> BACK TO CONTENTS PAGE

LESSON 1 HUMAN BIOLOGY & AEROBIC FITNESS

To completely understand how aerobic exercise is performed and fitness is achieved, we need to know what happens from the moment we start to exert ourselves.

When a movement in the human body occurs, energy must be released to cause that movement. This energy release occurs via a chemical reaction where adenosine triphosphate (ATP) is converted to adenosine diphosphate (ADP) plus free phosphorus, and large amounts of energy.

The energy produced is primarily motion (i.e. the movement of muscles), and heat (which is lost). The body's use of energy is not particularly efficient since a lot of energy is usually lost during any movement.

The small amount of available ATP in muscles is only sufficient to support a single explosive muscle contraction - such as throwing a ball, or a golf swing. If a sport, or some other performance, demands repeated muscle contractions then the ATP required must be constantly replenished from other fuel sources in the muscle.

ADP can be reconstituted by adding energy to it - this converts it back to ATP.

ATP is stored in every cell of the body, and is able to be transported throughout the body.

SOURCES OF ATP

ATP can be supplied to the body by three different ways:

1) ATP-PC System

Here, the compound 'phosphocreatine' is broken down to produce ATP. When phosphocreatine breaks down it produces phosphorus, creatine and energy. The energy produced is then able to be used by ADP to create ATP. Phosphocreatine is then able to be reconstituted with the addition of energy (which comes from foodstuffs and not from stored ATP/ADP reactions). These sources of energy are quickly rebuilt after effort, to the extent that 50% of the energy source is available around 30 seconds later, and 80% of this energy is restored within 2 minutes.

2) Lactic Acid System

When a maximal effort is continued beyond the extent of the phosphate energy system, energy is provided from glycogen stored in the muscles. This system involves glucose (or glycogen) going through various chemical processes to produce ATP plus lactic acid. One glucose molecule is broken down into carbon dioxide and water in the presence of oxygen, and in turn, produces two ATP molecules.

The amount of ATP produced this way is small. This is a more complex procedure using only carbohydrates as its food fuel, and not requiring oxygen for the process.

This energy is used, for example, in 400 metre track races and 100 metre swimming events. Continuous activities which lead to exhaustion in 45-50 seconds result in maximal values for lactic acid accumulation. A problem with this process is that increased lactic acid levels can affect blood pH. Blood pH should be around 7.3, and never drop below 6.8. Nevertheless, the lactic acid system is self-limiting and so should not normally develop such problems. Generally, the result will be a feeling of fatigue which will cause an athlete (or someone doing heavy bursts of work) to slow down. Once lactic acid is produced, it requires 45 to 60 minutes to be removed, and for the athlete to recover.

3) Oxygen System

This process involves the formation of carbon dioxide, water and ATP - from fats, proteins and/or carbohydrates, in the presence of oxygen. This process can produce large amounts of ATP. One molecule of sugar can result in the production of 36 molecules of ATP.

This is more complex than the ATP-PC system. The only limiting factor for this system is usually the supply of oxygen.

The body will normally try to use this system, and only use other systems to produce ATP if oxygen is in short supply. The short supply of oxygen can occur when:

- Activity first starts.
- Activity is placing higher demands on oxygen than what can be supplied by breathing.

THE OXYGEN SYSTEM IS AN AEROBIC SYSTEM. THE ATP-PC AND LACTIC ACID SYSTEMS ARE ANAEROBIC SYSTEMS.

The body uses anaerobic systems for energy supply only when aerobic systems cannot meet the demand.

Example

If a person is running a marathon, breathing may not be supplying ample oxygen to produce ATP through this system. Hence, the lactic acid system may be used, resulting in a build-up of lactic acid - OR, the ATP-PC system may be used, resulting in a depletion of phosphocreatine in the muscles.

After completing exercise, there may be a lactic acid build-up, and if so, the body needs to remove this excess. This lactic acid removal requires energy which is supplied aerobically - hence extra oxygen may be required. This extra oxygen requirement (after exercise) is called the ‘oxygen debt’.

Krebs Cycle

This is one particular series of reactions occurring in the oxygen system.

Two main chemical reactions occur in this cycle:

1. Production of carbon dioxide.

> BACK TO CONTENTS PAGE

2. Oxidation (i.e. removal of electrons).

Carbon dioxide produced in this cycle is eliminated from the body by breathing out.

The Krebs cycle can be explained as follows:

- Aerobic glycolysis produces pyruvic acid from glucose.
- This pyruvic acid enters the cycle, giving off carbon dioxide which is transferred to the lungs and breathed out.
- Electrons are removed from hydrogen to produce H+ ions, and electrons. These electrons enter the electron transfer system for further chemical reactions.
- Eventually water is formed from hydrogen ions and electrons removed in the Krebs cycle.
- Energy is released as electrons are transported in the Electron Transfer System, and this energy is used in the formation of ATP from ADP and free phosphorus.

The urea or Krebs cycle can be described in simple terms as follows:

1. Carbon dioxide (CO_2) and Ammonia (NH_3) combine (along with ATP and orthinine) to produce citrulline.
2. Citrulline with ammonia produces arginine.
3. Arginine produces urea and orthinine.
4. The orthinine produced in stage three completes the cycle by being used again in stage one.

Summary of The Aerobic Energy System

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O +$ energy

The above formula is a simplified version of what occurs when stored foods e.g. carbohydrates, fats, proteins or in this case the simple sugar molecule glucose, are oxidised to produce carbon dioxide (CO_2 - which is respired out of the body), water (H_2O) and energy. The energy is used to convert ADP to ATP.

ENERGY DEFINITIONS

Energy is the capacity to do work.

Work is the transference of a force over a distance (i.e. work = force x distance).

Power is a measure of work carried out per unit of time.

$$\text{Efficiency} = \frac{\text{Work Output}}{\text{Energy Input}} \times 100$$

THE NATURE OF ENERGY

- Energy cannot be created or destroyed - it simply changes form.
- All energy in a person's body is ultimately derived from solar energy.
- Chemical energy is an important form of energy for man.

Suggested Tasks:

Throughout this course you will be provided with suggested tasks and reading to aid with your understanding. These will appear in the right hand column. Remember: these tasks are optional. The more you complete, the more you will learn, but in order to complete the course in 20 hours you will need to manage your time well. We suggest you spend about 10 minutes on each task you attempt, and no more than 20 minutes.

LEARN MORE »»

Suggested Tasks

We have covered a lot of complex information here. Try summarising this information in another way, such as -

Flash cards

Mind Maps

Spider diagrams

Flow Charts etc.

> BACK TO CONTENTS PAGE

UNITS OF MEASUREMENT

Work and power are measured as:

- Kilopond metre (i.e. kpm where 1 kilopond = 1 kilogram)
- Watts

Power is measured as work per unit of time (e.g. kilopond metres per minute)

Energy is expressed as:

- Kcal or calories (where 1 Kcal = 1000 calories)
- Kilojoules
- Litres of oxygen per minute (where 1l/O_2/min = 5 k/cal, but it can vary though).

ENERGY PRODUCTION PATHWAYS FROM DIFFERENT FOODS

1) Fats (triglycerides in the body)

- Hydrolysis of triglycerides produces glycerol and FFA.
- Beta oxidation of glycerol produces acetyl CoA.
- Acetyl CoA enters the Krebs cycle.

2) Carbohydrates

- Carbohydrates break down to glucose (simple sugar).
- Glycolysis of simple sugars produces pyruvic acid.
- Pyruvic acid produces acetyl CoA which enters the Krebs cycle.

3) Proteins

- Proteins break down into amino acids.
- Deamination may occasionally occur to produce keto acid, which in turn can move into the krebs cycle.

RESPIRATORY QUOTIENT (i.e. RQ or Re)

This is a measure of the relationship between carbon dioxide produced and oxygen consumed.

- If you are metabolising fats, the respiratory quotient = 0.7
- If you are metabolising glucose, the respiratory quotient = 1.0
- If you are metabolising protein, the respiratory quotient = 0.8

Note: This means if you are metabolising fat, you need more oxygen than if metabolising glucose or carbohydrate.

RESTING QUOTIENT

When resting it is normal for the body to be metabolising a combination of both fat and glucose.

- If you are metabolising 66% fat and 33% glucose, the respiratory quotient = 0.8