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COACH IN RUNNING FITNESS

THE BODY IN SPORT

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THE BODY IN SPORT AND ATHLETICS

The human body is a highly complex living 'machine' and anatomy deals with the study of the component parts and structure of the body. Athletes come in all shapes and sizes and have different skin colours, but their bodies all work in exactly the same way. As you develop an understanding of how the body is built you are better able to understand how it responds to exercise and training. You do not need the detailed, complex knowledge of a doctor but you do need to know the basic structures of your body and how they work together.

CELLS - THE BUILDING BLOCKS OF LIFE

A cell is a unit of living material and is the basic building block of life. All living things are made up of one or more cells. Human bodies are made up of millions of tiny, living cells. Cells make up our skin, our bones, muscles, brains and all the other parts of our bodies. Everything we do involves millions of tiny cells of different shapes and sizes working together. Each type of cell or group of cells carries out a different job. As a result not all cells look the same. Some cells, for example, are designed to:

- carry messages - nerve cells carry electrical messages
- carry chemicals - red cells in the blood carry oxygen around the body
- support the body - bone cells make up the skeleton
- move the body - muscle cells can create force

Each cell has its own job to do but all cells live, grow and finally die, to be replaced by new cells.

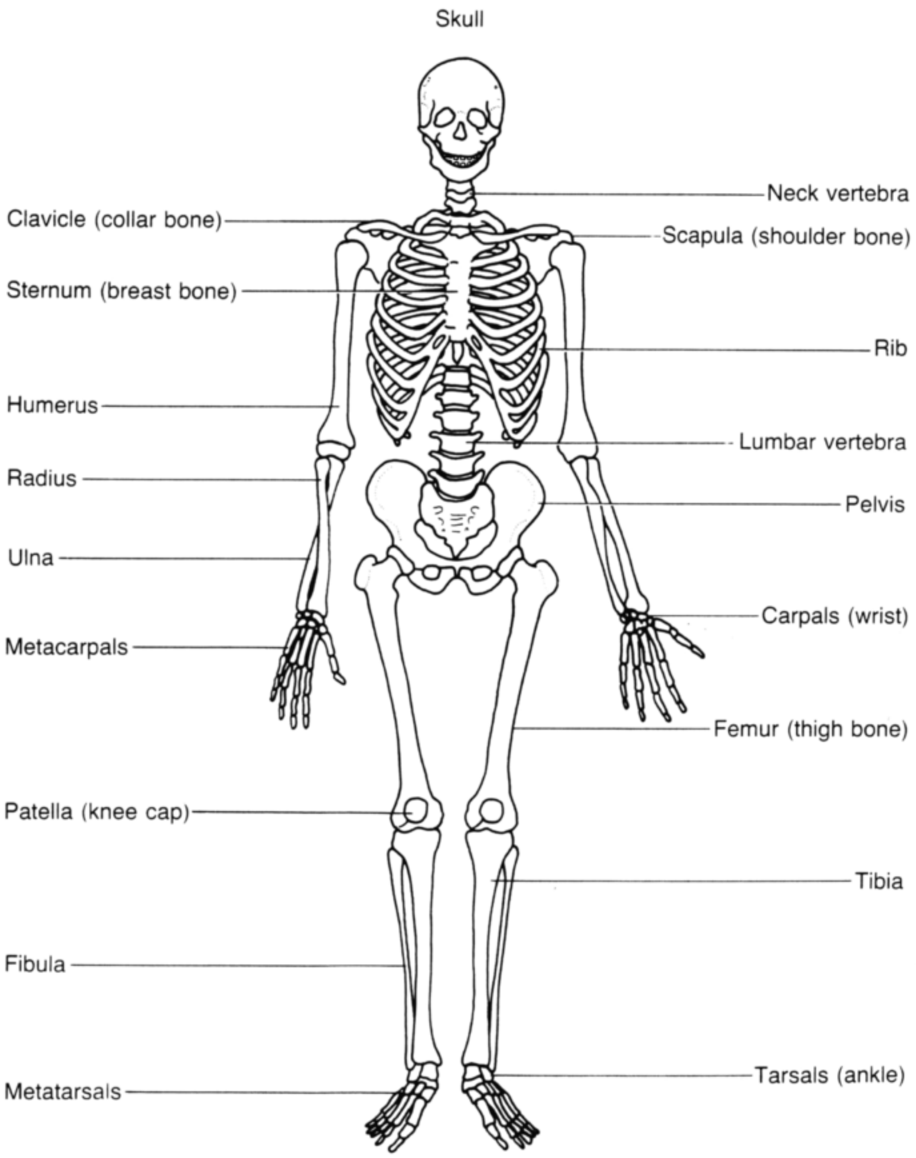
THE SKELETON

Human beings, like most large animals, have a skeleton inside their bodies. A skeleton is a system of bones and other supporting material. It has three important functions:

- Support - It gives support to the rest of the body, like the framework of a building. Without this support we would be a shapeless lump
- Protection - It gives protection to important and delicate organs of the body. The skull, for example, protects the brain
- Movement - It provides anchorage for muscles. Muscles fixed to the skeleton can operate joints. This allows us not only to move parts of the body with a high degree of precision and control but also to move the body as a whole.

In the human skeleton there are over two hundred bones. Some are long, some short, some round, some flat but all bones have the same basic structure. The five main classifications of bones are : Long (e.g. femur), Short (e.g. tarsal bones of the foot), Flat (e.g. frontal bone of the skull), Irregular (e.g. vertebrae) and Sesamoid (e.g. knee cap). When a baby develops inside its mother's womb some cells form a tough, flexible substance called cartilage. During childhood and adolescence much of the cartilage slowly changes to bone. The gristle you can feel in your ears and at the end of your nose is cartilage that doesn't change to bone.

Bone is very hard and strong and has to stand up to large forces. Bones have living and non-living parts. The living part makes the bones slightly flexible and lets them absorb sudden shocks. The non-living part of a bone makes it rigid and gives it strength.

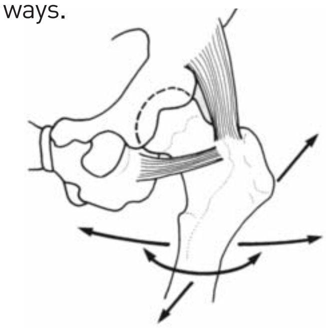


The human skeleton

The bones of the skeleton act as a system of levers. In most parts of your body the bones are not actually joined. Instead, they fit closely together, forming joints. At each joint the bones are linked by tough, flexible ligaments. The different joints between your bones allow you to move in different ways.

This is a hinge joint, the bones can move in one direction only

Knee joint



This is a ball and socket joint, the bones can move in almost any direction.

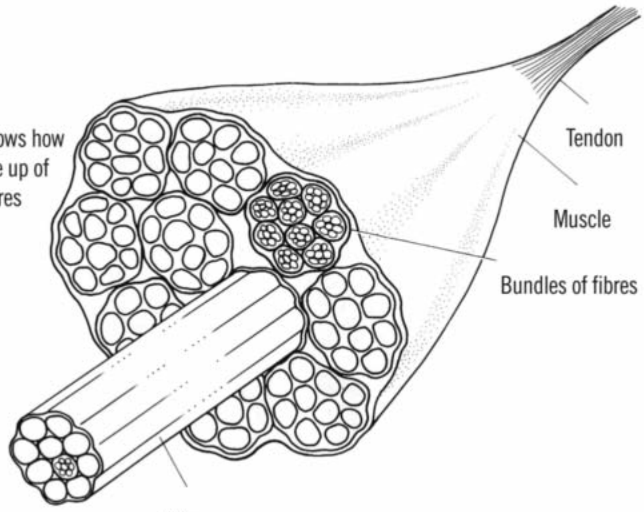
Hip joint

Each kind of joint allows a different sort of movement. Freely Movable joints comprise of four main groups: Ball and Socket (e.g. hip), Hinge (e.g. elbow), Pivot (e.g. radius and ulna) and Gliding (e.g. carpal joint of the wrist). Whenever we move, bones move. But what makes bones move?

MUSCLES

Bones are moved at joints by the contraction and relaxation of muscles attached to them. You have over 600 muscles in your body and these make up approximately 40% of your weight. You use these muscles to move, breathe and even stand still.

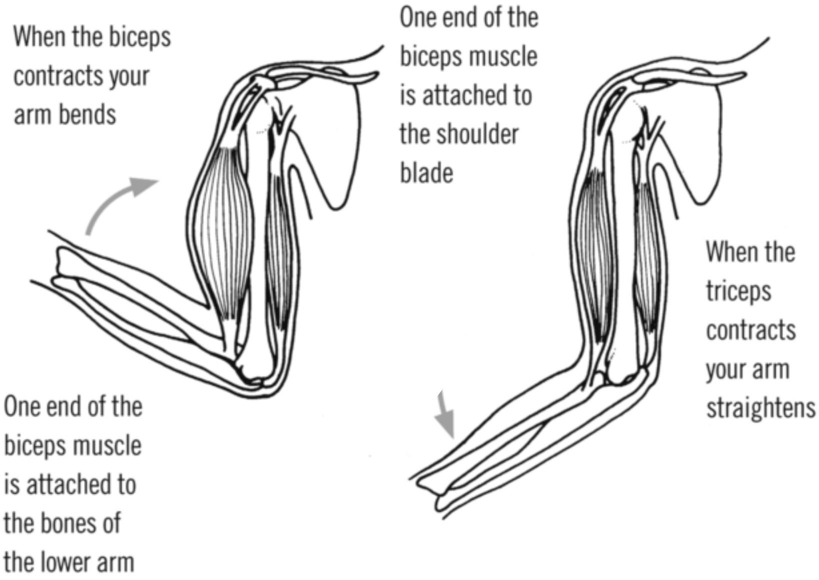
The muscles you use to control your movements consist of bundles of long, thin cells called muscle fibres. Each bundle of fibres is held together by a tough sheath. A similar sheath round the outside holds the whole muscle together. At each end of the muscle all these connecting sheaths join together forming the tendons which anchor the muscle to bone.



Inside a muscle

Muscles are attached by the tendons to bones on either side of a joint. Most muscles only work across one joint of the body. Some muscles work across two joints, such as the hamstrings, which work across the hip and knee joints.

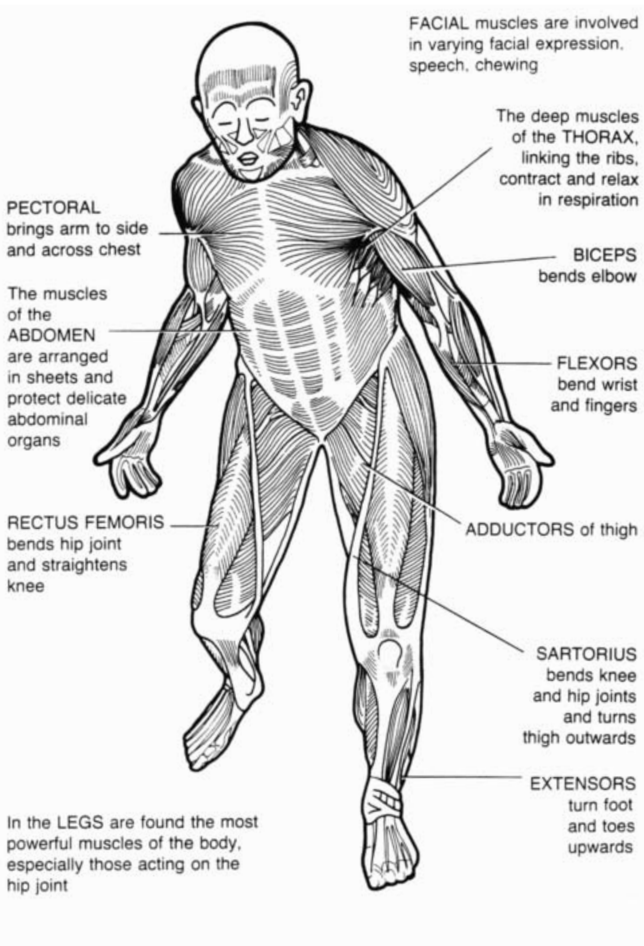
Movement is caused by muscles pulling on a bone. Muscles can only pull, they cannot push. This is why most of your muscles are arranged in opposing pairs. When one muscle tenses and contracts its partner relaxes and stretches to allow movement. If both muscle groups contract at the same time and with equal force the joint is fixed and there is no movement. The elbow joint is a good example of the action of opposing muscle groups. The biceps muscle bends the arm at the elbow and is opposed by the triceps muscle which straightens the arm.

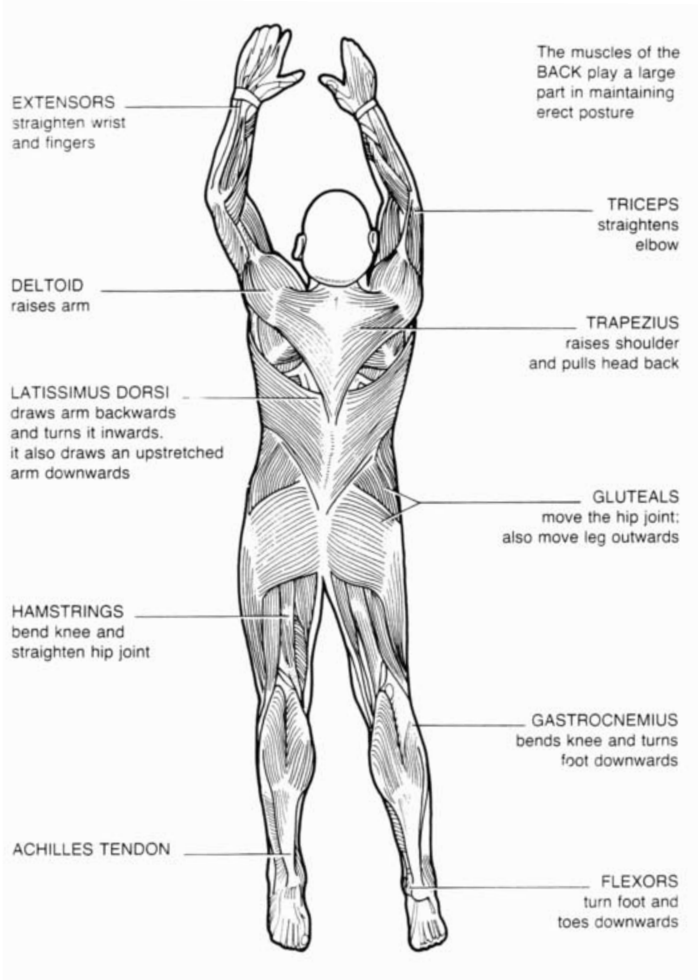


MUSCLES IN THE UPPER ARM

Movement is rarely produced as the result of the contraction of just one muscle. In body and limb actions, groups of muscles are usually involved in making a single movement. The contribution that each muscle in the group makes can vary considerably according to the effort and action required.

Training programmes should always provide a balanced development of a muscle and its opposing muscle. There should also be a balanced development of the muscles on the right and left side of the body. Training which results in an unbalanced development of one muscle or group of muscles over its opposition generally leads to injury of the weaker muscle or makes the risk of injury much greater.





MUSCLE FIBRE TYPES

The meat we see and buy at a butcher's shop is the muscle tissue from various mammals. One of the things that is most noticeable is that the meat from different animals is of different colours. The breast meat of chicken or turkey, for example, is noticeable pale and white and we know that when chickens or turkeys attempt to fly it is usually as an emergency response with very fast, but largely ineffective, flapping of their wings. The meat from cattle, however, is very red and we know that cows generally don't move very fast or do repeated sprints around their fields. If we go back to look at our chickens and turkeys, we do notice that their leg muscle meat, which powers their everyday slow walking around, is pink or even quite reddish. As early as the late 19th century, researchers had found that the red meat was composed of 'red' muscle fibres and the pale or white meat was composed of fibres of a different type, 'white' muscle fibres. The pink meat would have a mixture of the 'red' and 'white' fibres, showing that, in any one mammal, not all muscles in that animal necessarily have the same fibre composition.

As research continued, it was recognised that the red muscle fibres are consistently characterised by a greater endurance capacity but a relatively slow action. The opposite was true for white muscle fibres. These white fibres are consistently characterised by a high speed of contraction but a relatively low endurance. On the basis of the speed of contraction, the two types of fibre have been referred to as **Fast Twitch** and **Slow Twitch** muscle fibres.

The red, slow twitch muscle fibres are now categorised as **Type I** muscle fibres. The speed of contraction of these fibres is relatively slow but they do have great endurance capacity because the energy for contraction comes predominantly from aerobic sources. The distinctive red colour is due to the high quantity of myoglobin and blood in the muscle. The myoglobin is a pigment that increases the speed with which oxygen is absorbed into the tissue. There are four distinct properties that Type I fibres have which permit them to be efficient in the rapid utilisation of oxygen:

- a dense network of blood carrying capillaries
- the presence of myoglobin
- relatively small fibres which are closer to the blood supply
- a high number of mitochondria, which are the 'aerobic powerhouses' of the muscle cells.

Slow twitch and fast twitch are the extremes of muscle fibre type and intermediary types have been identified. It is now recognised that there are at least three major types of fibre, since the fast twitch, **Type II**, muscle fibre can be subdivided into an intermediary, between the fast twitch and the slow twitch, the **Type IIa** muscle fibre. The 'pure' fast twitch fibre is now referred to as the **Type IIb** muscle fibre.

Type IIb fibres contract about twice the speed of Type I, slow twitch muscle fibres but tend to tire very quickly. Energy is produced in these Type IIb fibres using predominantly the lactate system. The Type IIa muscle fibre shares features of both the Type I and Type IIb and can be thought of as being fast twitch, lactate/aerobic fibres. This fibre type is capable of obtaining the energy it needs from both the lactate and aerobic energy systems. A summary of the classification and characteristics of the three muscle fibre types is shown below:

MAIN CLASSIFICATION:	Type I	Type IIa	Type IIb
Also known as:	Slow Twitch (ST)	Fast Twitch a (FTa)	Fast Twitch b (FTb)
Also known as:	Slow Twitch Oxidative (SO)	Fast Twitch Oxidative Glycolytic (FOG)	Fast Twitch Glycolytic (FG)
Aerobic Capacity	High	Moderately High	Low
Capacity for operating in the absence of oxygen	Low	High	Highest
Number of Mitochondria	High	Intermediate	Low
Contractile Speed	Slow	Fast	Fastest
Fatigue Resistance	High	Moderate	Low

Human skeletal muscle tissue is never solely slow twitch or fast twitch. The muscles of different people have different overall percentages of Type I, Type IIa and Type IIb fibres. Each individual in each of their muscles has a mixture, or composition, of the three fibre types. Also, for each individual the percentage of the different muscle fibre types is not a constant throughout the body but varies from muscle to muscle. The muscles that are predominantly concerned with maintaining posture are contracting the majority of the time. It is not surprising to discover that these muscles, which require great endurance, have a high percentage of Type I fibres. Examples are the muscles of the back and the soleus muscle in the calf.

It used to be thought, and taught, that an individual's percentage composition of muscle fibre types was fixed at birth and could not be changed by training. Research, however, has shown that training does have a significant effect on the functional capacities of skeletal muscle and perhaps on the percentages of fibre type composition. It would appear that Type IIa fibres can be 'converted' into Type I fibres by endurance training and into Type IIb fibres by sprint training. There is also evidence that some Type I fibres may be 'converted' to Type II fibres by sprint training and that a small proportion of Type IIb may be converted into Type I fibres by endurance training. The table below shows the results of a research experiment that supports this theory.

	Percentage Composition		
	Type I	**Type IIa**	**Type IIb**
Hard Endurance Training for 18 Weeks	**69**	**20**	**11**
Hard Sprint Training for 11 Weeks	**52**	**8**	**40**

Jansson, E., Sjodin, B. and Tesch, P. (1978)

Effects, on the same distance runners, of different types of training on the percentage of different fibres in a thigh (vastus lateralis) muscle

In summary, we can say that with appropriate training, Type I fibres can become 'faster' and more anaerobic, while Type II fibres can become 'slower' or more aerobic. For the athlete who has predominantly slow twitch fibres, sprint training will improve their speed. The fastest speed attainable will still be far less than for an athlete who has a greater percentage of fast twitch fibres. Conversely, endurance training will improve the endurance of the athlete who has a high percentage of fast twitch fibres but the final endurance of that athlete will still not be as good as the athlete who has a higher percentage of slow twitch fibres to begin with.

HOW MUSCLES PULL

Muscles work like engines by burning fuel to produce movement. They are energy converters changing the chemical energy in the food we eat into the energy of movement. When your muscles are relaxed the fibres are relatively soft. When you want to move the muscle, fibres within the muscle contract in order to exert a force. This does not always mean that the muscle itself contracts or shortens overall. The greater the force you need to produce, the more fibres you use and the more the muscle will tend to bulge out. Muscle contractions are of two major types:

- Dynamic contractions
- Static contractions

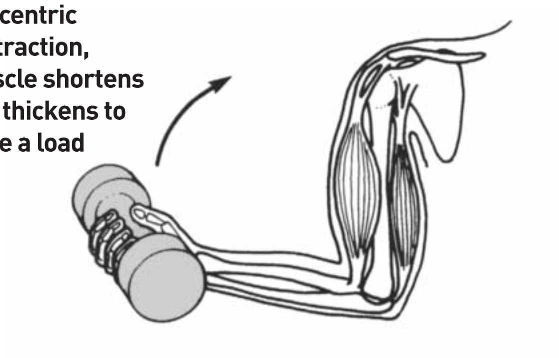
DYNAMIC CONTRACTIONS

When a contraction results in a change in muscle length and movement at a joint or joints this is called a dynamic contraction. When the contraction force is greater than the load to be lifted, the dynamic contraction results in a shortening of the muscle. This is known as a concentric contraction.

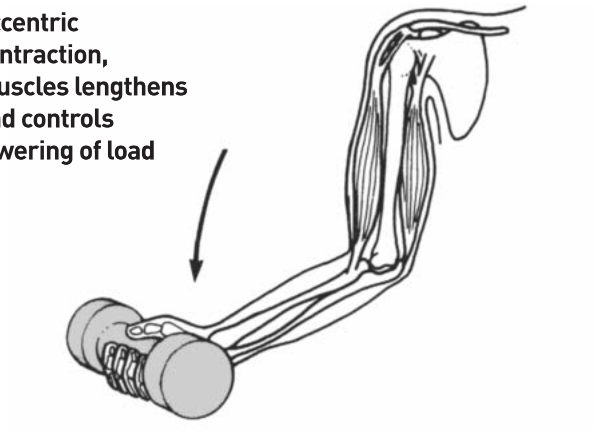
If the contraction force is slightly less than the load to be lifted, then the dynamic contraction results in a lengthening of the muscle. This is known as an eccentric contraction. Eccentric contractions tend to be 'controlling' contractions as can be seen from the example when the athlete jumps down from a box to the floor.

Dynamic contractions of the biceps muscle

Concentric contraction, muscle shortens and thickens to raise a load

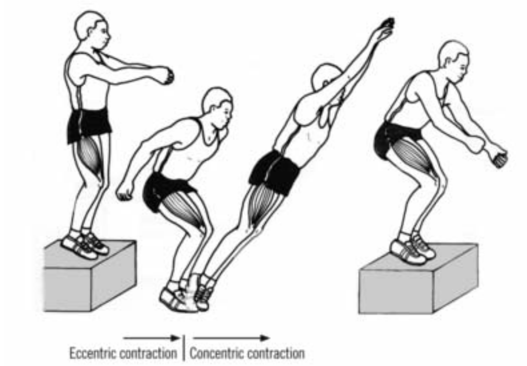


Eccentric contraction, muscles lengthens and controls lowering of load



STATIC CONTRACTIONS

This type of contraction is more commonly known as an isometric contraction. When a muscle contracts isometrically it develops tension, but there is no lengthening or shortening of the muscle and no movement. Such contraction is very common and can be observed when an attempt is made to move an immoveable object. Isometric contractions occur in athletics when opposing muscles act to stabilise a joint or parts of the body, such as the abdomen or 'core'. Most of the visible contractions a coach will deal with in athletics are dynamic but they should not forget the important role of the postural control muscles and plan to develop the isometric strength and endurance of these muscles.



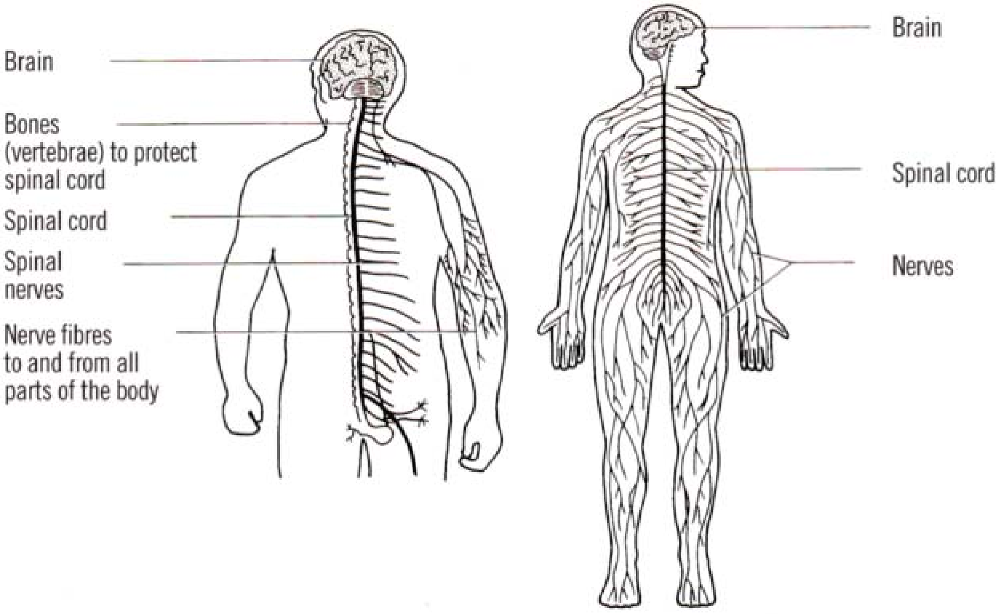
Dynamic contractions of the thigh muscle

An example of isometric contractions taking place in athletics events is during the "on your marks" and "set" positions of a sprint start.

Muscle contractions can be of various types and they all act to exert a pulling force on a bone. But what makes the muscles pull?

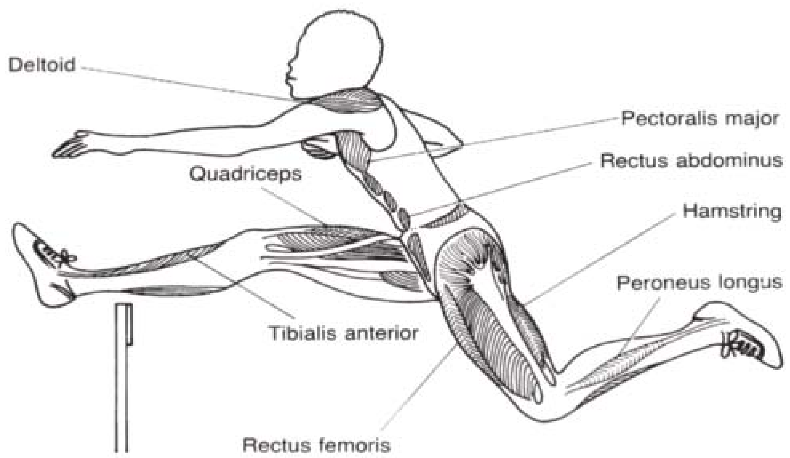
THE NERVOUS SYSTEM - GETTING INFORMATION FROM PLACE TO PLACE

The nervous system is the network that includes the brain, spinal cord and the many nerves that branch off the spinal cord to all parts of the body. The actual contraction process of a muscle fibre is started when it receives a nervous impulse, which is an electrical signal carried by the nerve cells. Your muscles pull when they receive signals from your brain telling them to do so. These signals are carried by nerves made up of special nerve cells.



The Nervous System

The nervous system's signal to the muscle determines the number of individual fibres that contract. When a light load is placed on a muscle only a few fibres of the entire muscle need to contract to perform the task. As the loading increases more and more muscle fibres must be signalled to contract. The nervous system allows coordinated movements of the body and acts as a two-way system. In addition to the signals coming from the brain to the muscles, there is information going back to the brain. This information includes all the senses, and how fast and with what force a muscle is contracting and the position of the various joints.



Muscles involved in a hurdle clearance

In coaching it is useful to be able to analyse the muscle actions of basic athletic skills. For example, if you are coaching a hurdler you need to know the muscles involved in the hurdle clearance. By understanding how muscles work and identifying the principal muscle groups that are involved in a particular skill you are in a better position to devise training programmes and exercises specific to the athlete and event.

EXERCISE PHYSIOLOGY

The study of how the body functions and the changes that occur as a result of regular body exercise is known as exercise physiology. When you know how the body produces the energy for muscular contractions you will be able to plan more effective training for your athletes. In addition, a good coach knows and understands the basic physiological differences that can occur between individuals.

Muscles work like engines by burning fuel to produce movement. They are energy converters changing the chemical energy in the food we eat into the energy of movement. This chemical or metabolic energy of movement can be produced in different ways by three separate energy systems.

THE ENERGY SYSTEMS

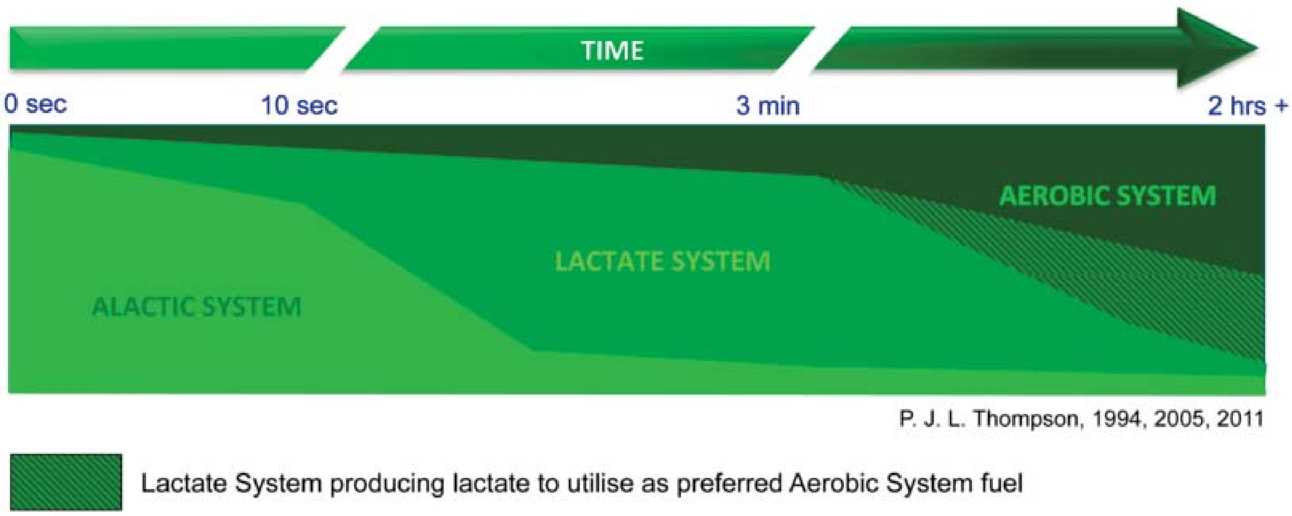
The three metabolic energy systems operating in our bodies provide the energy we need to contract muscles. These energy systems operate continuously and it is how long and how hard we do whatever physical activity that determines which system contributes most.

The three energy systems are:

1. The Aerobic System - The muscle energy system which requires oxygen
2. The Lactate System - The 'linking' energy system which is capable of operating without oxygen and produces lactate and acid
3. The Alactic System - The stored, start-up energy system which is capable of operating without oxygen but does not produce lactate or acid.

Although these three energy systems are distinct they actually work together continuously to provide the energy needed for movement. There is no 'switch' inside of our bodies that suddenly says, "O.K., now you're going to switch to the aerobic system." Or, "Now, you're going to switch to the lactate system or to the alactic system."

The following diagram illustrates the contribution of the three energy systems over time, assuming that the athlete is trying to perform at their optimal intensity for the duration of the activity. The word 'optimal', in this use, means the most intense performance that the athlete can maintain for the duration of the activity. You will see that the 'Time arrow' is not continuous but broken at 10 seconds and approximately 3 minutes so that the important changes in emphasis can be more clearly shown.



Contribution of the three energy systems over time

The aerobic-anaerobic split refers to how much the aerobic and anaerobic energy systems are emphasised in a particular activity. Long distance endurance athletes, for example, produce most of their energy aerobically and with the lactate system; while sprinters, hurdlers, jumpers and throwers depend more on anaerobic processes for their events.

SUMMARY OF THE THREE ENERGY SYSTEMS

System	System	System	System	System
Aerobic system	Uses oxygen and fuel stores to provide energy	Prolonged low to moderate intensity work	Aerobic endurance training, e.g. steady state running, cycling, swimming for 20-30 minutes or longer	Improved transportation of oxygen to the working muscle, use of fuels and removal of waste products
Lactate system	Capable of operating when oxygen is present or absent but produces lactate and acid	The 'linking' energy system that can provide energy over the complete range of durations and intensities	Repetition training, fartlek and circuits where higher intensity work is required with partial recovery during short lower intensity periods	Improved ability to generate energy from this system and to create and use lactate as an aerobic fuel source
Alactic system	Capable of operating when oxygen is absent and no lactate or acid produced	Immediate high intensity activity but can only sustain it for a few seconds	High quality speed and power work (2-8 secs.) with enough rest to allow full recovery and replenishment of the CP	Improved ability to perform maximal efforts and a greater capacity to produce such efforts repeatedly

There is one important exercise time, ten seconds, in high intensity exercise that marks a major shift in emphasis from one of the three energy systems to another. After approximately 10 seconds of maximal muscular activity the energy system providing the majority of the energy shifts from the Alactic system to the Lactate system. If we want the athlete to do maximal intensity work it has to be of only 2-8 seconds duration with sufficient recovery.

AEROBIC ENERGY - THE ENDURANCE ENERGY SYSTEM

The aerobic system requires oxygen. This system is emphasised in lower intensity exercise and is the basic system which provides the energy for most human activity from birth to death. As such it is also important in recovery from exercise of all intensities. It is very efficient and does not produce waste products. The heart and lungs are important in aerobic activity as oxygen and fuel are carried to the muscles in the blood.

The aerobic system resists fatigue. It takes longer to overload than either of the other two energy systems. To train the aerobic energy system a minimum of 20 minutes duration of activity must take place. The work load for aerobic training can be either continuous or broken up into repetitions of harder and easier running or exercise. Correct aerobic training will improve aerobic energy production in the muscle and also improve the efficiency and function of the heart and lungs, the oxygen transport system.

ALACTIC ENERGY SYSTEM - THE 'FIRST 10 SECONDS' ENERGY

The alactic system is the one referred to as the 'stored' or 'start-up' energy system. This system provides the majority of energy when our athletes do bursts of high speed or high resistance movements lasting up to 10 seconds. The stores of energy, Creatine Phosphate (CP), in the muscle which are used up in the intense burst of activity return to normal levels within 2-3 minutes of rest.

The alactic energy system is developed by alternating periods of exercise and rest. The work time should be very intense, usually of 2-8 seconds and should not exceed 10 seconds, as this is the limit of the energy system. The rest periods should be 2 to 3 minutes, depending on the duration of intense activity, to allow the muscle energy, CP, stores to build up again. If an athlete shows the effects of fatigue, allow more rest time or decrease the work time.

LACTATE ENERGY SYSTEM - THE 'LINKING' ENERGY SYSTEM

The lactate energy system is called the 'linking' system because it provides the bridge between the capabilities of the aerobic and alactic systems. In the late 1990s our understanding of how the body produces metabolic energy changed dramatically. As a coach you are probably aware that lactic acid can form when you're exercising, particularly when it's an intense activity. You may believe, or have been told, that it only forms when you 'run out of oxygen', that it is a useless waste product, that the burning sensation that comes, for example, from a long, fast sprint is caused by this lactic acid. You may also believe that the soreness that comes the day after a hard training session is again caused by lactic acid and that massage will help to get rid of this waste product. From all this you may still believe the old view that lactic acid in the body is very bad news.

The reality is very different. All the old beliefs of how bad lactic acid was are now known to be unfounded. It is not produced just when the body 'runs out of oxygen', it doesn't produce burning sensations and it doesn't produce muscle soreness. Far from being a troublesome waste product, lactic acid or part of it, can help us produce more energy, more quickly. We now know that lactic acid, as such, just does not exist in the body. As soon as it is formed it splits up, separates, into a 'lactate bit' and an 'acidic bit'. The lactate bit is definitely not a 'bad guy' but is instead is a 'good guy' playing a positive and central role in our metabolism and in how we produce energy. Understanding this role of lactate in the body is important and can be applied to produce major improvements in athletes' performance.

The lactate system is capable of operating without oxygen but is operating all the time, like all of the three energy systems. This energy system is more emphasised in exercise of high levels of intensity but this high intensity may prevent the removal of the lactate and acid bits if not enough oxygen is available. When it does operate without sufficient oxygen, the lactate and acid accumulates within muscle cells and the blood.

The lactate is a useful source of fuel for the athlete and correct training helps the body both use and clear lactate but the acid is a major cause of fatigue, which eventually slows the athlete. The more intense the exercise rate, the faster the rate of acid accumulation to high fatigue-causing levels. For example, the 400 metre sprinter will accumulate high levels of acid after 35-40 seconds. The 800 metre runner runs more slowly and accumulates acid at a slower rate, reaching high levels after about 70-85 seconds.

As you are sitting and reading this you are producing lactate and acid and, at the same time, you are using it and moving it around the body but you are not building up high levels of the acidic bit and so you are not aware of the process. Lactate production within your muscles occurs in healthy, well oxygenated individuals at all times. Coaches and athletes, however, are not so much concerned with rest as to what happens during exercise and in the recovery from exercise.

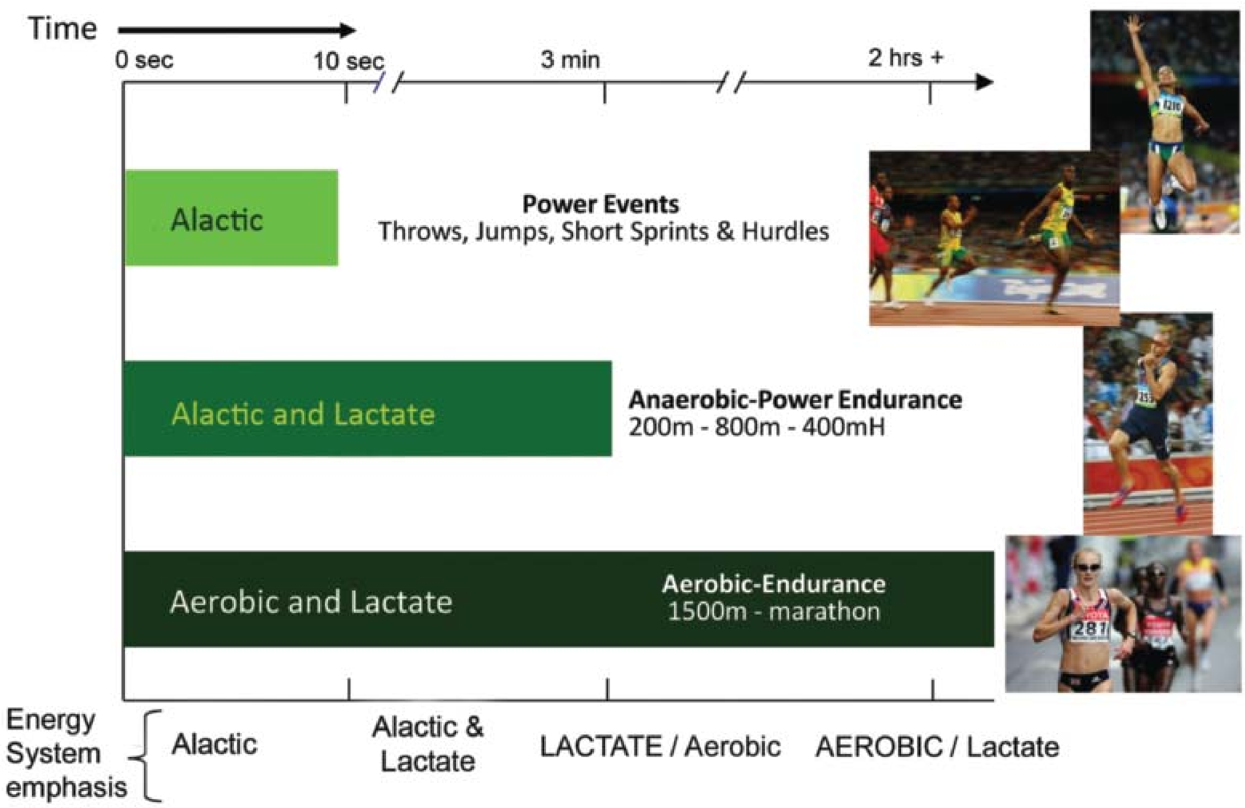
Getting rid of acid after very intense activity is a slower process than the replacement of energy stores in the Alactic system. It may take more than one hour for lactate and acid levels to return to their pre-exercise level. Recovery activities such as walking, easy running or more active running following intense efforts will speed up the removal of the acid. The first ten minutes of active recovery produces the greatest reduction in lactate and acid levels.

The lactate energy system may be developed by continuous activities or varying the intensity of repetition of work loads of 10 seconds to almost any duration. Rest periods and recovery activity will depend on the duration of the work and should be thirty seconds to ten minutes to allow utilisation of the lactate and removal of most of the acid that is produced.

Summary of the Development of the Three Energy Systems

	ALACTIC	LACTATE	AEROBIC
Duration	0-10 secs	10 secs-1+ min	1-60+ mins
Distance or Continuous	20m-80m	80m-400m	300m-15+ km
Intensity Maximal	80%-100%	50%-80%	
Repetitions	3-4	1-5	3-20+
Recovery/Reps	2-3 mins	30 secs-10 mins	30 secs-3 mins
Sets	1-4	1-4	1-4
Recovery/Sets	5-8 mins	5-20 mins	5-8 mins

The athlete's body is capable of emphasising any combination of the three energy systems. Different events demand different types and amounts of muscle activity. Consequently, different energy systems predominate in the various events. Improving performance is often the result of carefully designed training programmes that aim to increase the capability of emphasising specific energy systems and muscles.



Energy Systems and the Events of Athletics

In summary, all three energy systems work continuously:

- the relative contribution of energy from each energy system to a particular physical activity will depend on the energy requirements, which will be directly related to the intensity and duration of the exercise
- different events have different types and amounts of activity
- different events therefore emphasise different energy systems.

In the early stages of athlete development (Fundamentals, Foundation and Event Group Development stages) there should be a general development of all the energy systems. As the athlete enters the Specialisation and Performance stages the development of the energy systems can shift to those emphasised in an athlete's chosen event.

THE CARDIO-RESPIRATORY SYSTEM - GETTING OXYGEN AROUND THE BODY

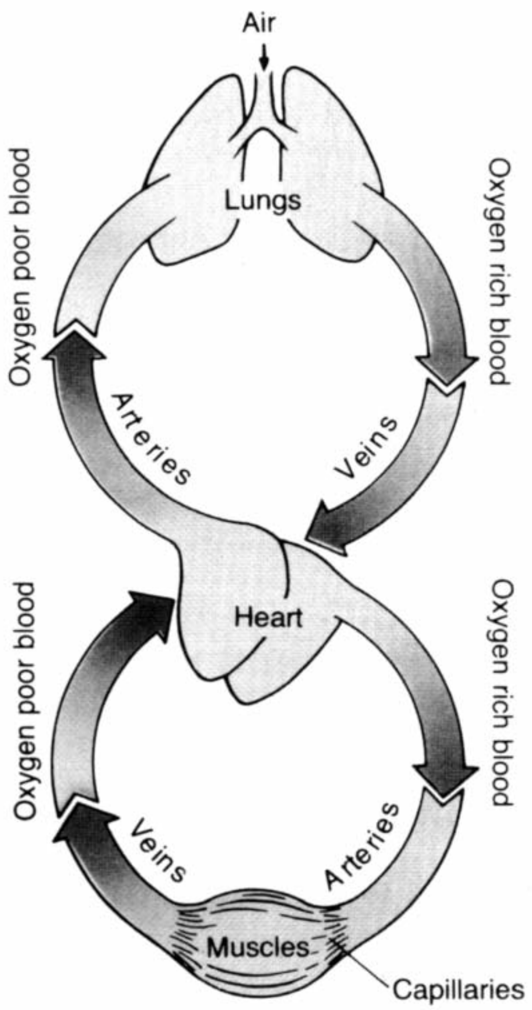
The cardio-respiratory system is responsible for getting oxygen, fuel and nutrients to the working muscles. It is also used for taking waste products away from the muscles. It consists of the lungs, the heart, the blood vessels and blood.

LUNGS - GETTING OXYGEN INTO THE BLOOD

Air is taken into the lungs through the nose and mouth. In the lungs oxygen from the air is absorbed into the blood. When the body is at rest about 10 litres of air is breathed every minute. During hard exercise this breathing rate can go up to 120-150 litres per minute. The maximum amount of air that can be taken in through the nose is about 50 litres per minute. For most athletic activities breathing should be through an open mouth.

THE HEART - LIFE'S PUMP

Your heart works night and day pumping blood around your body. It is a large pump made of muscle and never stops working from before you are born until you die. Every muscular contraction of the heart is called a heartbeat. When you exercise your muscles need more oxygen so your heart beats faster to pump more oxygenated blood to them. This increase in heart rate will be from a resting level to a maximum rate which varies from individual to individual and can be over 200 beats per minute. This heart rate can be best felt in the pulse at the wrist or side of the neck. Training has the effect of not only making the heart beat faster but to increase in size so that it may pump more blood with each beat. Training then, increases the size, thickness and strength of the heart muscle and the size of the chambers inside the heart so that the whole heart gets bigger and stronger.



Oxygen is taken from the blood in the capillaries and used in the muscles

The cardio-respiratory system

THE BLOOD VESSELS AND THE BLOOD

The blood travels around the body through a network of tubes called blood vessels. Arteries are the blood vessels that carry blood away from the heart. Arteries divide into small capillaries which penetrate into all body tissues so that the blood supply is close to every cell in the body. These capillaries are where all the material transported to the cells is transferred and where all the waste products are taken into the blood. Capillaries join up to form veins which return the blood to the heart. Training has the effect of increasing the number of capillaries in the muscles, which means they can work more efficiently.

Blood carries chemicals and other substances around the body. This is why the blood and the vessels in which it flows is called a transport system.

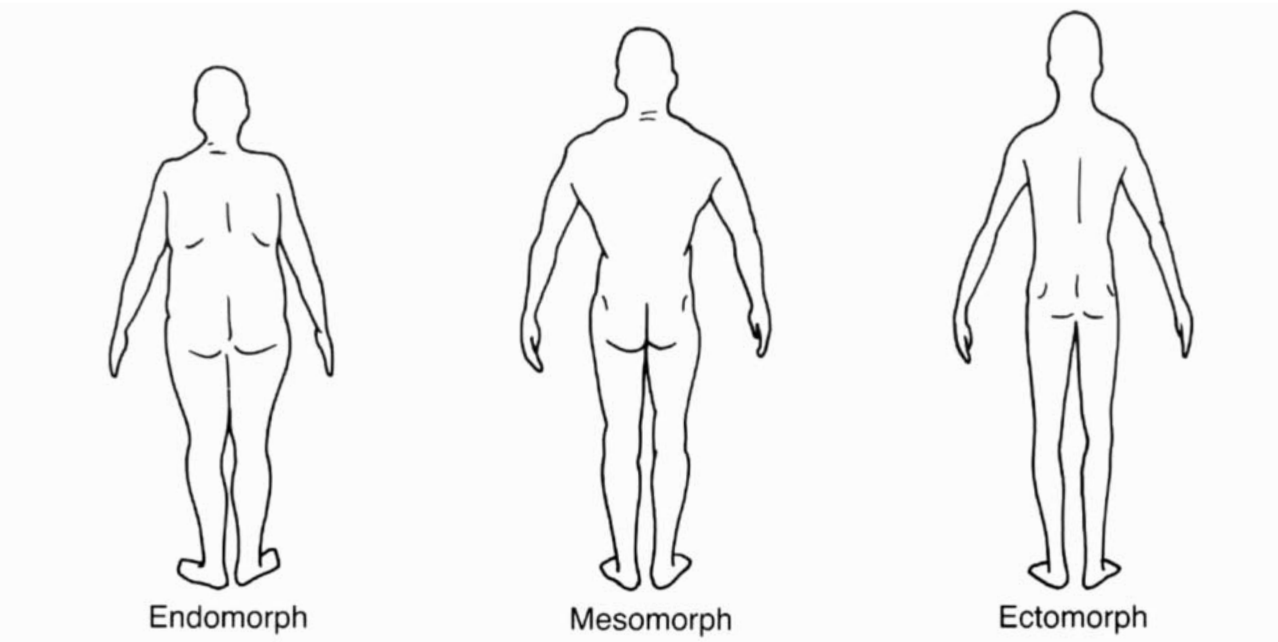
Blood is important for:

- Carrying oxygen from the lungs and food from the digestive system to the cells of the body. Red cells in the blood transport oxygen
- Carrying carbon dioxide from the cells to the lungs where it is removed and breathed out of the body
- Carrying waste materials from body tissues to the kidneys where they are excreted
- Preventing infection by healing wounds and fighting germs
- Releasing oxygen in the capillaries so it can be used in the muscles

INDIVIDUAL DIFFERENCES

Each athlete is an individual. Individuals come in all shapes and sizes but for both males and females we can recognise that there are three main body types:

- Endomorph type — These individuals tend to have a less well defined body outline and can become fat very easily
- Mesomorph type — Individuals who are well proportioned and muscular
- Ectomorph type — Thin individuals who tend to be tall



The three basic body types

The three extremes of these body types are illustrated above. Most people are a combination of one or more of the body types. In athletics, certain events lend themselves to particular body types. For example, long distance athletes and high jumpers tend to be ectomorphic. Sprinters, hurdlers and jumpers tend to be mesomorphic and throwers an endomorphic and mesomorphic mix.

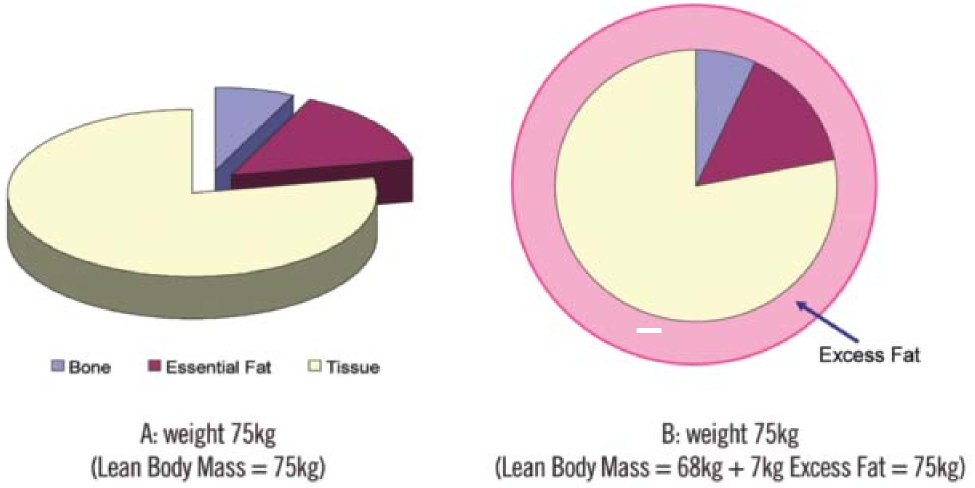
When you are asked to advise a young athlete what event they may be best suited for in the long term it is necessary to take into account their body type. You should also assess their muscle type, whether they are a predominantly fast or slow twitch muscle fibre type. Coaches should, however, always remember the stages of athlete development and encourage multi-event and event group development before any specialisation into a specific event.

BODY COMPOSITION

If you weigh the body you are weighing two components:

- Lean body weight — Bone, muscle, other tissue and essential fat. This is sometimes called lean body mass, LBM
- Excess fat — Stored in various sites around the body

The individual's body composition refers to the relationship between lean body weight and excess fat. Improvement in performance should come from increasing lean body weight and decreasing any excess fat.



Two individuals, A and B, with the same body weight but very different 'fitness'

The illustration shows that two people can have the same body weight but very different body compositions. Athlete A has the same body weight as athlete B of 75 kg but no excess fat. Athlete B has a weight of 75 kg but a lean body mass, LBM, of 68 kg, meaning that he is carrying an unnecessary 7 kg of excess fat. Coaches should beware of using weight alone as a measure of an athlete's fitness. Since muscle weighs more than fat it is possible for an athlete to show an increase in weight as their LBM increases and their fitness improves.

SUMMARY

In this section on the human body in sport we have looked at the basics of anatomy and exercise physiology and have seen how the body produces movement and how it produces the energy for this movement. The predominant energy system will depend upon the duration and intensity of the activity. With an understanding of the energy systems a coach can begin to build training sessions to develop the energy systems. In the early stages of athlete development, in the development, (Fundamentals, Foundation and Event Group Development stages) there should be a general development of all the energy systems. As the athlete enters the Specialisation and Performance stages the development of the energy systems can shift to those emphasised in an athlete's chosen event. All athletes, however, require a basis of aerobic development to provide a healthy cardio-respiratory system and as a 'foundation for life', before considering the training for any athletics' event specific energy system requirements.

COACH IN RUNNING FITNESS
THE BODY IN SPORT SELF TEST

Now you have read about the basic principles of anatomy and physiology, use this information to help you complete the following self-test to check your understanding and application of the topics introduced. This piece or work is not formally assessed but is to be used as a support resource to assist in your development. Take the time to carefully read each question and use the resource to help you answer it. There is space to record your answers throughout.

From the list of the left, identify the "Property" of the Body Parts' listed on the right. For example, if you think that the function of the skeleton is "G" - "Carry information around the body by electrical signals", write "G" in the Answer column next to Skeleton.

1. Properties	Body Part	Answer
A Supports the body like the framework of a building	Ligaments	
B Joins muscle to bone	Skeleton	
C Approximately 200 in the human body	Nerves	
D Can only pull cannot push	Muscles	
E Joins bone to bone	Cells	
F Unit of living material that is the basic building block of life	Bones	
G Carry information around the body by electrical signals	Tendons	

Place the correct letter in the Answer column.

2. Metabolic energy systems. Place the correct letter in the blank space.	Energy system	Answer
A Uses oxygen and produces easily disposed waste products	Lactate energy system	
B Intense activity for less than 10 seconds	Aerobic energy system	
C The energy system emphasised in the 400 metres race	Alactic energy system	

For the following questions, please identify the ONE CORRECT ANSWER from the options listed, and write the letter in the Answers column.

Question	Options	Answer
3 When you lower your body weight slowly, as in a half squat, the action of your quadriceps (thigh) muscles is	**A** plyometric **B** concentric **C** plastic **D** eccentric	
4 Slow twitch muscle fibres produce	**A** high forces (power) for short periods of time **B** smaller forces for longer periods of time **C** high forces for long periods of time **D** smaller forces for short periods of time	
5 Maximal velocity running is best improved by	**A** general strength training **B** strength endurance training **C** speed strength training **D** general gymnastic training	

For the following questions, please identify the ONE CORRECT ANSWER from the options listed, and write the letter in the Answer column.

Question	Options	Answer
6 Athlete Development means	**A** young athletes should specialise as early as possible **B** individuals are doing the right things at the right time for their long term, not necessarily immediate, development **C** coaches should focus only on the immediate competition needs of their athletes when planning training **D** in the first three stages the athlete should compete as little as possible and competition is not important.	
7 The number of training sessions in a training week (microcycle) is dependant on	**A** training age **B** stage of athlete development **C** chronological age **D** all of the above	
8 The energy system(s) emphasised for General Endurance in the training of an athlete in the Foundation stage is/are	**A** the lactate system **B** the aerobic system **C** the alactic system **D** the aerobic and lactate systems	
9 Which of the following sessions would improve maximal speed in sprinting for an athlete with a training age of 6 years	**A** 10 x 30m (maximum acceleration) [3'] **B** 2 x 4 x 150m (maximum) [3' and 8'-10'] **C** 2 x 3 x flying 30s (maximum) [2'-3' & 5'-7'] **D** 2 x 300m (400m pace) [10']	
10 Which statement is appropriate for young athletes (11-15 years)?	**A** young athletes should not be encouraged to train/compete over very long distances/marathons **B** repetition training sessions should be included on a daily basis **C** a young runner should avoid all other sports **D** continuous runs should be the daily training	
11 Metabolic energy systems - As you are sitting and reading this - is your lactate energy system producing energy	**A** only if I think about it **B** no **C** yes **D** only if I hold my breath	
12 The intensity (pace) to develop General Endurance with Continuous training is	**A** same for all athletes **B** individual, based on actual aerobic capacity and fitness **C** same all over the training year **D** individual, based on goal pace of competition	

For the following questions, please identify the ONE CORRECT ANSWER from the options listed, and write the letter in the Answer column.

Question	Options	Answer
13 Athletes reach their full performance capacities in athletics at	**A** 18 years of age - same for all athletes **B** just after puberty, based on maturation **C** between 25 and 30 years of age, in general **D** always between 21 and 23 years of age	
14 What type of strength is improved by running in water without touching the bottom?	**A** maximal strength **B** strength endurance and reactive strength **C** strength endurance **D** reactive strength	
15 Skeletal muscle is attached to bone	**A** by muscle fibres growing into the bone **B** by both ligaments and tendons **C** by ligaments at both ends of the bones **D** by tendons at both ends of the muscle	
16 Energy Systems: Match three from the following four statements: a. Aerobic system, using fat as an energy source b. Lactate system c. Aerobic system using predominately carbohydrate as an energy source d. ATP present in the muscle	developed by long slow distance runs of over 2 hours developed by interval training with very active recoveries used in first 1 to 4 seconds of high intensity movements.	
17 List four types of continuous running training	1 2 3 4	
18 What is the following session developing: 3 X 5 x 500 (5000m pace) [100m active roll on and 5']	**A** an emphasis on the lactate and aerobic energy systems **B** an emphasis only on the lactate energy system **C** an emphasis on the aerobic system **D** maximal speed	
19 The difference between repetition training and interval training is	**A** no difference - they are the same **B** interval training always has longer, less active recoveries than repetition training **C** in interval training the training effect occurs in the faster sections of the session **D** in interval training the training effect occurs in the interval between the faster sections of the session	

For the following questions, please identify the ONE CORRECT ANSWER from the options listed, and write the letter in the Answer column.		
Question	Options	Answer
20 Concerning maximum strength which of the following statements is correct	**A** runners should be as strong as possible **B** runners should be as strong as necessary **C** runners need strength for the leg muscles only **D** strength is not relevant for runners	
21 The energy system(s) emphasised for Event Specific Endurance training of a middle distance runner is / are	**A** the lactate system **B** the aerobic system **C** the alactic system **D** the aerobic and lactate systems	
22 What type of strength helps the body to save metabolic energy, to use less metabolic energy, when you are racing or training	**A** reactive strength **B** mental strength **C** technical strength **D** having strong arms	
23 Concerning flexibility which of the following statements is correct	**A** flexibility can be improved by static stretching in the warm up **B** runners only need flexibility in the legs **C** flexibility reduces body tension and should be excluded from runners' training **D** optimal flexibility helps the athlete to produce optimal force	
24 What fuels are available for the marathon runner from within their bodies and used during the race	**A** glycogen **B** fat and glycogen **C** glycogen, lactate and fat **D** protein and fat	

ANSWERS

After completing the CiRF Body In Sport self-test, use this table to check your answers. Correct answers show areas where your understanding is good. Incorrect answers are areas where it would prove useful to read the relevant section again and discuss with other coaches.

1 - E, G, F, A, D, B, C	8 - B	15 - D	19 - D
2 - C, A, B	9 - D	16 - A, B, D	20 - B
3 - D	10 - A	17 - Fartlek, long slow distance, lactate threshold reps, tempo runs	21 - D
4 - B	11 - C		22 - C
5 - C	12 - B		23 - D
6 - B	13 - C		24 - C
7 - D	14 - C	18 - A	

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