeter before the lesson and familiarise yourself with it so you can show students how to use it.

3. Students will use a stadiometer or tape measure to measure their standing and sitting heights. A stadiometer is a medical device for measuring height. The sliding horizontal headpiece will allow students to measure height more accurately.

   To collect accurate height measurements they will need access to a wall. When students measure their height, they should do this without shoes and with a ruler or other flat object to ensure that the measurement on the wall is to the top of their head. They should take a deep breath in, breathe out, relax, and stand tall without going on tiptoes.

   You could ask three students to measure a fourth student’s height separately without taking the precautions above to illustrate the variation in readings they will obtain.

4. See the Student sheet on page 85 for the protocol for obtaining evidence. Students may find it easier to keep the steady rate if they have access to a metronome. For a step rate of 30/minute set the metronome at 120 beats per minute (4 clicks = one step cycle). There are also online metronomes and free metronome apps.

5. The pulse oximeter is used for two things during this experiment: the heart rate and the percentage oxygen saturation in arterial blood. Students must not wear the pulse oximeter whilst exercising. They must ensure that they have access to a pulse oximeter immediately after finishing their exercise.

   If you don’t have enough pulse oximeters, you could get the students to calculate their heart rate in beats per minute by counting the number of beats in 15 seconds at the end of each minute of exercise. Ideally, however, all data submitted to the ‘Live Data Zone’ should be collected using the same equipment, i.e. pulse oximeter.

Expected results

The pulse oximeter measures the percentage oxygen saturation in arterial blood and pulse rate.

Pulse rate

Pulse rate increases with exercise, and may rise to 160–180 beats per minute following the step test. Resting heart rate is likely to be between 60 and 100 beats per minute, depending on the fitness of the individual and if they have consumed caffeine or smoked cigarettes. It can take up to 10 minutes for the pulse rate to return to resting value after hard exercise, although very fit individuals may have recovered at the end of 3 minutes.

Blood oxygen saturation

The percentage oxygen saturation in arterial blood, usually around 97–99%, may not change during exercise.
Students may realise that as the arterial blood delivers more oxygen to tissues, the blood returning to the heart and then going to the lungs will be more deoxygenated than when at rest. This gives a steeper concentration gradient across the alveoli walls in the lungs and more oxygen diffuses into the blood.

The increased demand for oxygen by muscle tissues during exercise is met by increased heart rate, increased stroke volume, and the lowering of the haemoglobin’s affinity for oxygen so that oxygen is given up more readily to respiring tissues.

During exercise, arterial blood delivers oxygen to muscles. The haemoglobin’s affinity for oxygen is lowered and so in the muscles, the oxygen is given up more readily to the respiring tissues (dissociation curve shifts to the right). Therefore, venous blood leaving the muscle tissues may have less oxygen than when at rest. However, this oximeter measures only oxygen levels in arterial blood. After prolonged exercise more oxygen may be extracted from the air in the alveoli, but this may not happen with short periods of exercise.

The oximeter is used when athletes train/compete at higher altitudes, to check their levels of arterial oxygen, as before acclimatisation, this baseline level is likely to be lower than normal.

Some research shows that in about 50% of trained athletes, their arterial oxygen saturation levels actually fall during exercise. This may be due to inadequate increases in their pulmonary ventilation (breathing rate and depth), but so far the evidence is inconclusive.

**Fitness levels and VO\(_2\)max**

The normative values for the fitness index are from the Harvard step test, which used an original bench height of 40–50 cm. For gym benches (usually 22 cm), students will be exercising at a lower intensity so we have found that they will over-estimate their fitness levels – this could be discussed. The equation also assumes students keep to the 30 steps per minute rate and full five minutes.

Typical values for VO\(_2\)max (estimated in Lesson 3) are given in the Student sheet for Lesson 3. These values are affected by gender, genetics, and age, as well as cardiovascular fitness. There is a way of directly measuring VO\(_2\)max in a lab using gas analysis, but that is not available to us. Students estimate their rate of oxygen consumption during the step test and should consider how well it might correlate with actual VO\(_2\)max (it is an indirect method; they are also not exercising at maximum possible intensity). They should also appreciate that the formula used does not consider body mass, and that height and mass may both affect how well people can carry out the stepping task. Total oxygen consumed can be found by multiplying the value in ml kg\(^{-1}\) min\(^{-1}\) by body mass in kg.

In Lesson 3, students will evaluate whether height or sitting height affects the calculation for VO\(_2\)max, for students of the same age, gender, and general fitness. Since the step is the same for students of all heights, taller people or people with long lower limbs use less energy to step a fixed height. This means they will not have to work so hard, their heart rate will be lower, and VO\(_2\)max is underestimated.