The ATP-PC system

You need to understand the role of the ATP-PC system in energy production for exercise and sports performance.

**Aerobic and anaerobic activity**

Sport and exercise activities are often described as aerobic, anaerobic or a mixture of both. This relates to how much the sport or exercise activity relies on the presence of oxygen for energy production. Those activities requiring oxygen are said to be aerobic, those that depend on energy production without the presence of oxygen are said to be anaerobic.

<table>
<thead>
<tr>
<th>Anaerobic activities</th>
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<tbody>
<tr>
<td>These types of activities:</td>
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<tr>
<td>☑️ are short in duration</td>
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<tr>
<td>☑️ require the use of fast twitch muscle fibres</td>
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<td>☑️ rely on strength, speed or power.</td>
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**ATP-PC**

ATP is the chemical form of energy that our body uses for all muscle contractions. There is sufficient ATP in the muscles for approximately 2–3 seconds of work; after this more ATP needs resynthesising (rebuilding). In the ATP-PC system the energy required to resynthesise ATP is provided by phosphocreatine (PC).

PC is made up of a molecule of phosphate and a molecule of creatine. There is enough PC in the muscle cell to continue to resynthesise ATP for approximately 8–10 seconds of physical work.

**Advantages / disadvantages**

The advantages of this system are that energy is released quickly and no waste products are formed. The disadvantages are the limited stores of PC and the 2–3 minutes required to fully recover these stores. This means there is insufficient recovery time during play in many sporting situations to recover the PC stores once they have been used.

**Recovery time**

Once the supply of PC has been broken down to resynthesise ATP, energy is needed from another energy system to resynthesise the PC stores. This energy is provided from the aerobic system.

The chemical bond between the phosphate and creatine molecule breaks, releasing energy that is then used to resynthesise ATP.

**Anaerobic activities**

Activities where the performer needs to jump or sprint are anaerobic activities.

**Now try this**

What type of activity would allow performers a 2–3 minute rest so they could use the PC system again during their competition?
The lactate system

You need to understand the role of the lactate system in energy production for exercise and sports performance.

The lactate system

The lactate system of energy production is anaerobic. This means that oxygen is not used in the process. This system produces energy relatively quickly, so it is good for short-duration, high-intensity activities.

The food fuel source carbohydrate is broken down by the body to form glucose. Some of this glucose goes into the blood stream, some is converted to glycogen and stored in the muscle cells and liver.

Recovery

The lactate produced through this system will accumulate unless there is oxygen available to break it down. As the lactate accumulates it changes the acidity of the blood, reducing the efficiency of muscle contraction, causing muscle fatigue. Therefore, this system can only be used maximally for 1–2 minutes before requiring recovery. A recovery time of approximately 8 minutes will aid the removal of lactate from the muscles and also give time to replace the glycogen stores in the muscles.

Anaerobic glycolysis

Glucose and glycogen are partially broken down by the lactate system to produce ATP.

ATP is used in this breakdown, but more ATP is produced than used, each molecule of glucose produces two net (additional) molecules of ATP.

Energy can be supplied by the lactate system for approximately 1–2 minutes of intense activity.

An aerobic glycolysis

Two ATP molecules are used to provide energy for the breakdown of glucose and glycogen (from carbohydrate).

Four ATP are produced, giving a net gain of 2 ATP molecules for energy for high-intensity exercise.

Without oxygen, pyruvate is converted into lactate.

You can go to page 18 to revise lactate accumulation.

Now try this

(a) What is the name of the by-product of anaerobic glycolysis that can lead to muscle fatigue?
(b) Why does this by-product cause muscle fatigue?
The aerobic system

You need to understand the role of the aerobic energy system in energy production for exercise and sports performance.

**Aerobic energy production**

The aerobic system uses oxygen in energy production. The advantage of this is that it yields large numbers of ATP molecules compared to either of the anaerobic energy systems. This makes it ideal to provide energy for endurance activities. The disadvantage of this system is that releasing the larger quantities of energy involves more chemical reactions. This makes the system slower, and unsuitable for anaerobic activity as it cannot produce the required amount of energy quickly enough for intense activity.

*Links* Go to pages 36 and 37 to revise anaerobic energy production.

**The aerobic system**

Stored fats and carbohydrates are used as the fuel source for this energy system. They are broken down into glycogen, glucose and fatty acids. There are three main processes within this system.

1. Glycolysis: this is identical to anaerobic glycolysis (see page 37). However, due to the presence of oxygen, pyruvate is broken down later in the process rather than forming lactate. Two net ATP molecules are produced.

2. Krebs cycle (or citric acid cycle) takes place in the mitochondria (see page 19). The pyruvate from anaerobic glycolysis forms Acetyl-CoA, which is broken down, using oxygen to form carbon dioxide and hydrogen. Two ATP molecules are released.

3. Electron transport chain, which is the final part of the process. Hydrogen from Krebs cycle combines with oxygen to form H₂O as a waste product, and 34 molecules of ATP are produced.

**Recovery time**

The time required for recovery of this system can be a few hours or as long as 2–3 days, depending on the intensity and duration of the exercise and your level of fitness. For example, after a marathon, it may take 2–3 days before your body is ready to run this type of event again.

**Energy for exercise**

Each energy system is used to generate energy for physical activity. The amount used will depend on the intensity and duration of the activity. For example, in a game of football, the aerobic system provides energy for the majority of the match. However, when a short sprint, a powerful kick or explosive jump is required, one of the anaerobic systems will be used. During a quiet spell in the game where intensity is low the anaerobic systems can be partially recovered from the aerobic system.

**Now try this**

Why is the aerobic system suited to low-intensity, long-duration activities?

Make sure you consider both parts of the question, low-intensity and long-duration.
Adaptations to energy systems

Regular training will cause adaptations to the energy systems involved in that training. You need to know what the energy system adaptations are and the impact these have on exercise and sports performance.

ATP-PC system adaptations
The ATP-PC system resynthesises ATP through the breakdown of phosphocreatine (PC). Although a very fast energy production system, it is limited by the stores of PC. If the body is able to store more creatine this will allow the ATP-PC system to be used for longer.

Lactate system adaptations
The lactate system is anaerobic, so produces lactate as a by-product of energy production. Lactate, if left to accumulate, can cause muscle fatigue. This system adapts by building up a tolerance to lactic acid, therefore the muscles do not become fatigued as quickly, extending the length of time this energy system can be used for before needing recovery.

Aerobic system adaptations
There are three main adaptations:

1. increased ability to use fats as a food fuel source
2. increased storage of glycogen
3. increased number of mitochondria.

Each of these adaptations increases our potential for aerobic energy production. With more fuel available and more sites to break down this fuel aerobically, energy production will be more efficient. This will allow performers to maintain a high level of performance for longer before fatiguing, or a quicker recovery between performances.

Now try this

(a) How does the aerobic system adapt as a result of long-term training?
(b) Why is this an advantage to the performer?
Energy systems: additional factors

You need to understand the additional factors affecting the energy systems and their impact on exercise and performance.

Diabetes
Diabetes is a common health condition. It is caused by the body's inability to regulate the amount of glucose in the blood.

There is a lack of insulin, or insulin function, so glucose remains in the blood rather than travelling into the cells.

This means blood glucose is too high, and there is insufficient glucose in the cells.

Therefore, diabetes impacts on the amount of energy we can use from the food fuel carbohydrate.

Types of diabetes

1. Type 1 diabetes
   This occurs when the body is not able to produce insulin. As the body cannot get energy from glucose it looks elsewhere, breaking down fat and protein.
   Although those with diabetes are encouraged to exercise, energy production would be limited to the ATP-PC system and the aerobic system unless insulin is injected into the body, or an insulin pump is used.

2. Type 2 diabetes
   This is the more common form of diabetes. It develops when not enough insulin is produced by the body, or when insulin is present but is not carrying out its function.

Hypoglycaemic attack
This is when blood sugar falls too low. Although encouraged, participation in sport can increase the risk of having an attack. This is why people with diabetes must monitor glucose levels before and after activity. Those on insulin may need to eat carbohydrates before exercise, during or after to help balance their blood glucose.

Implications for performance
Different sports will have different effects on blood sugar levels. For example, aerobic activity can lower blood glucose, but anaerobic activities can increase it. Having too high or too low blood glucose will negatively affect energy levels and therefore performance.

The lactate system in children
This energy system is still developing during childhood, and is not fully developed until around 20 years. This is due to:

- lack of muscle mass
- lower glycogen stores
- fewer essential enzymes required for energy production.

Implications for performance

- Children would not gain much from training anaerobically as their lactate system would not be able to adapt to the training.
- Children are better suited to aerobic exercise as their bodies can adapt and make improvements.

Now try this
Why is it important if you have diabetes to monitor your blood glucose levels before and after activity?
Your Unit 1 exam

Your Unit 1 exam will be set by Pearson and could cover any of the essential content in the unit. You can revise the unit content in this Revision Guide. This skills section is designed to revise skills that might be needed in your exam. The section uses selected content and outcomes to provide examples of ways of applying your skills.

Exam checklist
Before your exam, make sure you:
- ✔️ have a black pen you like and at least one spare
- ✔️ have double-checked the time and date of your exam
- ✔️ get a good night’s sleep.

Check the Pearson website

The questions and sample response extracts in this section are provided to help you to revise content and skills. Ask your tutor or check the Pearson website for the most up-to-date Sample Assessment Material and Mark Scheme to get an indication of the structure of your actual paper and what this requires of you. The details of the actual exam may change so always make sure you are up to date.

Types of question

- Identify
- Give
- Name
- State
- Explain
- Describe
- Analyse
- Evaluate
- Discuss
- Assess
- Justify
- To what extent...
- Short-answer questions
- Extended questions

Now try this

Visit the Pearson website and find the page containing the course materials for BTEC National Sport. Look at the latest Unit 1 Sample Assessment Material (SAM) to get an indication of:
- the number of papers you have to take
- whether a paper is in parts
- how much time is allowed and how many marks are allocated
- what types of questions appear on the paper.

Your tutor or instructor may already have provided you with a copy of the Sample Assessment Material. You can use these as a ‘mock’ exam to practise before taking your actual exam.
Here are some of the skills involved when responding to short-answer and long-answer questions.

**Give, name, state, identify, describe**
These types of questions are asking for knowledge about a body system, for example, its structure or function, or your ability to apply your knowledge.

**Worked example**
Marvin used free weights to bicep curl as part of his strength training programme.

State the name of the muscle contracting continually during the biceps curl.

**Sample response extract**
The biceps.

**Analyse, assess**
These command words can be more demanding, requiring you to look at something in detail, such as the impact of a type of training on a body system, or an analysis of movement.

**Worked example**
Analyse how the antagonistic muscle pair at the hip allow the diver to achieve the position shown.

**Sample response extract**
The muscle pair operating at the hip are the hip flexors and the gluteals. To achieve this shape, the hip flexors are the agonists, contracting to cause flexion at the hip, but this is only possible if the gluteals relax, taking on the role of the antagonistic muscle.

**Evaluate, to what extent**
These command words require a judgement, based on your knowledge or the information presented in the question, and a conclusion. They are used in long-answer questions.

**Graphs and data**
Use the information in the graph to help you. Clearly there is an increase in blood flow to the skeletal muscles. Why do we need this increased blood flow during exercise?

Using the graph above, explain the changes in blood flow to the muscles and digestive system during physical activity.
Long-answer questions

Here are some examples of skills involved when responding to long-answer questions.

**Worked example**

Rob plays rugby competitively. Out of season he uses aerobic training to develop his cardiovascular endurance. A sample of Rob’s aerobic training programme is shown here. He has three rest days.

<table>
<thead>
<tr>
<th>Monday</th>
<th>Tuesday</th>
<th>Thursday</th>
<th>Saturday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fartlek run</td>
<td>Long-distance run</td>
<td>Interval training</td>
<td>Fartlek run</td>
</tr>
</tbody>
</table>

Rob’s aerobic training causes adaptations to his muscular system.

Assess the impact of these adaptations on energy production and the effect this will have on his performance in rugby.

**Sample response extract**

Rob’s muscular system will have a greater number of mitochondria in his muscle cells. This is the site of aerobic respiration so his muscles will have more places for energy production, which increases the amount of energy that can be supplied aerobically so that Rob has the supply he needs to continue working to a good level all game.

Rob’s myoglobin stores in his leg muscles increase, making oxygen more readily available to the muscle. This oxygen can be used in energy production, delaying the need to switch to anaerobic systems which could lead to muscle fatigue. Rob’s muscles will increase their ability to store glycogen and triglycerides, providing further fuel sources for aerobic exercise, limiting the risk of fatigue during the game. These aerobic adaptations will also help Rob recover after high-intensity parts of the game as sufficient quantities of aerobic energy can be used to break down lactate reducing muscle fatigue.

**Show your skills**

Consider how your response to long-answer questions might include the following qualities:

- Demonstrate accurate and thorough knowledge and understanding.
- Apply knowledge to the context of the question.
- Display a well-developed and logically balanced discussion or analysis, showing an awareness of competing arguments.
- Contain logical chains of reasoning throughout and the linkages between / within body systems.
- Use technical language consistently and fluently.

**Now try this**

Becker is 35 years old and has high blood pressure. He is returning to physical activity after a ten-year gap and has joined a new gym.

Discuss the effects of participating in physical activity on the cardiovascular system for an individual suffering with high blood pressure.