I’ve got the power

Lesson 1

How much power do my muscles generate?

The student notes for this experiment are on page 80.

Aim

Students will investigate the power their leg muscles generate when they do step exercises. Using their results they will estimate how much work the body does during step exercises at different intensities. This will start to get the students to discuss how energy is provided to muscle cells to allow them to contract and be able to perform work, and to consider the different energy systems (aerobic and anaerobic) that produce the required ATP that is used as the body’s universal energy currency.

Equipment

<table>
<thead>
<tr>
<th>From your school</th>
<th>optional</th>
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<tbody>
<tr>
<td>stopclocks</td>
<td>• metronome</td>
</tr>
<tr>
<td>gym bench/ aerobic step/ sturdy box/ stair, of height 0.25–0.3 m</td>
<td>• music</td>
</tr>
<tr>
<td>bathroom scales</td>
<td>• tally counter</td>
</tr>
<tr>
<td>metre ruler</td>
<td></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.

Running the experiment

1 In the previous lesson ask students to measure their body mass in kg at home and bring this data with them to this lesson. They should measure their clothed mass, as they will be lifting their clothed weight during the experiment. Some may forget to measure their mass so have a set of bathroom scales available if possible – this will also ensure that measurements are standardised. No student should feel under pressure to take part, particularly if they are sensitive about their weight, and there is no need to share their mass in kg with the rest of the class.

2 Students ought to be reminded of the difference between mass and weight and of the units for both work and power.

3 Students will be counting how many times they can go up and down a step in 1 minute. They will need to measure the height of the step that they use. Ensure that they measure the height of the step, bench, or stair in metres rather than centimetres. If you have steps of different height, allow students shorter than e.g. 1.5 m to work on the lower steps to ensure they can step safely on and off the step. If using stairs, students should use a handrail.

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4. You could liaise with your PE department to ensure that there is enough space and equipment. Students should work in pairs. See the Student sheet on page 80 for the protocol for obtaining evidence.

5. Students should practise the step exercise prior to starting the actual test to enable them to get the correct rhythm. Students may find it easier to keep the steady rate if they have access to a metronome, which is set at 120 beats per minute (4 clicks = one step cycle). Ensure students step onto the step with one foot, followed by the other foot, and then step down from the step with one foot followed by the other. This whole cycle is one step. They can choose which foot to lead with and this can be changed during the test if they wish.

6. Emphasise the need for time to rest and recover following the exercise before moving on to the next measurement.

7. The PowerPoint presentation on the In the Zone website includes a tool for recording class results.

8. Discussion should be around how the energy is generated, the energy systems (aerobic or anaerobic) at different rates of stepping, and how we get the oxygen required for energy release to the muscles that require it. This can also encompass a brief discussion about ability to generate greater power and different fitness levels.

**Expected results**

In each case:
- the distance moved is the height of the step provided, in metres
- the force (weight) is each student’s body mass in kg multiplied by 9.8 ms⁻² (acceleration due to gravity) to give the value in newtons (N)
- total work done is force × distance × number of steps in 1 minute, and the unit is joules (J).
- power (the amount of energy transferred each second) is total work done (J)/time taken (s), and the unit is watts (W).

Hence:
- total work done will vary from student to student depending on their mass, the step height used, and how many steps they do per minute
- work done will vary for each student at each different activity level, depending on how many steps they do per minute at each level of intensity.

For example, for a person of mass 70 kg, their weight is 70 × 9.8 = 686 N.

If the step is 0.3 m high then for one step the work done is 686 × 0.3 = 205.8 J.

For 30 steps in 1 minute:
- their total work done is 205.8 × 30 = 6174 J
- their power is \( \frac{6174 \text{ J}}{60\text{ seconds}} = 102.9 \text{ W} \)

For 60 steps in 1 minute:
- their total work done is 205.8 × 60 = 12348 J
- their power is \( \frac{12348 \text{ J}}{60\text{ seconds}} = 205.8 \text{ W} \)

- the small amount of work done descending the step, as well as the slight forward and backward movement of the body with each step, is ignored.

**Next lessons**

In Lesson 2 you will be running a carousel of three experiments (B–D) on aerobic fitness, and CO₂ exhaled, pulse rate, and blood pressure before and after exercise. There are two stations for each experiment. Lesson 3 will give students the opportunity to analyse and evaluate all the data they have collected, calculating VO₂max as a measure of fitness, for example. This is also when they will be able to upload the data from Experiment D to the ‘Live Data Zone’ section of the In the Zone website (www.getinthezone.org.uk) and analyse and evaluate national data from UK schools.