4

DEVELOPING PHYSICAL FITNESS

The Body in Sport and Athletics

The human body is a highly complex living 'machine' and anatomy is learning about the 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 - 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.

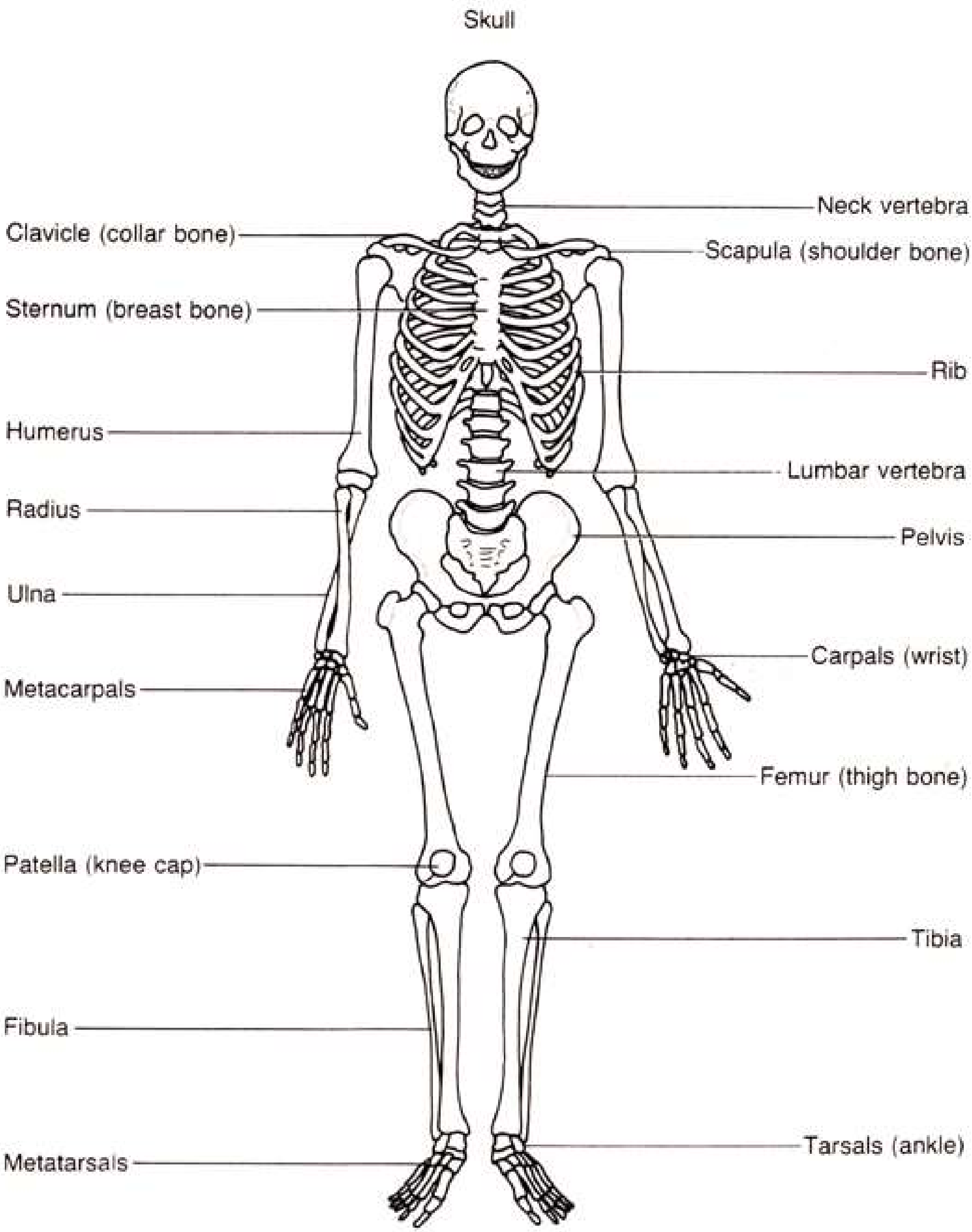
The Skeleton

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. 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.



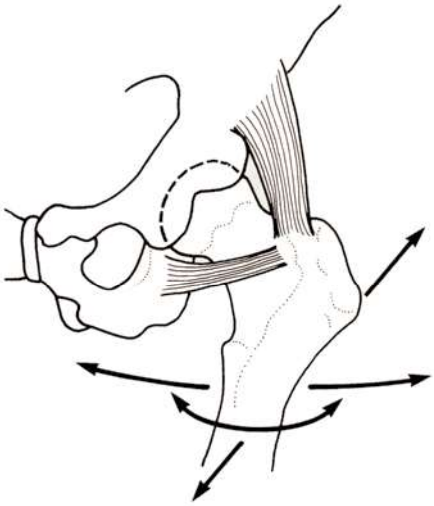
The human skeleton

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.



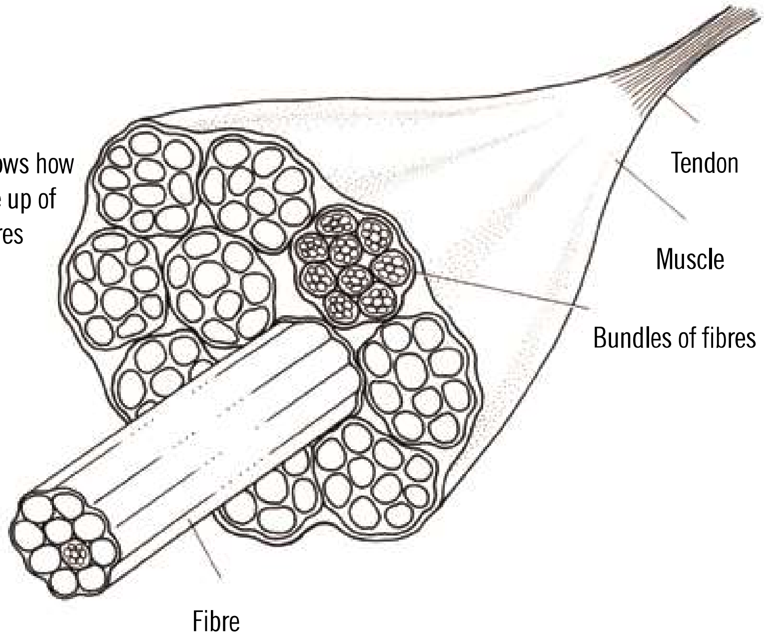
Hip joint

Each kind of joint allows a different sort of movement. 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.

This illustration shows how a muscle is made up of bundles of fibres



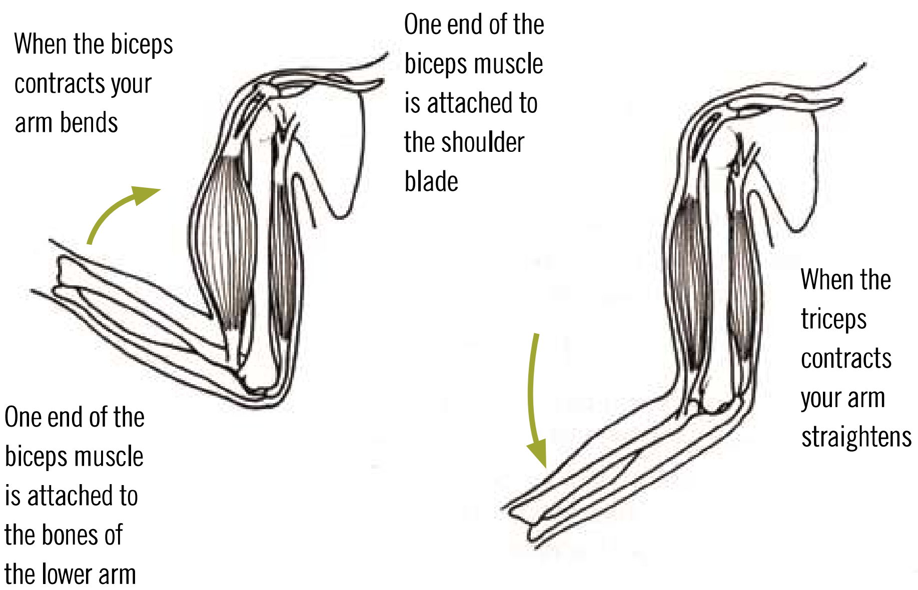
Inside a muscle

This illustration shows how a muscle is made up of bundles of fibres

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.

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.

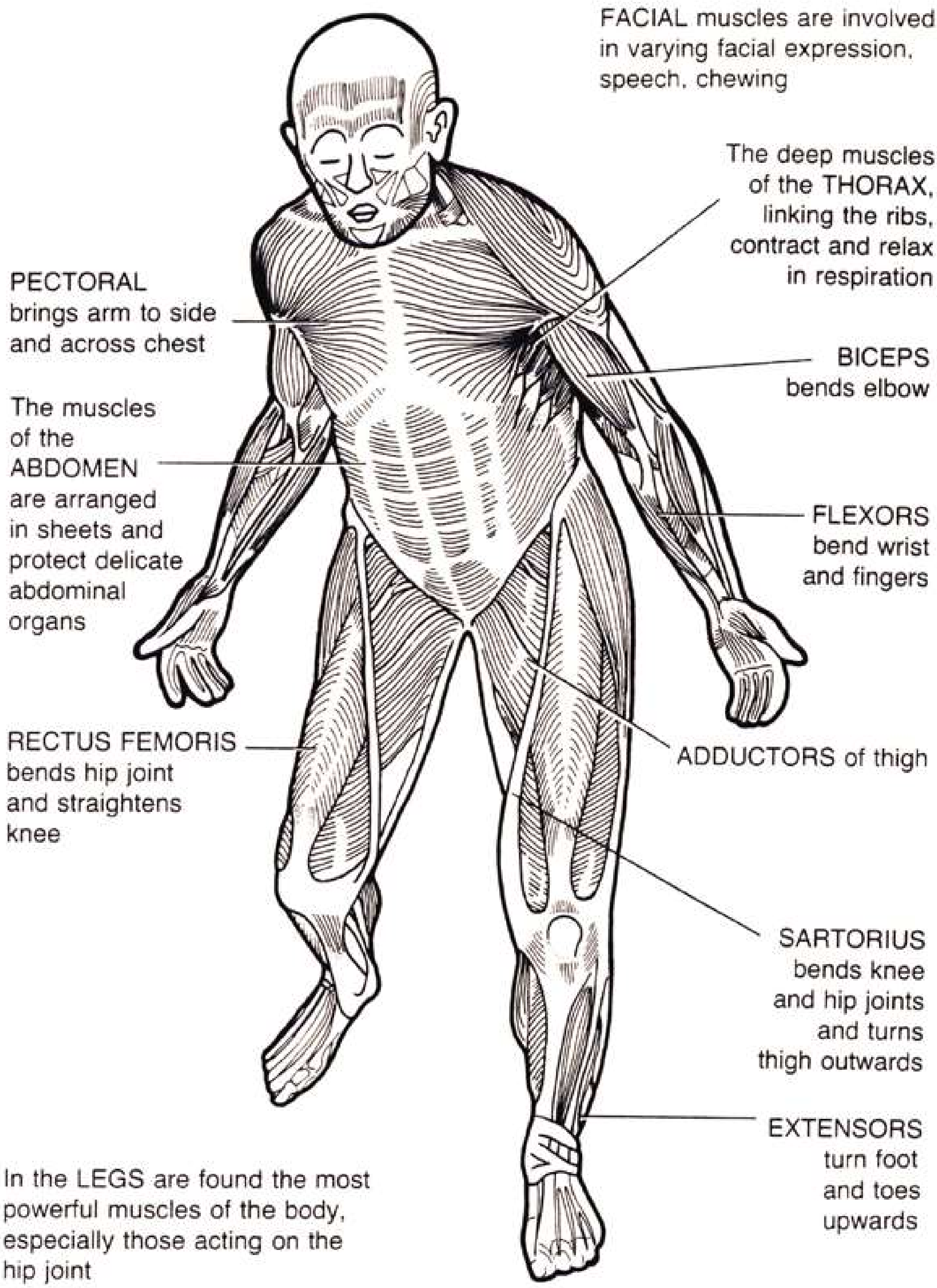


Muscles in the upper arm

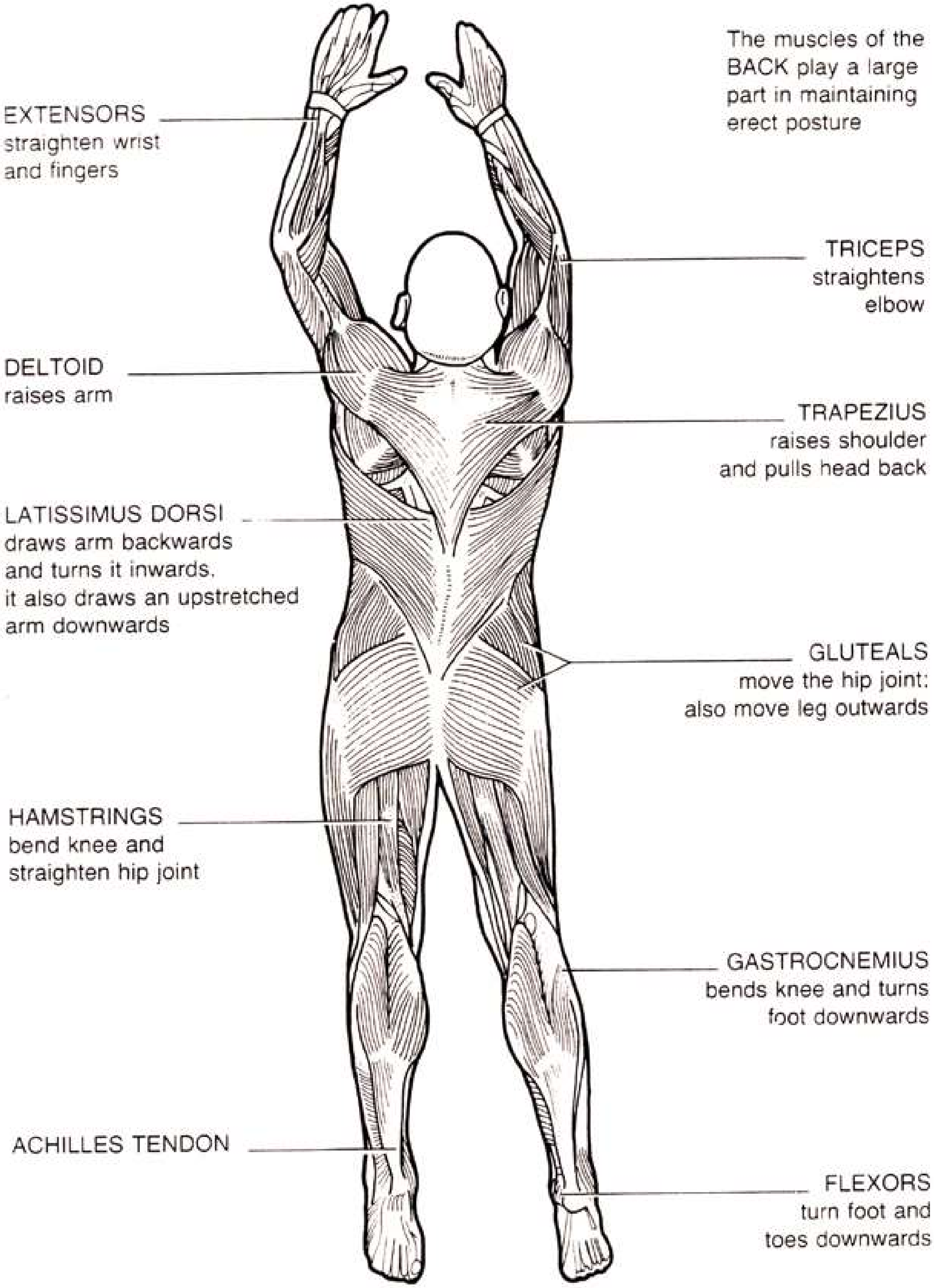
Movement is rarely produced as the result of the contraction of just one muscle. In body and limb actions, groups of muscles are usually involved in making a single movement. The contribution that each muscle in the group makes can vary considerably according to the effort and action required.

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.


KOREA
SAMSUNG
396
15TH ASIAN GAMES DOHA 2006



The skeletal muscles – front view



The skeletal muscles – back view

Muscle Fibre Types

We have seen how muscles are made up of bundles of muscle fibres. Not all muscle fibres are the same. Simply, there are two major types of muscle fibre found in each muscle:

- Fast twitch fibres
- Slow twitch fibres

Each individual in each of their muscles has a mixture of fast twitch muscle fibres and slow twitch fibres. Different people have different percentages of fast and slow twitch fibres. These percentages are determined at birth by heredity but some of the fibres may be changed by the type of training the athlete does.

The fast twitch muscle fibre is like the engine of a sprint type racing car. It can produce high speed movement for short periods of time. The chemical reactions involved in this fast movement mean that the athlete cannot use the fast twitch fibres for very long. A slow twitch muscle fibre produces less power and speed but can operate for much longer periods. It produces waste products that are easily disposed of and for this reason slow twitch fibres are very important in endurance events.

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.

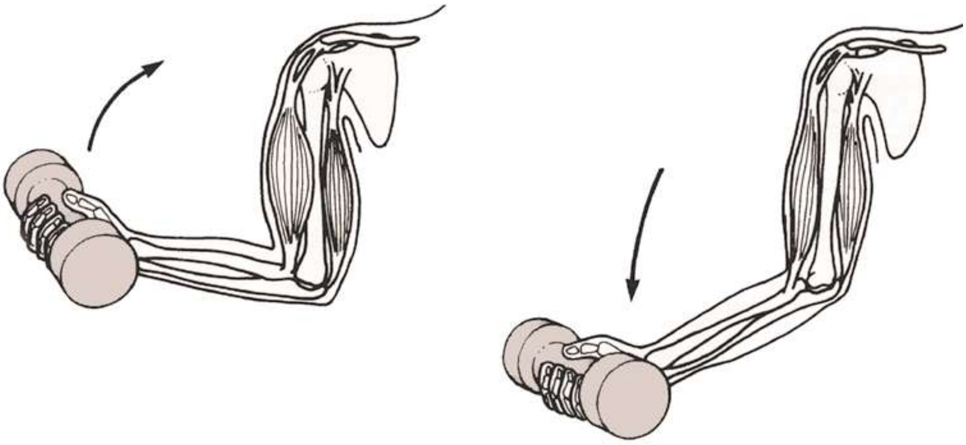
How Muscles Pull

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 muscles act by contraction. 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.

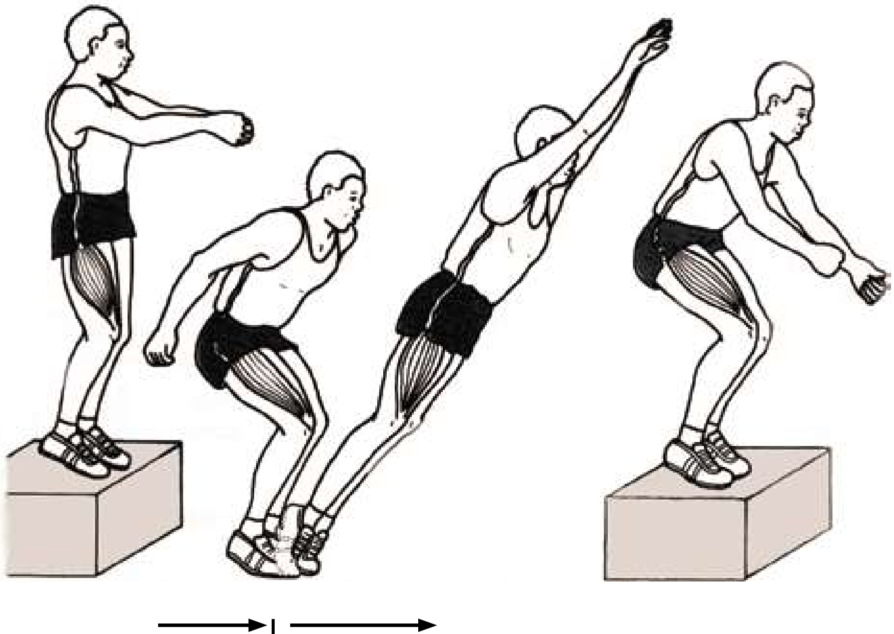


Concentric contraction,
muscle shortens and thickens to raise a load

Eccentric contraction,
muscle lengthens and controls lowering of load

Dynamic contractions of the biceps muscle

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.



Eccentric contraction | Concentric contraction

Dynamic contractions of the thigh muscle

Static Contractions

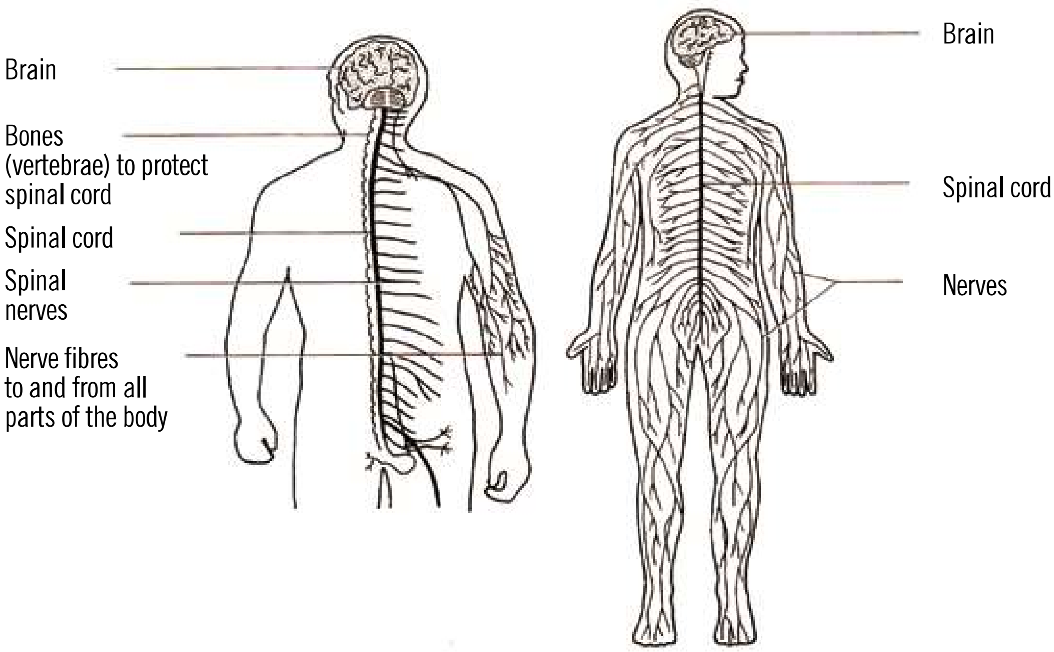
This type of contraction is more commonly known as an isometric contraction. When a muscle contracts isometrically it develops tension, but there is no lengthening or shortening of the muscle and no movement. Such contraction is very common and can be observed when an attempt is made to move an immoveable 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 he should not forget the important role of the postural control muscles and plan to develop the isometric strength and endurance of these muscles.

Isometric contractions – example the "On your marks" and "Set" positions

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*

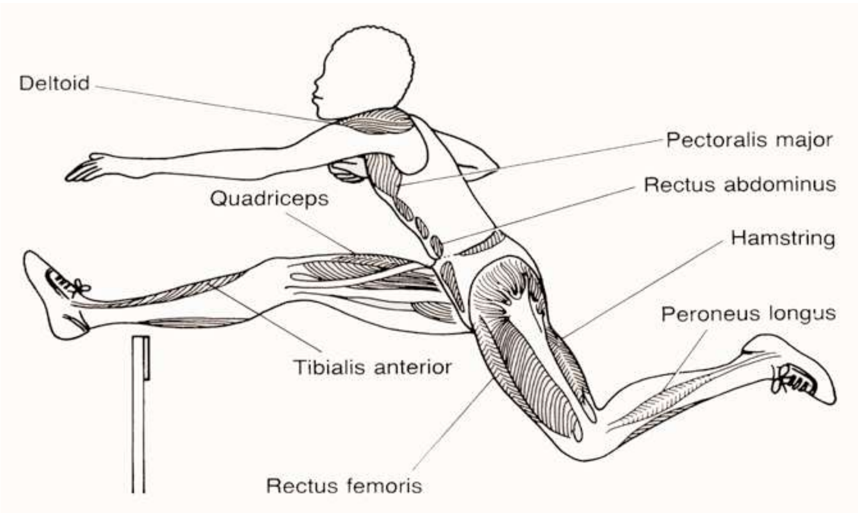
Your muscles pull when they receive signals from your brain telling them to do so. These signals are carried by nerves made up of special nerve cells. The actual contraction process of a muscle fibre is started when it receives a nervous impulse, which is an electrical signal carried by the nerve cells. 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 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.


ERITREA
Beijing 2008
1575

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.

In order to determine how metabolic energy is produced in our muscles we have to consider some important factors. "Is air we breathe, in the form of oxygen, required for this energy production?" If it is, we say the energy system is aerobic. If the energy system is capable of operating while there is no oxygen available from the air we breathe, then the energy system is anaerobic. Anaerobic simply means "in the absence of oxygen".

So, there are three energy systems operating in the bodies of our athletes. One of these is aerobic, requires oxygen and only operates when oxygen is present. Two are anaerobic, operating when oxygen is present but are capable of producing energy in the absence of oxygen.

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:

Aerobic Process

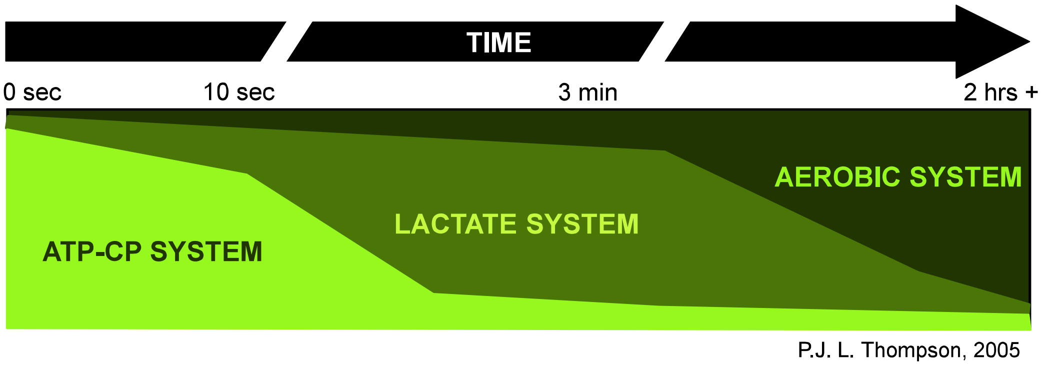
- **The Aerobic System**
  The muscle energy system which requires oxygen

Anaerobic Processes

- **The Lactate System**
  The 'linking' energy system which is capable of operating without oxygen and produces lactate and acid
- **The ATP-CP System**
  The stored, start-up energy system which is capable of operating without oxygen and uses 'CP' as fuel but does not produce lactate or acid.

Although these they 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 the ATP-CP system." It is how long and, equally important, how hard or intense we do whatever physical activity that determines which energy system is emphasised and contributes most.

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; while sprinters, hurdlers, jumpers and throwers depend more on anaerobic processes for their events. The aerobic-anaerobic split is determined by identifying how long and/or how hard our athletes work and the nature of their recoveries.

System	Characteristics	Energy Provided for	How Developed	Training Effects
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	No oxygen requirement 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 a fuel source
ATP-CP system	No oxygen requirement and uses CP but 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

Summary of the three energy systems

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 ATP-CP 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. Training the aerobic energy system must be a minimum of a total of 20 minutes duration. 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.

ATP-CP Energy System – *The 'First 10 Seconds' Energy*

The ATP-CP 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, '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 ATP-CP energy system is developed by alternating periods of work 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 ATP-CP 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 book 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.

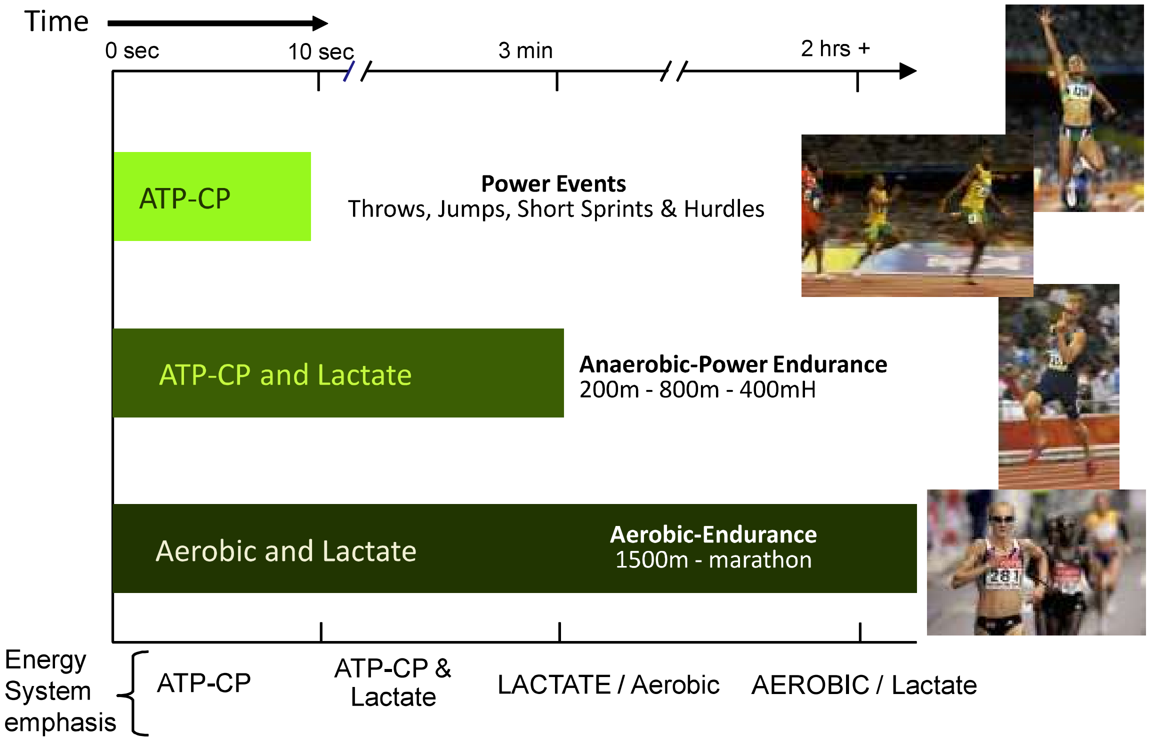
Getting rid of acid after very intense activity is a slower process than the replacement of energy stores in the anaerobic ATP-CP system. It may take more than one hour for lactate and acid levels to return to their pre-exercise level. Recovery activities such as walking, easy running or more active 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.

	ATP-CP	LACTATE	AEROBIC
Duration	0-10 secs	10 secs-1+ min	1-60+ mins
Distance	20m-80m	80m-400m	300m-15+ km or Continuous
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

Summary of the Development of the Three Energy Systems

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, in the Kids' Athletics, Multi-Events 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

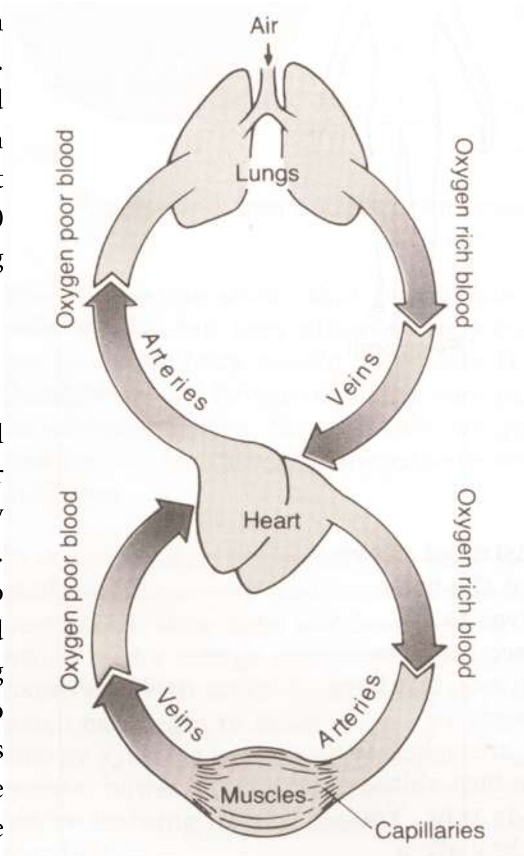
The cardio-respiratory system is responsible for getting oxygen, fuel and nutrients to the working muscles. It is also used for taking waste products away from the muscles. It consists of the lungs, the heart, the blood vessels and blood.

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 are 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.

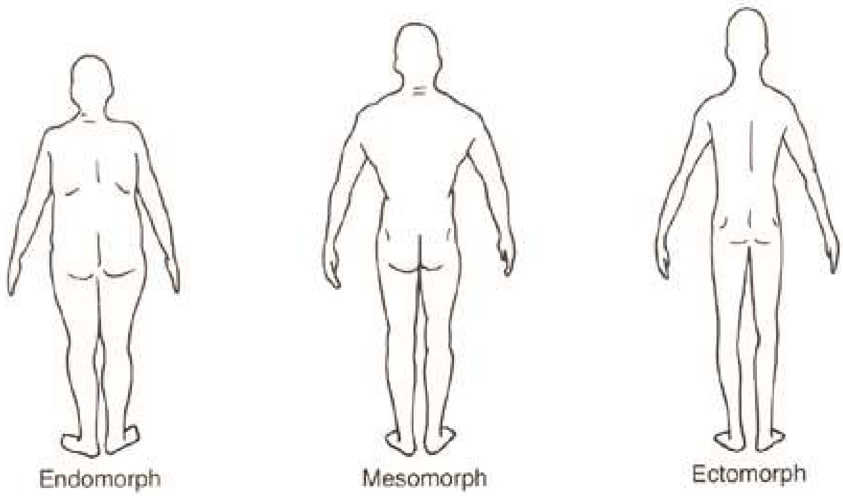
Blood carries chemicals and other substances around the body. This is why the blood and the vessels in which it flows is called a transport system. Blood is important for:

- 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

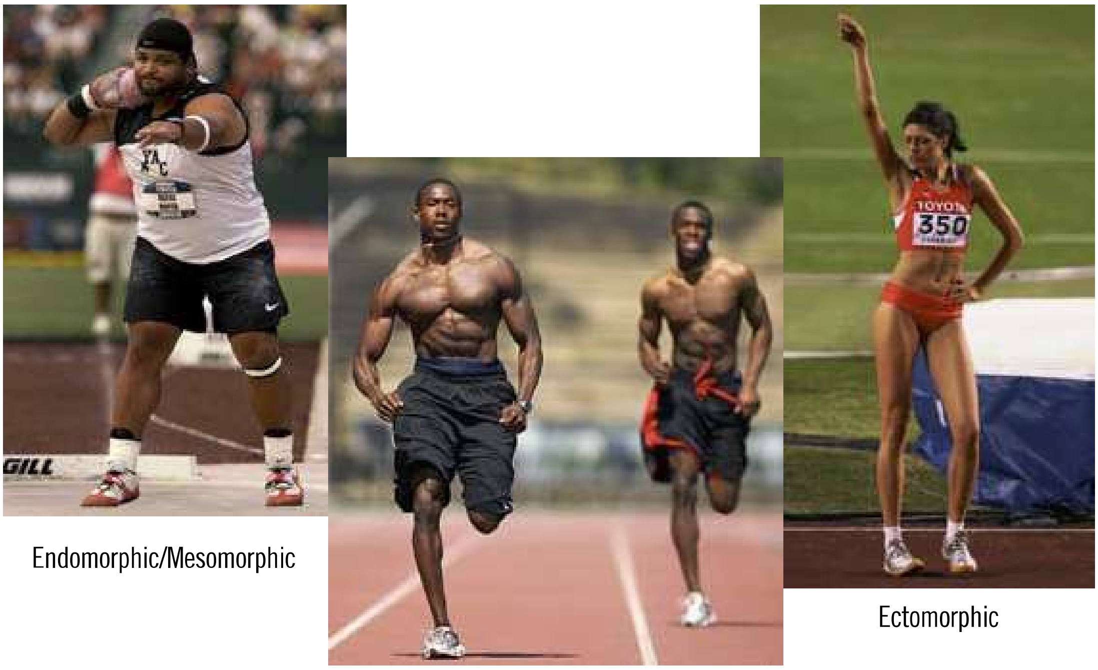
Each athlete is an individual. Individuals come in all shapes and sizes but for both males and females we can recognise that there are three main body types:

- 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 physique 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.



Endomorphic/Mesomorphic

Ectomorphic

Mesomorphic

Body Types

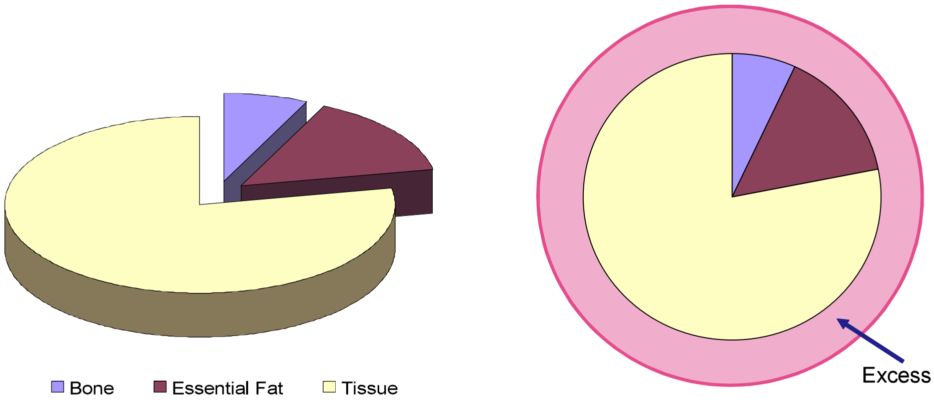
When you are asked to advise a young athlete what event they may be best suited for in the long term it is necessary to take into account their body type. You should also assess their muscle type, whether they are a predominantly fast or slow twitch muscle fibre type. Coaches should, however, always 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.



A: weight 75kg
(Lean Body Mass = 75kg)

B: weight 75kg
(Lean Body Mass = 68kg + 7kg Excess Fat = 75kg)

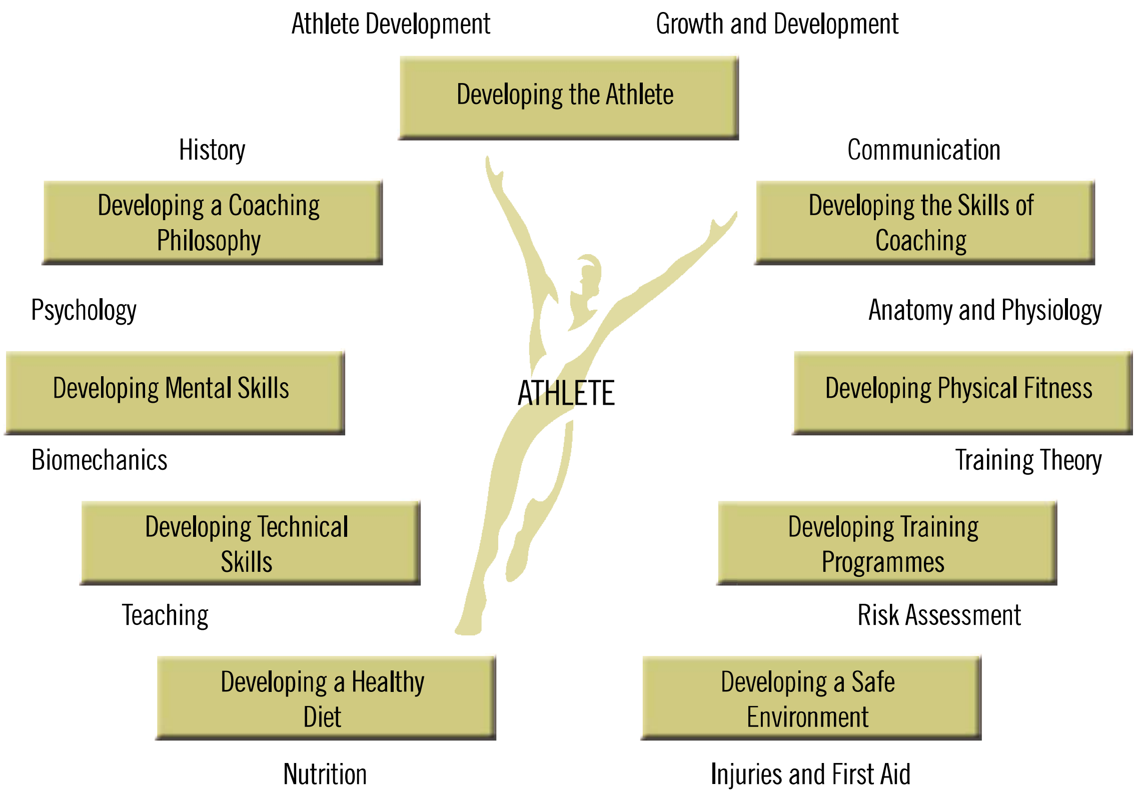
Body Composition – Two individuals, A and B, with the same body weight but very different 'fitness'

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 he improves in fitness.

In this chapter on the human body in sport and athletics 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. How hard and how long an activity is will decide which of the energy systems is emphasised to produce most of the energy required. 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 Kids' Athletics, Multi-Events 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.

The Components of Fitness

In athletics, records are made to be broken. Men and women around the world continually challenge and improve upon past performances in all events. These improvements in performance are generally a result of higher levels of fitness. This fitness comes from an improved understanding by coaches and athletes of training and its effects. Training theory is the bringing together of all information about athletics from social and scientific sources for the coach to apply in a practical way for the benefit of each athlete.



This information is used by the coach, along with the knowledge he has of the athlete, to produce effective training programmes. But before you begin to look at building training programmes it is important to understand what is meant by 'fitness' and how it can be developed.

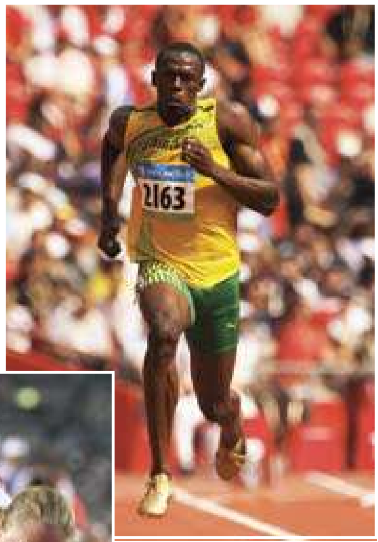
What is Fitness?

Fitness is how well a person is adapted to and capable of living a certain lifestyle. The fitness of an athlete is generally greater than that of the non-athlete. The athlete needs to be fit for the demands of his chosen athletic event in addition to being fit for the demands of day to day living. But what is fitness made up from? The principle of specificity states that there is a specific response to the specific nature of a training load. This specific response will tend to emphasise one or more of the components that make up fitness. These components of fitness are basic and respond well to training.

The Components of Fitness

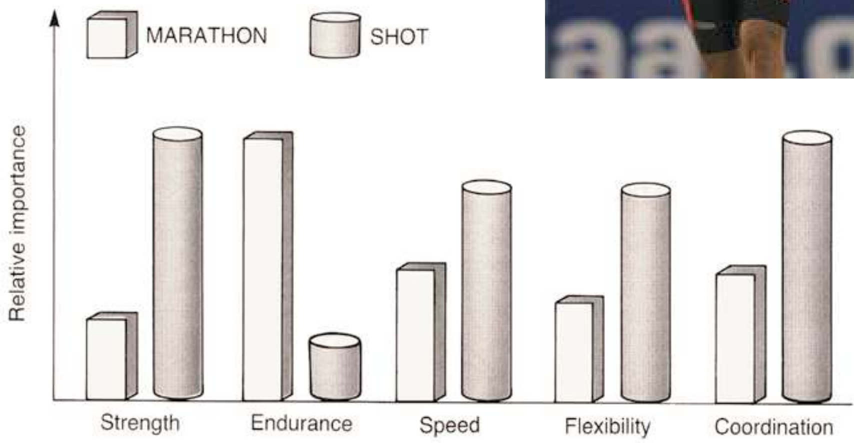
There are five basic components of fitness and these are endurance, speed, strength, flexibility and coordination.

- Endurance
- Speed } Power
- Strength } Power
- Flexibility
- Coordination



Each exercise in training will tend to develop a particular component of fitness. For example, when distance or duration is extended or maximal the exercise becomes endurance based. Quickness and frequency of movement would give a speed exercise. If the load of an exercise is high or maximal it is a strength exercise. The ability to move through a wide range of joint motion would be a flexibility exercise and activities that have relatively complex movements are called coordination exercises. This is a simplified view and in practice exercises usually develop two or more of the components of fitness.

Different events have different demands on fitness. The fitness of a distance runner is obviously very different to the fitness of a shot putter, as illustrated below. The table illustrates the relative needs for strength, endurance, speed, flexibility and coordination in these events.



Profile for the components of fitness for the marathon and shot

To provide a fitness foundation for all athletes and later to develop the specific fitness required for an event it is necessary for the coach to understand the characteristics of the five components of fitness and how to develop them.

Developing Endurance

Endurance

Endurance refers to the ability to perform work of a given intensity over a time period and is sometimes called 'stamina'. The main factor which limits and at the same time affects performance is fatigue. An athlete is considered to have good endurance when he does not easily fatigue or can continue to perform in a state of fatigue. Endurance, of all the components of fitness, should be developed first. Without endurance it is difficult to repeat other types of training enough to develop the other components of fitness. There are two basic types of endurance:

- **Aerobic endurance**
- **Anaerobic endurance**

Aerobic Endurance

Aerobic means 'with oxygen' and aerobic endurance means muscular work and movement done emphasising the use of oxygen to release energy from the muscle fuels. We have seen how the absorption and transport of the oxygen to the muscles is carried out by the cardio-respiratory system. Aerobic training leads to both a strong cardio-respiratory system and an increased ability to use oxygen in the muscles. Aerobic endurance can be developed by continuous or repetition running. The longer the duration of an event the more important is aerobic endurance.

Anaerobic Endurance

Anaerobic means 'without oxygen' and anaerobic endurance refers to the energy systems which are capable of operating without oxygen present. They allow muscles to operate using energy they already have in store. Anaerobic training of the right type which emphasises the lactate system allows the athlete to clear and tolerate the build up of the 'acid' part of lactic acid. Remember that lactic acid does not exist in the body. As soon as it is formed it separates into a 'lactate' bit and an 'acid' bit. We have seen that the acid is the 'bad guy' but the athlete can use the lactate as a fuel source.

There are two important types of anaerobic endurance. The first is speed endurance which involves principally the aerobic and lactate systems but emphasises the lactate system. Developing speed endurance helps an athlete to run at speed despite the build up of acid. The second type of anaerobic endurance is the endurance needed to maintain maximal velocity speed in sprinting, hurdling, throwing and jumping, where the ATP-CP system is emphasised.

Development of Endurance

The most important types of endurance training using walking and running are:

- **Continuous Training**
- **Repetition Training**

Continuous training simply means walking, running or doing whatever training activity without rest. Continuous training may be used to develop general endurance, specific endurance and for recovery. It usually takes place away from the track and provides a variety of pace, location and running surface in the athlete's training. Runs may be short, medium or long but it should be remembered that 'long' and 'short' are relative to the stage of development of the athlete and their fitness levels. The same distance might be a 'short' run for one athlete and a 'long' run for another athlete. The other type of continuous training which may be used throughout the year is 'Fartlek' training, where the athlete 'plays' with a variety of running speeds or rhythms.

Repetition training is breaking a total distance or any training load into smaller units which are repeated, hence repetitions. In walking and running the pace, distance and rest/recovery intervals and activity are prescribed. Usually done on the track but may be done in a park on grass or anywhere. Repetition training can be divided into two main types by pace or running rhythm: extensive and intensive. When the training emphasis is on general endurance, extensive repetition training is used; when the emphasis is on event-specific endurance, intensive repetition training is used.

Training loads are usually defined by the following parameters:

- Volume can be described by the running distance (m, km, miles) or the running time (sec, min, hours) or by the number of repetitions or number of sets of repetitions.
- Intensity, which would be the pace, rhythm or running speed (min/km, min/mile, seconds per 400m lap, etc.)
- Rest/Recovery is the time, or interval, between different repetitions or sets of repetitions (sec, min or distance).

Developing General Endurance

General endurance is developed mainly through continuous, extensive repetition and fartlek training. The pace used for both these methods should be based on the athlete's running rhythms. These methods should be applied throughout the training year, using the following guidelines and remembering that continuous training runs should also be use throughout the year for recovery and regeneration:

- **Slow Continuous Runs** (Goal: regeneration)
  Pace: Easy rhythm; Volume: up to 30 minutes; Rest: not applicable.
- **Long Slow Distance Runs** (Goal: general endurance)
  Pace: Marathon rhythm and slower; Volume: 60-150 minutes; Rest: not applicable.
- **Medium Continuous Runs** (Goal: general endurance)
  Pace: ½ Marathon to Marathon rhythm; Volume: 30-60 minutes; Rest: not applicable.
- **Fast Continuous Runs** (Goal: general endurance)
  Pace: 10 Km to ½ Marathon rhythm; Volume: up to 10-45 minutes; Rest: not applicable.
- **Extensive Repetition Training** (Goal: emphasise aerobic endurance)
  Pace: 3000m to 10,000m rhythm; Volume: increases with the competition distance; Rest: depends on the individual runs in the sessions (see sample sessions).
- **Fartlek** (Goal: aerobic and lactate endurance)
  Pace: rhythmic 'speed-play'; Volume: 10-45 minutes, increases with the competition distance; Rest: not applicable but the 'easier' sections should still be active running.

Here are some sample extensive repetition sessions:

a) 2 x 10 x 200 m (3000m pace) [between reps = to running time, between sets: 5 min]
b) 15 x 400 m (5000m pace) [between reps = to running time]
c) 1 min, 2 min, 3 min, 2 min, 1 min (10,000m pace) [between runs = to running time]

It is important to remember that when using extensive repetition training the coach must monitor the pace carefully to ensure it stays within the prescribed rhythm and does not compromise the athlete's ability to complete the session. Running too fast during extensive repetition training is a common mistake.

In the section on growth and development we read that testosterone has a number of effects in the body. Testosterone promotes muscle development and this is well known by most coaches. But it also has effects on the energy systems. Testosterone promotes an increase in the number of red blood cells which are responsible for transporting oxygen around the body and to the exercising muscles. It also increases the efficiency of the mitochondria, the parts of the muscle cells where oxygen is used to make energy. Both of these effects mean that the production of aerobic energy is improved and training after puberty can now work towards developing the athlete's aerobic capacity.

Repetition Training and Interval Training

Repetition training may also be divided into two main types according to the recovery activity that takes place during the 'intervals', the time between the faster repetition sections.

- Repetition Training
- 'New Interval Training'

In standard Repetition Training the rest period between repetitions and sets may be passive, walking or easy running. But in the 'New Interval Training', which has become popular because of its effectiveness in developing both the aerobic and lactate energy systems, the recovery in the intervals is a very active 'roll-on', running recovery. New interval training is a type of repetition training where the training effect occurs in the interval between the faster sections. Only repetition training that has the training effect taking place in the interval should be called 'interval training'. To compare a classic repetition session of 15 x 400 (3000m pace) [90"] with new interval training:

Sample new interval training sessions:

15 x 400 (5000m pace) [100m roll-on] or
3 x 5 x 400 (3000m pace) [100m roll-on & 3 mins] or
3 x 5 x 400 (5000m, 3000m, 5000m, 1500m, 5000m) [100m roll-on & 800m roll-on].

What does 'a very active roll-on, running recovery' really mean? Some coaches find it useful to ask athletes to imagine that they are riding a bicycle. When you are pedalling along it is like being in the faster repetition distance of the session. When you come to the recovery interval it should feel like you stop pedalling – but you do not touch the brakes at all – you just roll, naturally on.

This very active 'roll-on', running recovery could be 25" to 35" or more per 100m for an inexperienced athlete. For experienced juniors and seniors in the Specialisation and Performance stages of athlete development, a 100m roll-on may easily be 25" or less. The roll-on recovery distance can be 100m, 200m, 300m or any distance that is suitable to the stage of development of the athlete, to provide variety and create different effects on the lactate energy system.

In summary, it is true to say that the term 'interval training' should only be used for the specific repetition training where the training effect takes place in the interval between the faster sections. So we can say,

"Interval training is always repetition training
but not all repetition training is interval training."

The effective coach knows this important distinction and uses the correct term to describe the training to be undertaken.

All repetition training can be varied by:

- **Repetitions** The total number of repetitions in a session – may be divided into sets.
- **Duration** Length of time or distance of one repetition
- **Intensity** Rhythm, pace, speed or velocity of the repetitions
- **Recovery** Time of the intervals between repetitions and sets
- **Recovery activity** From a walk to easy running or more active as in new interval training.

Pace for Endurance Training

Coaches use 'pace' in planning endurance training and it should mean,

"The running rhythm the athlete would use if they were racing that distance today – not their personal best"

Pace can be used as a guide for an athlete's running rhythms for their continuous on repetition training. For example, '800m pace' means the running rhythm for this repetition will be the same rhythm as the athlete would have used if they had been racing in a 800m race that day. But this should be their 800m mid-race rhythm and not their 800m finishing pace. Coaches planning training for running sessions should avoid using 'target times' for their athlete's repetition training. For example, a 36 seconds time for 200m might be an 'easy' effort for an athlete on a day when they are 'fresh'. The same time of 36 seconds may feel much harder and produce a different physiological response, or be unachievable for that same athlete, if the athlete is very fatigued.

To repeat, '3000m pace' means the running rhythm for the repetition will be the same mid-race rhythm as the athlete would have used if they had been racing a 3000m race that day, the day of the actual training, not their personal best for the distance. For example, an 82 seconds time for 400m might be an 'easy' effort for an athlete on a day when they are 'fresh'. The same time of 82 seconds may feel much harder and produce a different physiological response if the athlete is very fatigued from training, from other things in their life or if the weather is not good through wind, rain and/or temperature.

Using running rhythm and 'pace' means that the speed of the repetitions is adjusted each day to the athlete's fitness and energy levels. With training groups, using target times may fit one or two athletes in the group but not most of the athletes in the group. Using 'pace' means that every athlete trains at their individual rhythm and level of performance, developing the fitness that they need.

Developing Event Specific Endurance

Event specific endurance is developed mainly through intensive repetition training and only becomes a focus once the athlete has entered the Specialisation or Performance stages of athlete development. The pace used for this method should usually be the athlete's running rhythm for that event but may, close to the competition season during the competition period, be based on the target time for the competition distance.

Intensive repetition training, called 'acidosis training', leads to high concentrations of acid in the body and should be used carefully, if at all, with younger athletes.

- **Intensive Repetition Training** (Goal: event specific endurance)
  Pace: Based on event specific pace; Volume: increases with the competition distance; Rest: depends on the individual efforts in the session

The following table shows the types of repetition training you can do to develop endurance with an emphasis on the lactate system compared to the training with an emphasis on the aerobic system.

LACTATE/Aerobic		AEROBIC/Lactate
Relatively low	← Total Repetitions →	Relatively high
10 secs-2+ min	← Duration →	2-60+ mins
80m-600m+	← Distance →	300m-1200m+ or Continuous
80%-100%	← Intensity →	50%-75%
30 secs-10 mins	← Recovery →	30 secs-3 mins
Walk/easy run	← Recovery activity →	Easy/active run

Comparison of repetition training to shift the emphasis of endurance development from the Lactate to the Aerobic system

Endurance is used in two ways in athletics. It is used for an event group, which includes middle and long distance running and race walking, and as a component of fitness. This can be confusing and lead to some coaches to think that endurance is only relevant to the events of the endurance event group. But the 100m runner or the sprint hurdler needs endurance to maintain their maximum speed to the end of the race. The throws and the jumps events require athletes to have enough endurance to maintain performance through all the rounds of those events. This type of endurance emphasises predominantly the ATP-CP energy system. To develop this we have to use repeated maximal efforts of short duration with sufficient recovery:

		ATP-CP
Duration	→	0-10 secs
Distance	→	20m-80m
Intensity	→	Maximal
Repetitions	→	3-4
Recovery/Reps	→	2-3 mins
Sets	→	1-4
Recovery/Sets	→	5-8 mins

Developing anaerobic endurance emphasising the ATP-CP energy system

With a clear understanding of all that comprises the 'Endurance' component of fitness the effective coach can ensure that their athletes' endurance needs are met, appropriate for each athlete's age, maturation and stage of athlete development.


USA
Beijing 2008
3167

Developing Speed

Speed

Speed is the capacity to travel or move very quickly. Like all the components of fitness, speed can be broken down into different types. It may mean the whole body moving at maximal running speed, as in the sprinter. It may involve optimal speed, such as the controlled speed in the approach run of the jumping events. Or, it may include the speed of a limb, such as the throwing arm in the shot or discus, or the take off leg in the jumps. Speed includes the following types:

- **Maximal speed**
  - As fast as you can - may involve whole body or limb movement
- **Optimal speed**
  - Controlled speed in the approach to a jump, making a throw or the best average speed for whatever distance you are walking or running
- **Acceleration speed**
  - The rate of change in speed
- **Reaction time**
  - The time between a stimulus and the first movement of the athlete. Includes the reaction to the gun in the crouch start but also to how quickly an athlete responds to something in an event
- **Speed endurance**
  - The ability to continue to express either maximal or optimal speed as fatigue levels increase.

Maximal speed

Optimal speed

Acceleration speed

Reaction time

Speed endurance

At birth and through infancy a child's nervous system is in place but is not fully developed. As the nervous system develops and matures in childhood it becomes capable not only of sending clearer messages down the nerves but also capable of sending these clearer, more precise, messages down the nerves at a quicker, faster rate. The time when the nervous system has matured sufficiently so that the child can make and learn accurate muscular movement coincides with the time when the child can now make quicker movements. The time immediately following this nervous maturation can be considered as 'windows of opportunity' for the development of skill and speed.

In fact, we have seen that skill and speed are not the only components of fitness that have windows of opportunity. The diagrams for the developmental windows of opportunity for boys and girls show additional opportunities, for the development of strength, aerobic capacity and a second time for speed.

The first 'speed window' is related to the development of the nervous system and its ability to now carry messages much more quickly. This speed window does not mean that the athlete should now suddenly start doing 100m sprint repetitions. Instead there should be a development of reaction movements and quickly initiated movements. This can be done through a variety of speed-based multi-directional movements and games based on activities lasting less than 4-5 seconds with adequate recovery in between.

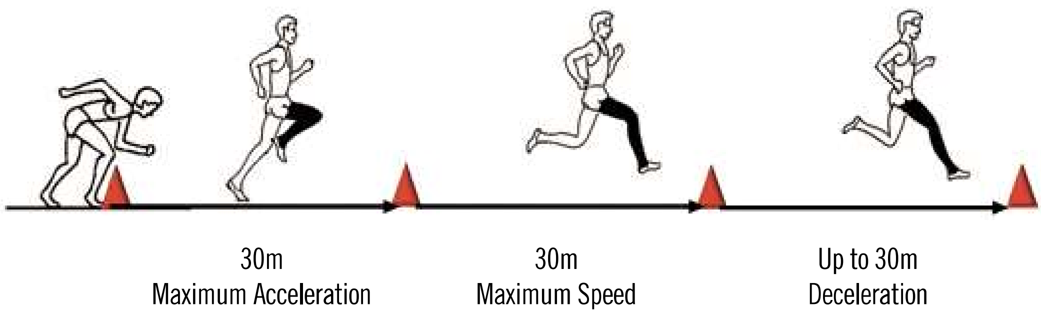
The second speed window occurs in adolescence due to the continuing development of the nervous system now having the addition of the developing energy systems. During this speed window all types of speed related work may now be carried out to the benefit of the developing athlete.

Development of Speed

Speed training involves development of a skill so that the technique is performed at a faster rate. To develop speed the skill must be practised on a regular basis at a maximum or close to maximum rate of movement. Maximal running speed, for example, is developed by runs over short distances at maximum effort. Perhaps the foundation exercise for developing maximal speed is the 'Flying 30s' which are maximal sprints over 10m, 20m, 30m or even 40 metres. The most common distance for senior athletes is 30 metres which is why the exercise is known as 'Flying 30s'.

The coach marks out an acceleration zone of 30m, and a 'maximal speed zone' of 30m with a run-out for controlled deceleration of up to 30m, as shown in the diagram. The skill of moving at speed should, like all skills, be practised before the athlete becomes fatigued. For this reason recovery times between repetitions and sets should be long enough to recover from any fatigue. In the case of this exercise which emphasises the ATP-CP energy system there should be recoveries of 2 mins - 3 mins between repetitions and at least 5 mins - 8 mins between sets.

Because this exercise requires intense effort and concentration to achieve maximal speed, there should not be more than 3 repetitions in a set. The coach can make the Flying 30s the whole session such as 3 x 3 x Flying 30s (max) [2' and 5'-8'] or part of the session, provided it is at the beginning when the athlete is not fatigued, such as 2 x 2 Flying 30s (max) [2' and 5'] before moving on to another activity.



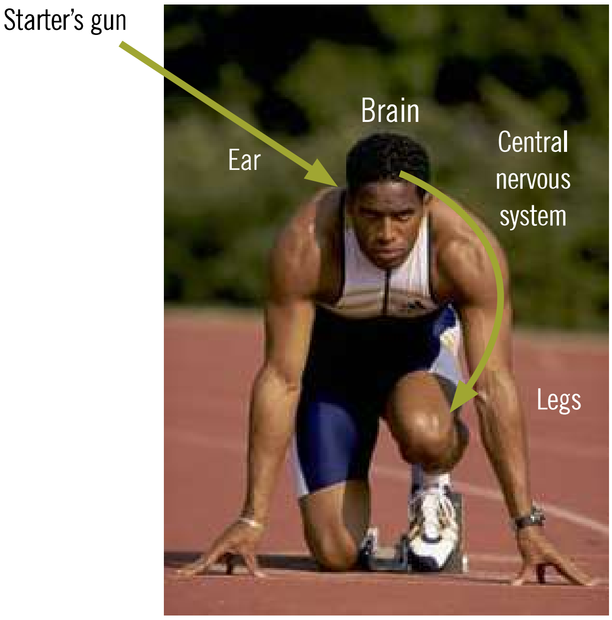
Flying 30s for the development of maximal velocity sprinting

The athlete accelerates maximally from a standing start position so that they attempt to achieve maximal velocity before the 'maximal speed zone'. Through the maximal speed zone the athlete tries to maintain frequency, how quickly their legs are moving. The athlete should not show any acceleration in the maximal speed zone as this should have already occurred. If the coach observes an athlete slowing on the maximal speed runs during a session he should stop the practice and move on to something more appropriate since the athlete is no longer practising maximal speed.

If the athlete is young or has a low training age, they may be capable of 'Flying 10s' where the 'maximal speed zone' is just 10 metres long. But the acceleration zone should still be 30m and the deceleration zone should still be up to 30m. They can then develop to 'Flying 20s' and for senior athletes with a high training age and a stable, uninterrupted training background, to 'Flying 30s' and even to 'Flying 40s'.

Reaction Time

When considering speed it is important to include reaction time. Reaction time is the time between a stimulus and the first movement by the athlete, such as the firing of the starter's pistol and the athlete's movement from the blocks. There are many factors both physiological and psychological which influence reaction time and the initiation of movement. It also includes the athlete's response to what happens during a competition. How long does it take the athlete to react. Simple reaction time games can be great fun for young athletes and in the Kids' Athletics stage of athlete development these games ensure that the first window of opportunity for speed is optimised. Reaction time for athletes of all chronological ages and training ages can be improved with practice, provided the practice situation is realistic.



Reaction time of the athlete in the sprint start

Power

Power is the interaction of strength and speed, the relationship between speed of contraction and speed of movement. It relates how quickly an athlete can produce force and not merely how much force they can produce. Power lets athletes accelerate quickly and successful athletes are powerful athletes. This quality of speed of movement and strength to increase power output should be developed, once a basis of speed and a foundation of maximum strength has been developed. Power is of obvious importance in the 'power' events of sprinting, hurdling, jumping and throwing but is still of importance in those events which emphasise endurance such as walking and distance running.

	ATP-CP
Duration	0-10 secs
Distance	20m-80m
Intensity	Maximal
Repetitions	3-4
Recovery/Reps	2-3 mins
Sets	1-4
Recovery/Sets	5-8 mins

Summary of the development of speed emphasising the ATP-CP energy system

With a clear understanding of the different types of speed the coach can devise exercises to develop and improve the athlete's speed capacities, at the right time in an individual athlete's developmental pathway and in the correct way.

Developing Strength

Muscular strength is the ability of the body to exert force. Strength is important to every event in athletics for both males and females, provided this is functional strength. Muscle fibres within the muscles respond when subjected to weight or resistance training. This response makes the muscle more efficient and able to respond better to the central nervous system.

Strength is a very important component of fitness for all athletes but the important question is frequently asked, “Is training for strength appropriate for children and young athletes?” With a sound knowledge of growth and development and the stages of athlete development, the coach now knows that young athletes can begin learning the ‘techniques of free weight lifting’ from about the ages of 8 - 11 years when they are in the ‘skill’ window of opportunity. Then, once they are mature enough and have entered the ‘strength’ windows of opportunity, they can start ‘free weight training’ for strength gains.

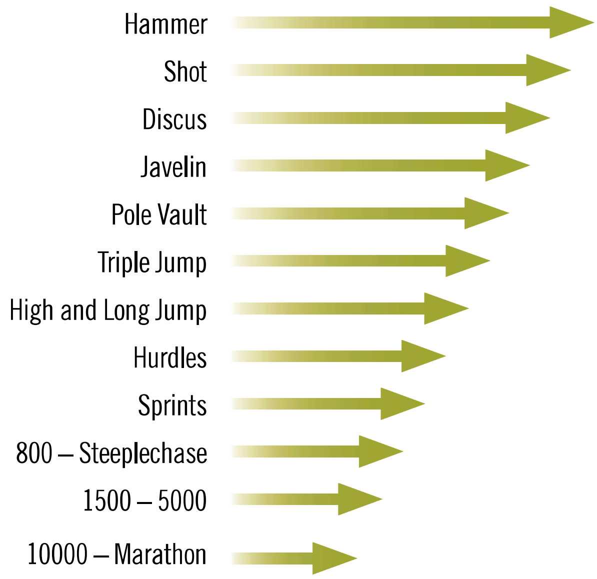
Types of Strength

Muscular strength is the ability of the body to exert force and may be broken down into four types:

- **Maximum strength**
- **Power**
- **Strength endurance**
- **Reactive Strength**

Maximum Strength

This is the greatest force that a contracting muscle can produce. Maximum strength does not determine how fast a movement is made or how long the movement can be continued. It is relatively more important in events where a large resistance needs to be overcome or great forces controlled.



Representation of maximum strength contribution to various athletics events

The relevance of maximum strength for all athletics events is often ignored. Maximum strength is a necessary basic quality as a foundation for power development but has little value in itself. Athletes should be strong but not be 'weightlifters' and their maximum strength must be evaluated in its contribution to their abilities as a powerful athlete.

Power

Power is the interaction of strength and speed, the relationship between speed of contraction and speed of movement. It relates how quickly an athlete can produce force and not merely how much force they can produce. Successful athletes are powerful athletes and this quality of strength should be developed, once a foundation of maximum strength has been developed. Power is of obvious importance in the 'power' events of sprinting, hurdling, jumping and throwing but is still of importance in those events which emphasise endurance such as walking and distance running.

Reactive Strength

Reactive strength is the potential of the athlete to use the elastic properties of their muscles and tendons. When a muscle works eccentrically, that is when the muscle is creating force but the dynamic contraction results in a lengthening of the muscle, it 'stores' energy. We have seen this in the section on the 'Body in Sport and Athletics' where you can see a picture of an athlete jumping down from a box to the floor and then springing up again. The athlete moves from an eccentric action to a concentric action.

This storage of energy by the muscles and tendons is similar to when you stretch a rubber or an elastic band. As you stretch the band it becomes longer and stores energy. If you release the band it very quickly, almost explosively, releases the stored energy and returns to its normal length. In athletics this process is called the 'stretch-shortening cycle', also known simply as the SSC. The stretch-shortening cycle describes the capacity of the muscles and tendons to produce high concentric forces within a very short time after an eccentric stretch. These high concentric forces are called reactive strength.

Unlike maximum strength and power there are two specific mechanisms in reactive strength:

- Storage of Energy - while the muscle is stretching energy will be stored (eccentric phase)
- Reflex actions - this permits energy to be regained quickly at shortening (concentric phase).

Reactive strength is an independent dimension of strength and will not automatically be improved by higher maximum strength or power capacity. It is often over-looked in the running and walking events but provides a vital element to performance in these, as well as in the traditional 'power' events.

Strength Endurance

This is the ability of the muscles to continue to exert force in the face of increasing fatigue. Strength endurance is simply the combination of strength and duration of movement. Performing an exercise, such as sit-ups, to exhaustion would be a test of strength endurance. This strength characteristic determines an athlete's performance where a movement is repeated over a fairly long period of time. Runs between 60 seconds and 8 minutes, for example, require a lot of strength endurance. The ability to sprint, hurdle, throw or jump repeatedly in training or competition and maintain performance levels also requires strength endurance.

Development of Strength

Weight training and resistance training will both develop strength. If there is an increase in muscle mass as a result of training this is called hypertrophy. Muscle hypertrophy is associated more as a result of training for maximal and reactive strength rather than strength endurance. When strength training stops the principle of reversibility indicates that some strength will be lost and the muscle mass may reduce. Reduction in the muscle mass is known as atrophy. Muscle atrophy is a direct result of low, or no, activity and may be a factor in injury rehabilitation.

Maximum strength is best developed by exercises which involve a low number of repetitions and a large resistance or loading. Power is developed through fast repetitions using an appropriate loading and strength endurance is developed using a high number of repetitions with a low resistance. Reactive strength is developed by using exercises which utilise the SSC such as bounding. These methods can be combined by the coach into an overall strength programme and these combinations will vary for different events.

For young athletes, we have seen in the chapter on growth and development that the strength 'window of opportunity' is related to the hormonal changes that occur at puberty. When the athlete reaches this level of maturity they can safely shift from 'weight training for technique development' to 'weight training for strength gains'. Testosterone is the hormone associated with the development of secondary male sexual characteristics but it is important to note that this hormone is also present in females. In females it is present in much less significant amounts than males and once puberty occurs for girls the hormone responsible for female characteristics, oestrogen, becomes dominant. For girls there are effectively two strength windows. The first occurs just prior to puberty when any strength gains and nervous, or neural, adaptations achieved at this time will remain after puberty. The second window for girls occurs after puberty when further strength training for functional strength development can commence.

For boys, the window of opportunity for strength occurs in the twelve to eighteen months after puberty, as testosterone levels rise and peak. Boys could do strength training before puberty but the effects would not be as effective as waiting for the testosterone levels to rise.

Free Weights

The term 'free weights' is given to weights that, when they are moved, the path of the weights is free to move anywhere. Free weights include barbells and dumb-bells. Barbells are long bars that are held by the athlete with two hands. Dumb-bells are short bars that permit weight to be lifted either singly or in both hands. The advantages of sometimes using dumb-bells include identifying muscular imbalances. With free weights, whether using a barbell or dumb-bells, where and how the weights move is controlled 100% by the athlete. With 'machine weights', while the athlete may be able to lift very heavy weights, the path of movement of the weights is controlled by the machine.

The advantages of using free weights, rather than machine weights, include:

- Offering a greater variety of movement
- Muscular imbalances are highlighted
- Permit whole body exercises which help develop stability of the joint areas
- Producing greater power output than machine weights
- Contributing to the development of core stabilisation strength.

It is recommended that all athletes use free weights where ever possible. Machine weights may have some role to play in the initial rehabilitation after injury but, for the healthy athlete, machines do not develop functional strength. Machine weights are also expensive and require more maintenance. With free weights it is possible to improvise inexpensive, safe and appropriate equipment and environments.

Hicham El Gourrouj, double Olympic champion in 2004, using a basic free weights training room

In strength training the following terms are used to describe an exercise:

- Resistance
  - the load a muscle or group of muscles is required to move
- Repetitions
  - the number of times the exercise is performed without stopping, referred to by coaches and athletes as 'Reps'
- Sets
  - a specified number of repetitions comprises one set.

Three sets of ten repetitions, for example for a back squat exercise would be written:

- Back Squat 3 x 10 x (resistance) [recovery between sets]

For structuring weight training sessions to develop strength for athletes in the Specialisation and Performance stages the coach should think of using the '3-5 Rule' to guide the structure of the weights session.

The '3-5 Rule' for Strength Training

3-5	Sessions per week
3-5	Exercises per session
3-5	Sets per exercise
And, for maximal strength or power:	
3-5	Repetitions or Reps per Set
3-5	Minutes recovery between sets

This 'rule' is intended as a useful guide to structure successful weight training sessions but in practice it may not be possible to have the time to schedule 3-5 weight training sessions per week. Or, it may not be appropriate to the stage of development of the athlete to have 3-5 weight training sessions per week. If this is the case, a minimum of two strength sessions per week are necessary to develop strength.

Free weights permit whole body movements which develop many muscles and muscle groups at the same time. They also help the athlete to control their joints and develop postural strength. In this book we will look at two of the most important basic free weight lifts used for strength training.

- The Stiff-leg Deadlift
- The Squat

The first of these, the Stiff-leg Deadlift, helps to develop the correct feel for raising and lowering a weight while maintaining a correct body position. It also lays the foundation for more advanced lifts such as the Clean and Snatch.

In the Stiff-leg Deadlift and the Squat the technical characteristics of the trunk position are essentially the same. The athlete should start with a vertical trunk. The chest should be pushed forwards and at the same time the shoulder blades should be pulled backwards and downwards towards the hip joints.


The athlete should feel as they were trying to hold a money note between the shoulder blades. They should try to maintain this chest and shoulder position, and feeling of 'holding the note', through the whole movement of the lifts.

The Stiff-leg Deadlift

The stiff-leg deadlift is considered an essential foundation exercise for:

- Understanding the importance of shoulder position in maintaining posture
- Development of eccentric control in the hamstring, gluteal (buttocks) and lumbar spine regions
- Raising awareness of what a 'normally straight back' feels like under loading
- Stimulation of overall strength increases
- Increased ligament and tendon strength.

Front view at 45° *Side view*

Technical Characteristics

Start and Finish Position

Athlete's awareness of the 'Centre of Pressure' on the sole of the foot

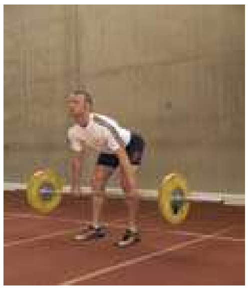
Keep holding a note between the shoulder blades

- The soles of the feet remain flat on the ground with the centre of pressure at the mid-foot.
- The bar starts in contact with the mid-thigh.
- The feet should be shoulder-width apart and facing forward
- The knees should be slightly bent. Note that this is not as some coaches think a straight-leg deadlift. This knee position is crucial and once the bent knee position has been established it should not be adjusted at all during the movement of the lift.
- The trunk is vertical. The shoulders are directly over the bar. The chest should be pushed forward and the shoulder blades pulled backwards and downwards, as if trying to hold a money note between them.
- The hands are placed one thumb length from the edge of the rough marking on the bar. This is just wider than shoulder width.
- The arms are straight with elbows pointing along the bar and with wrists flexed. The athlete maintains locked arms through this lift.

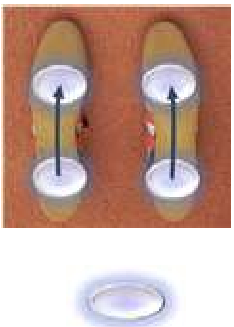
The Descent

Athlete's awareness of the 'Centre of Pressure' on the sole of the foot

- Maintaining the straight back and with the shoulders pulled back and bent knee position, the bar is lowered under control directly down the front of the thighs.
- This movement is aided by flexing at the hips and moving the hips backwards but not the knees, as the bar gets lower. There should be no movement, no straightening or further bending, of the knees.
- It is important to maintain a straight back with the normal slight inward curve in the lower spine throughout the movement.
- The coach should emphasise the importance of the athlete pulling the shoulder blades back together. "Imagine you are holding a money note between them" and pushing the chest forwards throughout the movement. Losing this shoulder position will mean the hamstring stretch will not be felt.
- The descent continues until the Hamstrings, the back of the thigh, become fully stretched and tight.
- Most athletes feel this before the bar reaches the knees. If the athlete has flexible hamstrings and a greater range of movement is needed to feel the stretch, then this is OK as long as the athlete's back does not become horizontal. If the athlete does not feel the stretch before this point and the knees are in the correct position and the shoulders appropriately pulled back, progressively add more weight to the bar until the athlete does feel the stretch.



The Ascent



Athlete's awareness of the 'Centre of Pressure' on the sole of the foot

- From the bottom position with a full stretch on the Hamstring muscles the trunk is returned to the start position through hip extension and raising the trunk.
- There should be no movement, no straightening of the knees, as the athlete returns to the start position.
- The bar should return along the same path as it descended until the athlete has regained the start position.

The Squat

The Squat is the foundation lift for any athlete who wishes to gain functional strength. Squats are considered essential exercises for:

- Stimulation of overall strength increases
- Increased ligament and tendon strength
- Increased bone density
- Development of the muscles around the 'core', the lower back, hips and knees
- Improved neuromuscular coordination and efficiency that will improve performance in movements which are biomechanically similar.

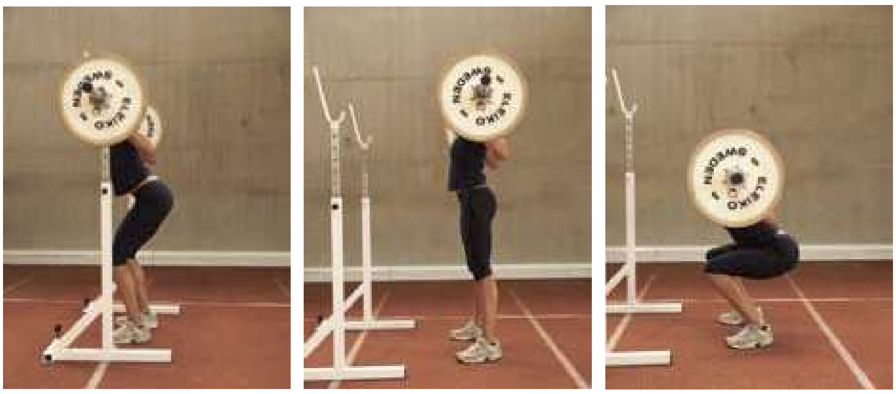
There are many variations of the Squat but we shall focus on the three types that most athletes will use:

- The Back Squat
- The Front Squat
- The Overhead Squat

As a coach you will see other variations of squats as you do your coaching. As you observe and analyse these variations you should evaluate in what ways these might be useful in your athletes' functional strength development.

The Back Squat

Rear view at 45°



Side View

Technical Characteristics

Preparing to lift the Bar

- Place bar in squat rack - slightly below shoulder height.
- Always walk forwards into squat frame.
- Stand mid-bar so the bar is positioned across the top of the back - across the trapezius muscles.
- Hands are evenly spaced - elbows are bent to less than 90º.
- Position feet directly under bar.
- Pull shoulder blades back fully - imagine that you are holding a money note between the shoulder blades - then push chest upwards and outwards.
- At the same time - pull the shoulders down towards the hip joints.
- Fully prepare body and mind before lifting bar.
- Stand straight and take 2–3 steps backwards to the 'start position'.

Start and Finish Position

Athlete's awareness of the 'Centre of Pressure' on the sole of the foot

- Start with - and keep - feet flat on floor - shoulder-width apart with toes pointed slightly outward in a natural position - this will be '5 to 1' on a clock for most athletes.
- The athlete should feel the 'centre of pressure' - where they are aware of feeling the 'weight' - on the forefoot with the whole foot flat on the floor.
- Keep head 'up' throughout lift.
- Maintain normal curve in lower spine throughout lift.
- Maintain shoulder blade and chest position throughout lift.
- Athletes with long legs or poor flexibility may benefit from a wider stance.

The Descent

Athlete's awareness of the 'Centre of Pressure' on the sole of the foot

- Before moving - take a deep breath in - hold until final stages of lift.
- Before moving - tighten lower back, abdominal and gluteal (buttock) muscles - pulling everything tight in this way is known as 'bracing' the trunk.
- A good coaching cue is for the athlete to imagine that the feet are 'ripping up the floor' by 'pushing' outwards throughout the lift – the feet should not move but this cue really activates the gluteal muscles.
- Begin by flexing at the hips and knees simultaneously - that is at the same time.
- Keep trunk upright throughout lift - maintaining a normal lower back curve.
- Knees should move in line over the toes - a common fault that should be avoided is for athletes to bring their knees inwards during the descent.
- As the athlete descends they should be aware of the 'centre of pressure' moving from the forefoot towards the heels.

The Bottom Position

Athlete's awareness of the 'Centre of Pressure' on the sole of the foot

- During the movement, the athlete must maintain a normal lumbar back curve, with the chest pointing upwards.
- The downward movement finishes when hip joint passes below top of knee.
- This means the knees will bend past 90º:
- This is important for athletes since the hamstring and gluteal muscles do not become fully involved until the hips pass below the knee.
- The pressure on the knees is reduced as the knees pass through 90º
- Always stopping the descent at 90 º means the athlete will never develop strength through a full range of movement.
- Feet stay flat on the floor throughout lift.
- In the bottom position the athlete should be aware of the 'centre of pressure' now on the heels.

The Ascent

- From the bottom position - drive upwards to the start position - leading the movement with the chest.
- In the ascent the athlete should be aware of the 'centre of pressure' of the weight moving from the heels - to finish in the start position - under the forefoot.

Young athletes and weight training

Young athletes should learn the techniques of weight lifting at a young age and then use weights for strength development when they are mature enough. For strength endurance they can use resistance exercises with bodyweight, circuit training and medicine ball exercises.

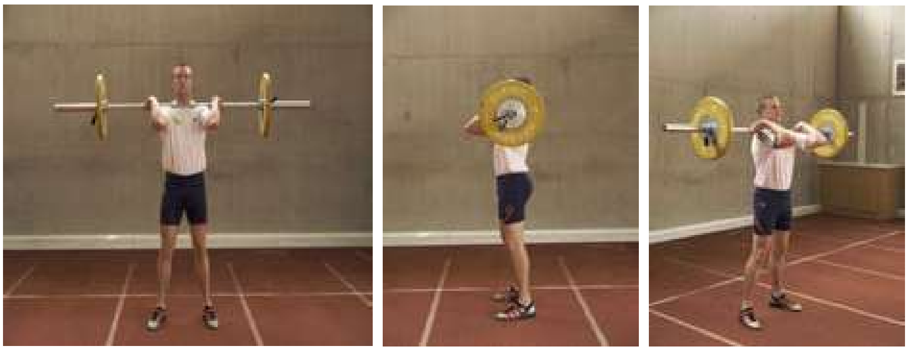
The Front Squat

Technical Characteristics

Start and Finish Position

Athlete's awareness of the 'Centre of Pressure' on the sole of the foot

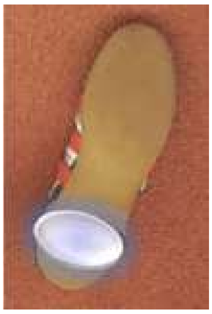
- Front squats move the weight of the bar more onto the thighs during the movement.
- With the bar in front of the body the athlete will get immediate feedback if the upper body leans too far forward. This lift may, therefore, be a progressive stage in teaching posture in back squats.
- Bar rests on upper front deltoids held in place by a clean grip with hands spaced slightly wider than shoulder width apart.
- Elbows are high and level with bar. Wrists should be extended and the grip relaxed.
- The action of the head, shoulders, trunk, hips, knees and ankles are exactly the same in this exercise as the back squat.



Descent and Ascent

- The action of the head, shoulders, trunk, hips, knees and ankles are exactly the same in this exercise as the back squat.

Bottom Position



- The bottom position is very similar to the Back Squat with the thighs below parallel to the ground and the knees pointing along the same line as the toes.

The Overhead Squat

This exercise is often over-looked but it is an excellent conditioning movement for all events and is one of the best exercises for developing trunk strength throughout the full range of movement. It is also a vital component of the squat snatch lift.

Technical Characteristics

Start and Finish Position

Athlete's awareness of the 'Centre of Pressure' on the sole of the foot

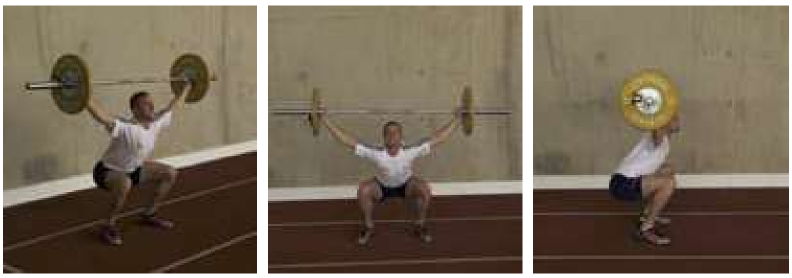
- In the overhead squat the bar is held in a wide grip above head.
- Once in place the hands should pull apart from each other - without moving on the bar. This helps to create shoulder stability.
- The arms should remain fully extended throughout the exercise with the elbows pointing along the length of the bar.
- The bar is positioned above and slightly behind the head.

Descent and Ascent

- The action of the head, shoulders, trunk, hips, knees and ankles are exactly the same in this exercise as the back squat.

Bottom Position

- The bottom position is very similar to the Back Squat with the thighs below parallel to the ground and the knees pointing along the same line as the toes.



The recommendations and statements made on strength and conditioning training in this book reflect the advice of Clive Brewer, an IAAF Consultant for Strength and Conditioning, with contributions, consensus and input from athletics coaches representing all IAAF Areas. The materials for the Stiff-leg Deadlift and the Squats were written specifically for the IAAF by Clive Brewer.

Strength Endurance Training and Conditioning

The development of muscular conditioning depends on a number of factors. These factors include the stage of development and experience of the athlete, the type of strength that is to be developed and the facilities available. Exercises that use body weight alone as a resistance are a good way to start strength endurance training, especially for younger and inexperienced athletes.

There are other resistance exercises which require a minimum of equipment. An example of these are exercises using medicine balls. A medicine ball, or an improvised, similarly weighted object, can be used to develop the general strength endurance and coordination required for walking, running, jumping and throwing.

Exercises Using Body Weight

Exercises that use an individual's body weight are very effective. They require no equipment or facilities and you can do them anywhere. Body weight exercises offer the opportunity for variety and progression. This can be seen with some of the variations available on a simple exercise such as press-ups, also known as push-ups.

Press Ups

The basic press-up is carried out from a front support position with a straight back and the head in natural alignment with the spine. The arms should be shoulder width apart. If strength levels are low, the athlete may rest the lower body on the knees rather than the feet.

Variations on the Press-up	
● Finger tip Press-up	Front support on finger tips
● Press-up touching chest	Touch your chest in between press-ups
● Press-up clapping hands	Clap your hands in between press-ups
● Press-up with feet raised	Front support with your feet on a bench or box
● Press-up raising one leg	Raise alternate straight legs each time you lower the body
● One arm Press-up	Front support with one hand behind your back
● Press-up from handstand	From a handstand against a wall, touch your forehead to the ground

Here are some more examples of resistance exercises using body weight alone:

Triceps Dip

Back support using a chair or box, starting in the 'up' position.


Sit Ups

Make the exercise with bent knees and hands on the chest, shoulders or sides of the head - not clasped behind the head. Draw the navel towards the spine before moving upwards.

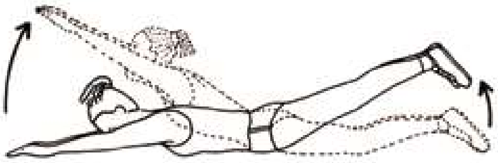


Leg Raise

Lying down but with the upper body raised up onto the elbows. Ankles are dorsiflexed and legs are raised one foot's length above the ground.


Back Extension

Lying face down alternately raise arms and then legs

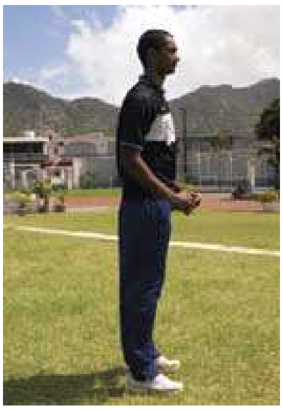


Chinnies

Sit-ups bringing alternate elbows to opposite knee.

Squats

Standing with feet shoulder width apart, squat as low as the athlete is able.



Squat Jumps

From a standing position repeatedly make a quarter squat and then jump as high as possible. On landing, sink the hips into another quarter squat position to absorb the landing and immediately jump again as high as possible.

Circuit Training

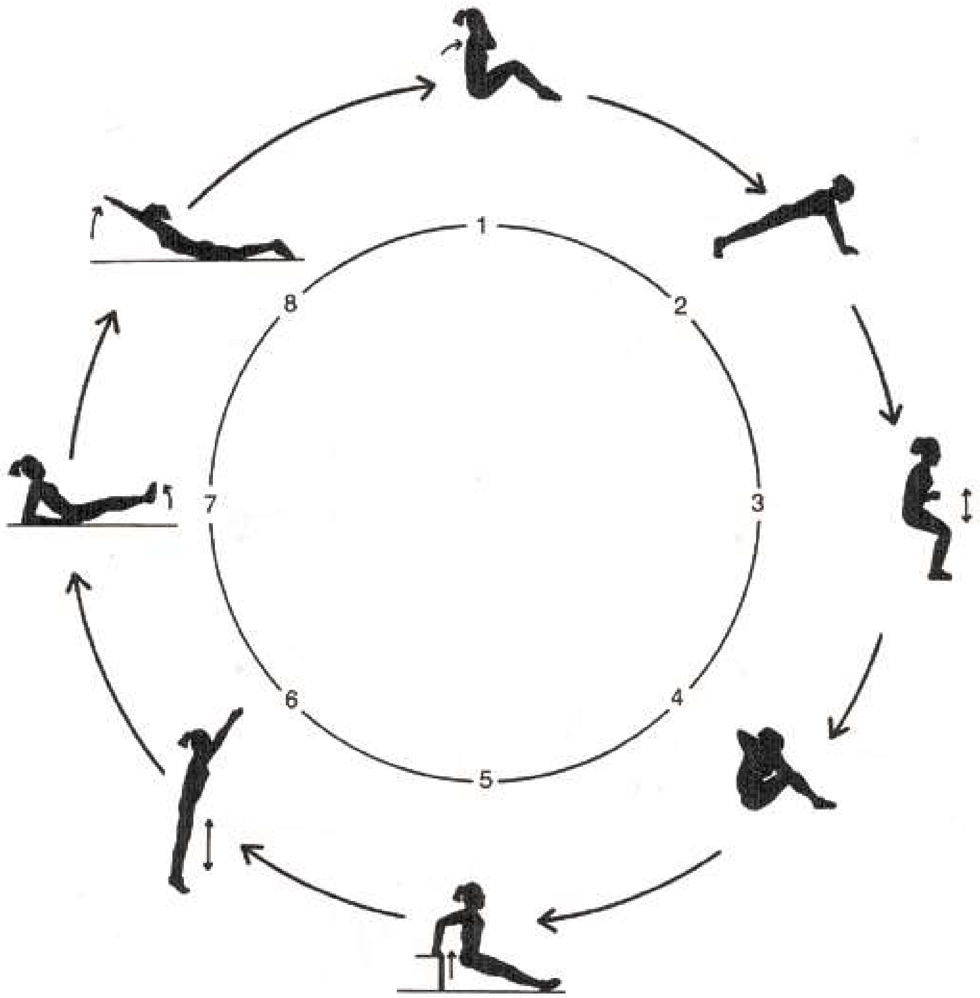
Circuit training is the term given to resistance exercises grouped together to achieve general or specific conditioning. Exercises are performed in a circular arrangement which allows athletes to progress from one exercise 'station' to the next until all stations have been visited. The completion of all exercises is one circuit. This type of training is ideal for small or large groups of athletes working together.

The coach should think of the body in four basic areas when planning a circuit training session

Exercises for each area should be worked in sequence, so that one leg exercise, for example, is not followed by another leg exercise.

The volume and intensity of exercises can be varied in many ways to make circuit training progressively demanding. Time is a good guide for setting work loads for the beginner. It allows each individual to perform the number of repetitions they are capable of and can easily be monitored by the coach.

The following is an example of a general conditioning circuit, using body weight as a resistance.



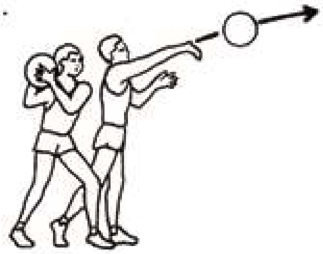
Number of circuits	1 - 5
Time at each station	30" - I' 30"
Recovery between exercises	1 5" - 45"
Recovery between circuits	2' - 5'

A general conditioning circuit

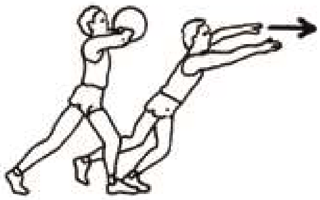
Exercises with Medicine Balls

The following are examples of exercises using a medicine ball:

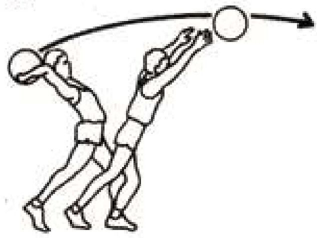
1.



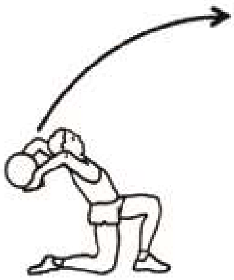
2.



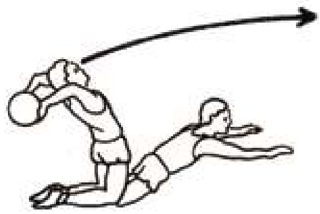
3.



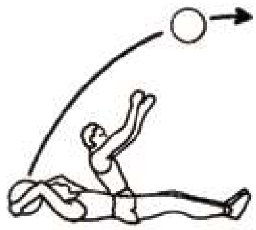
4.



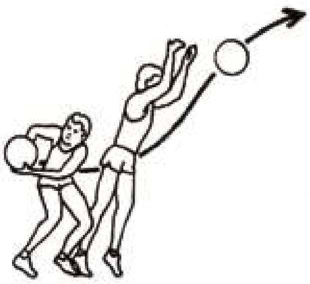
5.



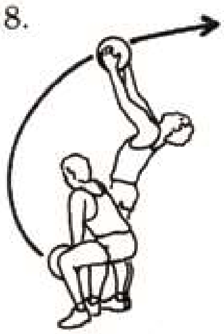
6.



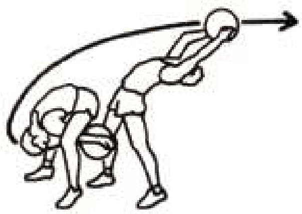
7.



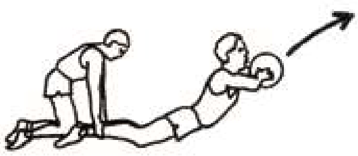
8.



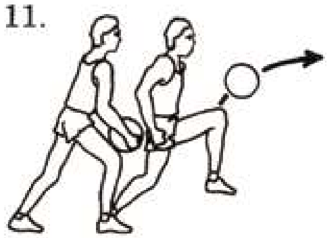
9.



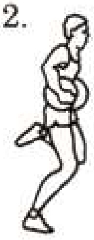
10.



11.



12.



Developing Flexibility

What is Flexibility?

Flexibility is the ability to perform joint actions through a wide range of motion. The natural range of motion of each joint in the body depends on the arrangement of tendons, ligaments, connective tissue and muscles. The limit to a joint's range of motion is called the 'end position'. Injuries can occur when a limb or muscle is forced beyond its normal limits. Flexibility training may not reduce the risk of injury by gradually increasing a joint's range of motion but may help to express power through the optimal range of motion.

Restricted flexibility is one of the common causes of poor technique and performance. Poor flexibility can also hinder running speed and endurance since the muscles have to work harder to overcome the resistance to an efficient stride length. Flexibility tends to decrease as we get older, while females are usually more flexible at all ages. Young athletes should do regular individualised stretching programmes to develop flexibility where it is needed and maintain existing flexibility. This can prevent the loss of flexibility that comes with age.

A traditional broader definition of flexibility has been,

"the ability to perform a range of movement in a joint or a series of joints."

Coaches and athletes have over many years created many ways and means to enhance flexibility. Unfortunately, many of these methods have improved flexibility but may have been carried out at the wrong time to benefit the training session or competition or have given improvement at the cost of joint stability. Traditional passive stretching has been incorrectly used for several decades based on the ritual of a typical athletics warm up routine. For the past several years there has been an increasing use by informed and innovative coaches of a much more active, dynamic approach to flexibility exercises in the warm up. These more active, dynamic exercises are called 'mobilisation exercises' and are designed to prepare the body for the session which follows.

There are two main types of flexibility activities:

- **Flexibility exercises in the warm up**. Mobilisation exercises should be chosen for the warm up which access the athletes' existing range of motion (ROM) and prepare the body for the activity about to be undertaken

- **Flexibility exercises to increase ROM**. These exercises are aimed primarily at a long term programme to increase the range of motion, ROM, in a joint or series of joints. These exercises may be part of a cool down to a session or form a separate flexibility session itself.

Flexibility in the warm up

There is no evidence that traditional passive type stretching lowers the chance of becoming injured, which is one of the main reasons athletes have performed such exercises in the warm up. As a coach you want the athlete to work opposing muscle groups together actively in the warm up to optimise performance in the training or competition to follow. This is referred to as 'functional flexibility'. This is important because when an athlete performs a movement, especially a speed movement, the muscles required to move the body or an implement in the desired direction must contract quickly. However, the opposing muscle must relax equally as quickly for optimum performance. The functional flexibility needed is activated through an active, dynamic warm-up, using appropriate mobilisation exercises. Traditional static stretches do not provide this functional flexibility and may actually 'put the muscle to sleep' – something you definitely do not want in the warm up. Some examples of active, dynamic mobilisation exercises are shown in the following pages.

Examples of active, dynamic mobilisation exercises

Flexibility to increase the ROM

There are times when an athlete has a limited ROM at a joint or a series of joints and needs to work on improving this. This should be in a separate flexibility session, not in the warm up. Whenever an athlete does a flexibility session to increase the range of motion you want the selected muscle or muscle group that are stretched to relax and so enhance the range of motion. This protects not only the muscle but also the joint or joints involved with a specific muscle group. If athletes execute a passive stretch until they feel discomfort it means that pain receptors in the area being stretched are being triggered and the body is telling the brain something is not right. An athlete should not feel discomfort or pain during flexibility training.

Improving flexibility, like the development of other fitness abilities, is a slow process. To increase the range of motion of a joint the muscles have to be stretched beyond their normal point of resistance and the stretch held for a period of 15-30 seconds. The duration of holding the stretch within the 15-30 seconds range will vary according to the stretch being used and the fitness of the athlete. This work should be done several times a week using appropriate flexibility exercises. There are two main types of stretching exercise:

- Active stretching
- Passive stretching

In active stretching the athlete controls the movement. These exercises are usually done in the 'end position', as a static exercise and these can be used in the cool down, for between 6-10 seconds to regain any ROM 'lost' during the session. If the active, static stretch is to increase the ROM in a separate flexibility session, the stretches are held for between 15-30 seconds.

Examples of active, static stretching exercises

Example of passive stretching

In passive stretching the exercises are only performed in the end position, the static type of exercise. A partner controls the movement and great care is required. The athlete actively goes to the end position and the partner progressively applies pressure. At this point the athlete should concentrate on relaxing the muscles being stretched. Passive static stretching exercises can produce good improvements in range of motion provided the individual controlling the stretching is skilled in this type of stretching.

Sample Mobilisation Exercises for the Warm Up

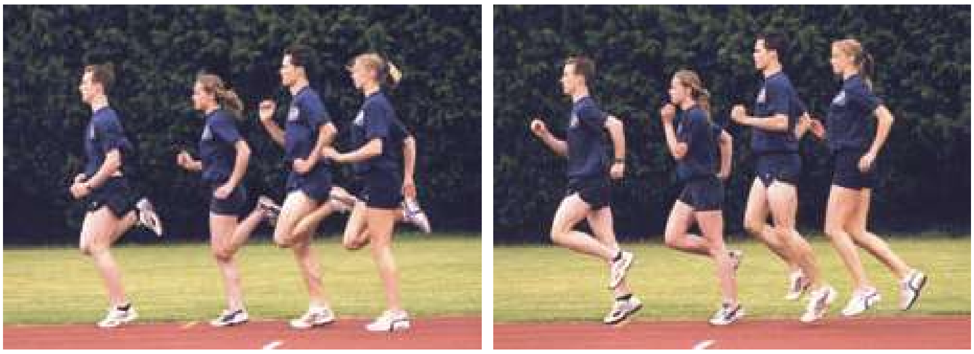
Slow to Fast ***Active to Dynamic*** ***General to Specific***

ARM CIRCLES

Either standing upright or while walking, circle one arm clockwise and the other arm counterclockwise. Alternate direction.

LEG SWINGS

Standing side-on to a hurdle or something similar, place hand on the hurdle for support and swing the outside leg forwards and backwards – flexing and extending the leg/hip and keeping the pelvis 'neutral'. Repeat for other legs. Another exercise can be done with body facing the bar, swinging leg to the side away from and across the body – adducting and abducting the leg/hip.



HEEL FLICKS

Small running steps, athlete quickly picks "toe up – heel up" behind them close to the body – ankle is 'cocked'.

WALKING LUNGES

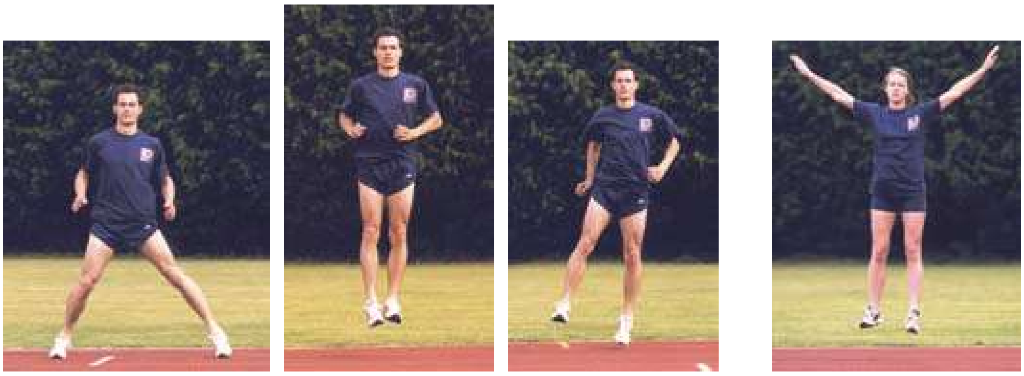
Long strides, high knee raises into low lunge position, feet always facing forwards, rear knee down towards the ground, front knee at approximately 90 degrees or less. Alternate arm and leg action.

Sample Mobilisation Exercises for the Warm Up

Slow to Fast ***Active to Dynamic*** ***General to Specific***

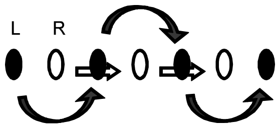
SKIPPING

SIDE STEPS



CARIOCA

Facing sideways, travelling to the right, left foot goes in front of right, right foot goes to the right, left foot goes behind right and then right foot goes to the right.



BACK SLAPS

Walking or skipping - stretch arms out to the side at shoulder height and then swing arms across body to slap the back. Alternate right on top, right underneath

Sample Stretching Exercises for Increase of ROM

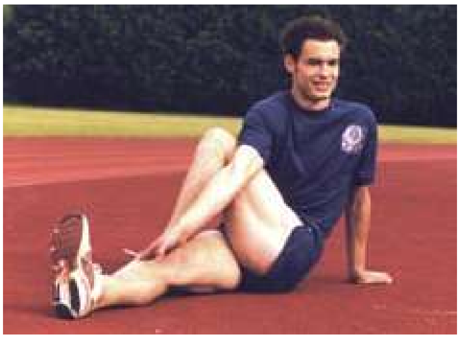
For the cool down or as a separate session for improving flexibility

CALF STRETCHES

ADDUCTOR STRETCH

QUADRICEPS STRETCH

IT BAND STRETCH



HAMSTRING STRETCH

SHOULDER STRETCH

Stretching exercises in the cool down:
hold for 6 -10 seconds

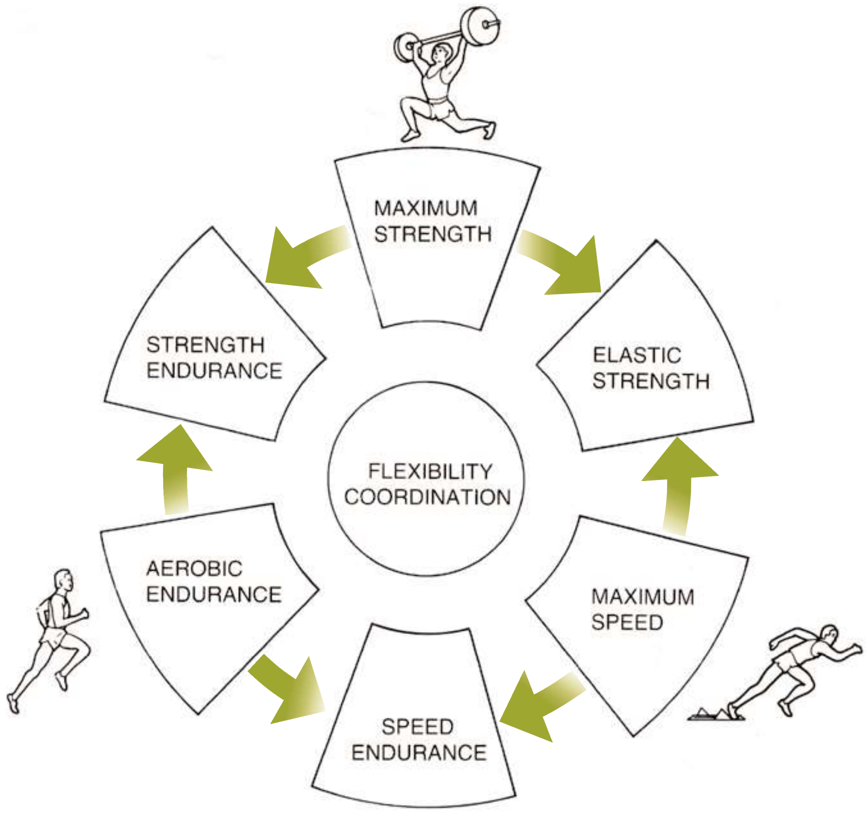
Stretching exercises in a flexibility session:
hold for 15 -30 seconds

Developing Coordination

Development of Coordination

Coordination is the ability to carry out complicated movements such as those involving more than one sequence or body part at the same time. It is the ability to carry these movements out at the optimal speed, efficiently and accurately. It is considered that an athlete with good coordination is capable not only of performing a skill well but also of rapidly solving a training task or learning a new skill. Coordination is one of the elements of 'physical literacy' and, in many ways, is required before a child can develop the other elements, which together make up physical literacy.

The coordination required for walking, running, jumping and throwing can be developed from a young age once the nervous system is mature enough. Girls between the ages of 8 and 11 and boys between the ages of 8 and 13 have exceptional rates of learning in the skill 'window of opportunity'. Basic coordination exercises and skills that are learned at this age become the foundation for later event specific skill development. In the mature athlete coordination exercises and drills remain important as they maintain a balance against the imbalances caused by very specific training.



Inter-relationship of the components of fitness

The components of fitness have been presented separately to identify the characteristics of each. In practice there is no such thing as a 'pure' strength exercise or a 'pure' speed exercise. The components of fitness contribute to overall physical fitness and an understanding of their inter-relationship allows the coach to plan training more effectively.