Factors Affecting Performance
Energy Systems

Summary
In every active sport, an athlete’s ability to meet their energy requirements has a major impact on performance. Our working muscles get their energy from the breakdown of ATP. The anaerobic and aerobic energy systems provide energy for the resynthesis of ATP. This video explains these processes, and identifies the key features of the different energy systems. Various sports are used to illustrate the way the energy systems are used under different conditions. Topics covered include:
* Where does energy come from?
* The ATP-CP energy system
* The lactic acid system
* The aerobic energy system
* The interplay of energy systems

(This video functions as a companion video to “Factors Affecting Sports Performance: Training”).

Worksheets and Glossary
The accompanying worksheets have been designed to reinforce the fundamental concepts explained in the video, and to build on this knowledge using information that is beyond the scope of the video itself. A comprehensive glossary explains specific terms used in the video and the worksheets.

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ENERGY SYSTEMS

‘Energy can neither be created nor destroyed but merely transformed from one form to another.’ Law of Conservation of Energy

Using the information from the flow diagrams above, explain how the energy we use in our bodies originated from the sun.

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In our body ATP is the only source of energy for biological work (e.g. movement). Describe how the body derives energy from ATP.

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Resynthesis of ATP is necessary so that it can continue to supply energy for biological work (e.g. muscular contraction). In order for this process to take place energy is required as well as a free phosphate. The energy for ATP resynthesis originates from three sources. They are known as the ENERGY SYSTEMS. List the three energy systems below:

• ____________
• ____________
• ____________

The fuel for the energy systems comes directly from the food we eat. The main nutrients for energy production are:

• ____________
• ____________
• ____________
**ATP-CP SYSTEM**

When ATP splits, by breaking the bond between the second and third phosphate group, it provides energy for biological work (e.g. movement).

In order for ATP to keep supplying energy it must be resynthesised from ADP (Adenosine Diphosphate). When performing very high intensity short duration (< 8 seconds) the body will use the ATP stores in the muscles first. This supply of ATP will last for only 1-2 seconds before it needs to be resynthesised quickly. In this situation the body will use the fuel creatine phosphate (CP) that is also stored in the muscles in small amounts. This system operates anaerobically (in the absence of oxygen).

Using the diagrams below illustrate and explain how creatine phosphate is used to resynthesise ATP.

List the types of activities where the ATP-CP system would dominate.

Outline the advantages and disadvantages of these energy systems.

**EXTENSION QUESTION**

Detail the process and time frame for the resynthesis of creatine phosphate stores, in the working muscles, after a maximum effort in a 40metre sprint.
LACTIC ACID SYSTEM

The lactic acid system contributes the majority of energy for ATP resynthesis when strenuous activity is undertaken for between 10 seconds and 3 minutes, as well as repeating high intensity efforts required in many team sports.

The lactic acid system breaks down glucose in the absence of oxygen (anaerobic glycolysis), to produce a limited supply of energy for ATP resynthesis. This partial breakdown of glucose also produces the fatigue-causing by-product lactic acid.

This system supplies energy for ATP resynthesis quickly. It can provide energy for longer than the ATP-CP system because it uses a more abundant fuel i.e. glucose. However the lactic acid, which accumulates when this system dominates energy production, causes muscular fatigue. The more intense the activity the quicker the onset of fatigue. Once the intensity of the exercise is reduced and more oxygen becomes available lactic acid will be converted back to pyruvic acid and then eventually broken down to carbon dioxide and water.

List the types of activities where the lactic acid system would be the dominant energy system for ATP resynthesis.

When performing a maximum effort on a bicycle ergometer for 30 seconds there is a major accumulation of lactic acid in the gluteals, and quadriceps.

(a) Explain the reasons for this accumulation and its effects on muscle function.

(b) Describe what happens to the accumulated lactic acid after 2-3 minutes of low intensity cycling.

Outline the advantages and disadvantages of the lactic acid system.
AEROBIC SYSTEM

For activities that require a more sustained and plentiful supply of energy the body relies on the aerobic system. This system uses carbohydrates, fats and, at times, protein in the presence of oxygen. This produces a large amount of energy for ATP resynthesis.

\[
\text{FOOD} + \text{O}_2 \rightarrow \text{ENERGY} + \text{CO}_2 + \text{H}_2\text{O}
\]

The efficient functioning of the aerobic system also allows for quicker recovery from bouts of high intensity activity that take place in many sports.

List the types of activities that would use the aerobic system as the dominant source of energy for ATP resynthesis.

Explain the causes of fatigue when the aerobic system dominates energy production.

Describe the training effect known as “glycogen sparing”.

Explain the causes of fatigue when the aerobic system dominates.

Outline the advantages and disadvantages of the aerobic energy system.

EXTENSION QUESTION
Examine the role intensity plays in determining the relative percentages of carbohydrates and fats as fuel for a specific activity.
INTERPLAY OF THE ENERGY SYSTEMS

When you perform any activity all three energy systems are contributing energy for ATP resynthesis. Their relative contributions depend on two main factors. That is the intensity and duration of the activity. For example when the two girls were jogging along on flat ground they were able to comfortably talk to one another. This is an indication that the aerobic system was the dominant energy system (talk test). However the other systems would have been contributing some energy toward the total energy demand for this activity.

Colour each of the white columns to indicate the approximate energy output of the energy systems on different stages of the two girl’s run.

1. Jogging up a steep hill.

2. Jogging to the bottom of the hill.

3. Race to the post.
## ENERGY SYSTEMS SUMMARY

<table>
<thead>
<tr>
<th>ATP-PC</th>
<th>LACTIC ACID</th>
<th>AEROBIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUELS</td>
<td></td>
<td></td>
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<tr>
<td>RECOVERY</td>
<td></td>
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<tr>
<td>BY PRODUCTS</td>
<td></td>
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<tr>
<td>DOMINATE USES</td>
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</tr>
</tbody>
</table>

## REVISION QUESTIONS

1. Deduce which energy systems would be dominant in the resynthesis of A.T.P in the following performances:

<table>
<thead>
<tr>
<th>SPORT</th>
<th>Energy System(s)</th>
<th>SPORT</th>
<th>Energy System(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tour De France</td>
<td></td>
<td>Mountain Bike</td>
<td></td>
</tr>
<tr>
<td>1500m runner</td>
<td></td>
<td>Pommel Horse</td>
<td></td>
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<tr>
<td>High Jump</td>
<td></td>
<td>Touch</td>
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<tr>
<td>Triathlon</td>
<td></td>
<td>Netball</td>
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<tr>
<td>Javelin</td>
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<td>Baseball (batting)</td>
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<tr>
<td>Volleyball</td>
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<td>Darts</td>
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<tr>
<td>Surfboat Rowing</td>
<td></td>
<td>Surfboard Riding</td>
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</tbody>
</table>

2. Explain how A.T.P. can be used to obtain energy for work in our bodies.

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____________________________________________________________________
____________________________________________________________________

3. Describe the role creatine phosphate plays in the resynthesis of A.T.P.

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________

4. Clarify under what conditions lactic acid accumulates in our muscles and describe its effects. Give a relevant example to illustrate your response.

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
5. During a game of basketball all three energy systems are required in varying degrees throughout a game. Supply an example of a specific activity during a basketball game when each energy system would be dominant.

6. (a) Using the table below plot three different lines that represent the relative contributions for the three energy systems over a 5-minute period of maximal effort.
   (b) If you were swimming 400m estimate the % contribution from the three energy systems.

   (c) Choose a game and detail 3 different aspects of the activity where each of the energy systems would dominate.
| **GLOSSARY** |
|----------------|----------------|----------------|
| **ADENOSINE DIPHOSPHATE (ADP)** | A phosphate compound that is formed when ATP splits | **ENERGY** | The ability to do work |
| **AEROBIC** | With oxygen | **FAT** | A high energy fuel source that needs more oxygen to metabolise compared to carbohydrates |
| **AEROBIC ENERGY SYSTEM** | Chemical reactions occurring in the tissues of the body in which oxygen and fuels are metabolised to produce energy for ATP resynthesis. | **GLYCOGEN** | Stored carbohydrates |
| **AEROBIC GLYCOLYSIS** | The breaking down of glucose in the presence of oxygen | **GLYCOGEN SPARING** | A training effect that allows the body to use fat early in an endurance event allowing carbohydrates to last longer. Caffeine can have similar effect. |
| **ANAEROBIC** | Without oxygen | **GLUCOSE** | Simplest carbohydrate |
| **ANAEROBIC ENERGY SYSTEMS** | Chemical reactions occurring in the tissues of the body in which fuels are metabolised, without oxygen, to produce energy for ATP resynthesis. Include the ATP-CP system and the Lactic Acid System. | **GLYCOLYSIS** | The breaking down of glucose |
| **ANAEROBIC GLYCOLYSIS** | The breaking down of glucose in the absence of oxygen | **LACTIC ACID** | The by-product of anaerobic glycolysis from the partial breakdown of glucose |
| **ADENOSINE TRIPHOSPHATE (ATP)** | High energy chemical compound stored in small quantities in the body | **LACTIC ACID SYSTEM** | The breaking down of glucose in the absence of oxygen to produce limited energy for ATP resynthesis |
| **ATP-CP SYSTEM** | Also known as the Alactacid or Phosphate systems. An anaerobic energy system in which high energy phosphates are used to provide energy for ATP resynthesis. | **MITOCHONDRIA** | Structures found in all cells where aerobic respiration takes place |
| **BIOLOGICAL WORK** | Conversion of energy from one form to another. | **PROTEIN** | Used for building of body tissue and repair, and for energy in extreme circumstances |
| **CARBOHYDRATE** | Primary energy source for athletic performance. Stored in the liver and skeletal muscle as glycogen | **PROTOPLASM / CYTOPLASM** | Jelly-like substance found in cells |
| **CREATINE PHOSPHATE** | A high energy phosphate stored in the body in small amounts | **RESYNTHESIS** | To rebuild or recreate |